

UNIVERSITI TEKNOLOGI MARA

**EFFECTIVENESS OF EXERCISE
INTENSITY IN IMPROVING
CARDIORESPIRATORY FITNESS
AND BODY COMPOSITION
AMONG PEOPLE LIVING WITH
OBESITY: A SYSTEMATIC
REVIEW AND META- ANALYSIS**

**NURUL NAJWA BINTI AMINUL
MAHZAN**

MSc

July 2026

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NURUL NAJWA BINTI AMINUL MAHZAN

Thesis submitted in fulfilment
of the requirements for the degree of
Master of Science
(Sport Science and Recreation)

Faculty of Sports Science and Recreation

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 19th August 2025 to conduct the final examination of Nurul Najwa binti Aminul Mahzan on her Masters of Science thesis entitled “Effectiveness of Exercise Intensity in Improving Cardiorespiratory Fitness and Body Composition Among People Living with Obesity: A Systematic Review and Meta- Analysis” in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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ABSTRACT

Obesity is a prevalent global health issue, strongly associated with numerous comorbidities, including cardiovascular diseases, diabetes, and hypertension. Among the non-pharmacological interventions for obesity management, aerobic exercise modalities such as High-Intensity Interval Training (HIIT) and Moderate Intensity Continuous Training (MICT) have gained significant attention. However, the efficacy of HIIT and MICT in improving cardiorespiratory fitness (CRF) and body composition in obese individuals has yielded inconsistent findings in the literature. Therefore, this study aimed to evaluate and compare the effects of HIIT and MICT on CRF, body fat percentage, (PBF) waist circumference (WC), and visceral fat (VF) in obese adults. A comprehensive search of PubMed, Web of Science, MEDLINE, and Cochrane databases identified randomized controlled trials (RCTs) published up to October 2022. Eligible studies included individuals aged 18–60 years with a BMI ≥ 30 kg/m², and compared either HIIT or MICT interventions. A total of 21 studies were included in the analysis, and study quality was assessed using the TESTEX tool. Data were analyzed using RevMan 5 software. Results indicated significant improvements in cardiorespiratory fitness (CRF) with HIIT, with a weighted mean difference (WMD) of 0.64 (95% CI: 0.00 to 1.28; P = 0.05), although no statistically significant differences were found for body fat percentage (WMD = -0.37; 95% CI: -0.77 to 0.04; P = 0.06), waist circumference (WMD = 0.29; 95% CI: -0.55 to 1.13; P = 0.48), or visceral fat (WMD = -0.37; 95% CI: -0.88 to 0.14; P = 0.16). In short, both HIIT and MICT demonstrated comparable efficacy in improving key health parameters associated with obesity. These findings suggest that health professionals should prioritize individual preferences and safety considerations when recommending exercise regimens for obese population.

Keywords: Body Composition, High-Intensity Interval Training, Moderate Intensity Continuous Training, Obesity, Cardiorespiratory fitness, Body fat percentage, Waist circumference and Visceral fat, Systematic Review, Meta-Analysis.

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LIST OF SYMBOLS

Symbols

%	Percentage
CI	Confidence Interval
Df	Degree of Freedom
M	Mean
Max	Maximum
MD	Mean Different
Min	Minimum
n	Population
N	Sample Population
p-Value	Significance Level
R	Correlations
SD	Standard Deviation
Peak VO ₂	Peak Oxygen Consumption

LIST OF ABBREVIATIONS

Abbreviations

ACC	American College of Cardiology
ACSM	American College of Sports Medicine
AHA	American Heart Association
BIA	Bioelectric Impedance Analysis
BMI	Body Mass Index
CI	Confidence Interval
CRF	Cardiorespiratory Fitness
CRP	C-Reactive Protein
CVD	Cardiovascular Diseases
DEXA	Dual-Energy X-ray Absorptiometry
EPOC	Excess Post Oxygen Consumption
FITT	Frequency, Intensity, Type, Time
GDP	Gross Domestic Product
GRS	Genetic Risk Scores
HDL	High-Density Lipoprotein
HIIT	High-Intensity Interval Training
HRQL	Health-Related Quality of Life
HRR	Heart Rate Reserves
LDL	Low-Density Lipoprotein
MD	Mean Difference
MET	Metabolic Equivalent
MHR	Maximum Heart Rate
MICT	Moderate Intensity Continuous Training
NIH	National Institutes of Health
PBF	Percentage Body Fat
PICO	Population, Intervention, Comparison, and Outcome
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
QOL	Quality of Life

RCT	Randomized Controlled Trials
RMR	Resting Metabolic Rate
SE	Standard Errors
SSB	Sugar-Sweetened Beverage
TESTEX	Tool for the Assessment of Study Quality and Reporting in Exercise
VF	Visceral Fat
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-to-Hip Ratio

CHAPTER 1

INTRODUCTION

1.1 Introduction of Study

Obesity has emerged as one of the most significant global public health challenges of the 21st century, with far-reaching implications for health systems, economies, and quality of life. The World Health Organization (WHO) estimates that, in 2022, approximately 890 million adults globally were living with obesity, constituting around 16% of the global adult population. According to WHO the global prevalence of obesity has more than doubled between 1990 and 2022, with rates increasing rapidly in both developed and developing countries alike. Notably, the rise in obesity is associated with an increase in obesity-related comorbidities, such as type 2 diabetes, cardiovascular diseases, and certain cancers. In addition, obesity places a significant strain on healthcare systems, with rising treatment costs for obesity-related diseases becoming a growing burden worldwide. The global obesity epidemic is driven by a combination of factors, including poor dietary habits, physical inactivity, urbanization, and genetic predispositions.

In Malaysia, the obesity trend mirrors the global situation, with the country facing a rising prevalence of obesity among its population. The National Health and Morbidity Survey (NHMS) 2024: Nutrition reported that 23.1% of Malaysian adults aged 18 years and above were classified as obese in 2024, while 30.5% were overweight, leading to a combined prevalence of 54.4% for overweight and obesity (Institute for Public Health [IPH], 2024). Additionally, the survey revealed that 52.1% of Malaysian adults had abdominal obesity, which is a major risk factor for metabolic diseases (IPH, 2024). The increasing rates of obesity in Malaysia are concerning, as they contribute to the rising burden of chronic diseases such as hypertension, type 2 diabetes, and cardiovascular diseases, which are responsible for a significant proportion of the nation healthcare expenditure (Wan et al., 2017). The prevalence of obesity has risen steadily in recent years, with the NHMS 2023 reporting that 21.8% of adults were obese, emphasizing the growing public health challenge in the country (IPH, 2023). These statistics highlight the urgent need for public health initiatives aimed at reducing obesity rates and promoting healthier lifestyles in Malaysia.

The rise in obesity is strongly linked to a lack of physical activity, as many Malaysians largely attributed to a sedentary lifestyle and insufficient physical activity. According to the same NHMS report, only about 26.6% of Malaysian adults engage in physical activity of at least 150 minutes per week, the minimum recommended by the World Health Organization (WHO). The urgent need for tackle the obesity issues, the Malaysian government has implemented a variety of programs to increase participation in physical activities among the population. One such program is Fit Malaysia, a national initiative that encourages Malaysians of all ages to engage in physical exercise. Fit Malaysia organizes events across the country, such as fitness carnivals, running events, and sports activities, to promote physical activity in communities (MOH, 2021). Furthering the physical activity agenda, the Malaysian Ministry of Health (MOH) has also integrated physical activity promotion into the National Plan of Action for Nutrition 2016-2025. This policy aims to reduce obesity rates by encouraging healthier eating habits and promoting physical activity among all segments of the population, including children, adults, and the elderly.

Physical activity is widely regarded as the first-line treatment for obesity, as increasing daily movement and structured exercise directly enhances energy expenditure and promotes reductions in adiposity among overweight and obese individuals (Rotunda et al., 2024). Economic modelling studies indicate that population-level strategies encouraging physical activity are cost-effective by reducing future healthcare expenditures associated with obesity-related diseases, as increased activity lowers the burden of long-term treatment needs (World Obesity Federation, 2025). Moreover, because physical activity can be performed with minimal financial cost and delivered across community settings, it remains one of the most affordable and scalable interventions compared with pharmaceutical or surgical options for obesity treatment (World Obesity Federation, 2025).

Implementing physical activity among individuals with obesity is crucial for reducing the risk of non-communicable diseases (NCDs), including cardiovascular diseases (CVD), diabetes, and certain types of cancers. Obesity, a major risk factor for these conditions, significantly increases the likelihood of developing chronic diseases that result from metabolic dysfunctions and inflammatory responses (WHO, 2021). A nationwide study by the Ministry of Health revealed that over 50% of adults are overweight or obese, further compounding the risks of chronic diseases like CVD and diabetes. Given this context, encouraging regular physical activity is essential for

preventing and managing these diseases. Intervention programs that integrate physical activity as part of lifestyle changes can effectively reduce obesity-related NCD risks contributing to better long-term health outcomes and a reduced healthcare burden.

Physical activity is crucial for improving overall health, particularly for individuals with obesity, as it significantly helps in reducing the risk of obesity-related diseases, enhancing cardiovascular health, and promoting long-term weight management. The American College of Sports Medicine (ACSM) provides specific guidelines for exercise prescription in individuals with obesity to enhance physical fitness, promote weight loss, and reduce the risk of obesity-related health complications such as cardiovascular disease, type 2 diabetes, and hypertension. These guidelines emphasize exercises tailored to meet the needs and capabilities of individuals with obesity. According to the ACSM guidelines, aerobic exercise should form the core of an exercise program for individuals with obesity. This exercise is essential for improving cardiorespiratory fitness, promoting fat loss, and enhancing metabolic function and tailored to meet the needs and capabilities of individuals with obesity while considering potential barriers, such as joint pain, limited mobility, and low fitness levels, which are common in this population (ACSM, 2018).

Aerobic exercise is defined as physical activity that involves continuous and rhythmic movement of large muscle groups, which increases the heart rate and improves the efficiency of the cardiovascular system in transporting oxygen throughout the body. This type of exercise includes activities such as walking, running, cycling, and swimming, and is typically performed at a moderate to vigorous intensity for an extended duration (Donnelly et al., 2020). Two of the most commonly recommended forms of aerobic exercise for individuals with obesity are High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT). High-Intensity Interval Training (HIIT) involves alternating periods of intense exercise performed at 85%-100% of an individual's maximal heart rate (MHR) with short recovery periods of low-intensity exercise or rest (Buchheit & Laursen, 2019). These high-intensity bursts typically last between 20 and 60 seconds, followed by recovery intervals of equal or longer duration, repeated several times within a workout session. Meanwhile, Moderate-Intensity Continuous Training (MICT) involves sustained aerobic exercise performed at a moderate intensity, typically between 50%-70% of MHR, for a continuous period of 30 minutes or longer (Thum et al., 2017).

High-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) are two widely recommended forms of aerobic exercise for individuals with obesity. However, the comparative effectiveness of these two exercise modalities remains a topic of ongoing debate, with recent studies producing inconsistent results. HIIT has gained significant attention in recent years due to its time efficiency and effectiveness in promoting body composition among obese adults (Roy et al., 2018). Furthermore, HIIT has been shown to enhance cardiorespiratory fitness and improve the body ability to burn fat both during and after exercise, (Schumann et al., 2020). However, due to its demanding nature of HIIT may be less tolerable for individuals with severe obesity or joint issues, as it can lead to fatigue, shortness of breath, and muscle soreness (Thum et al., 2017). On the other hand, MICT is generally easier to tolerate, especially for individuals who may have limited physical fitness or those who are new to exercise. (Patel et al., 2020). Additionally, MICT is considered a safer and more sustainable option for individuals with obesity, particularly those with comorbid conditions such as hypertension or osteoarthritis, as it reduces the risk of injury and fatigue (Ryan et al., 2020).

Several systematic reviews and meta-analyses have demonstrated that HIIT leads to greater reductions in waist circumference, body fat percentage, and improvements in cardiorespiratory fitness compared to MICT (Maillard et al., 2018; Schumann et al., 2020). However, MICT remains an effective alternative for individuals who may find HIIT too intense or who are unable to tolerate the higher intensity required for interval training. Another findings reported by a systematic review and meta-analysis, HIIT and MICT show similar effectiveness across all body composition measures (Michael Wewege et al., 2017). For instance, a study by Sanca-Valeriano et al. (2023) found that both HIIT and MICT significantly improved insulin sensitivity and reduced fat mass in overweight and obese adults, with no significant differences between the two exercise modalities. Although both HIIT and MICT have been widely studied in obese populations, the research remains inconclusive regarding the extent of their comparative benefits. The inconsistent results regarding the comparative effectiveness of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in obese populations highlight the need for further exploration in this area. This study is expected to provide valuable insights into the relative effectiveness of HIIT versus MICT for obese adults particularly in adiposity reduction and cardiorespiratory fitness.

1.2 Statement of Problem

The prevalence of obesity continues to rise despite various interventions implemented by the Malaysian government. For instance, the Ministry of Health Malaysia (MOH) established a task force aimed at addressing the obesity epidemic (MOH, 2016). This task force was tasked with identifying the root causes of obesity in Malaysia and developing a comprehensive Plan of Action to mitigate the issue, taking into account Malaysian food habits and physical activity patterns (MOH, 2016). The task force outlined 26 food policy options, 29 physical activity policy options, and three overarching policy strategies (MOH, 2016). Notably, the government placed significant emphasis on physical activity, as evidenced by the larger number of physical activity policy options compared to food-related policies. This prioritization underscores the critical role of physical activity in managing obesity. Furthermore, the Ministry of Health (MOH) published the National Strategic Plan for Active Living in 2018, which provided strategies to promote physical activity among Malaysians (MOH, 2018).

Exercise has long been acknowledged as a non-pharmacological pivotal component in the management of obesity plays a significant role in obesity treatment and should not be underestimated (Jayedi et al., 2024; Yin et al., 2020). Aerobic exercise, specifically, has been shown to be an effective modality for weight loss (Niemiro et al., 2024; Wang et al., 2022). Several studies have demonstrated that aerobic exercise alone can result in notable weight loss (Donnelly et al., 2013; Jayedi et al., 2024; Yin et al., 2020). Recent meta-analysis finding further affirmed the role of exercise as effective approach in treating obesity (Rugbeer et al., 2021). However, the optimal exercise prescription for improving body composition and cardiorespiratory fitness (CRF) remains unclear (O'Donoghue et al., 2021). This uncertainty points to the need for careful consideration when designing aerobic exercise training programs for individuals with obesity-related conditions (Armstrong et al., 2022).

MICT (Moderate-Intensity Continuous Training) remains a well-established and safe exercise strategy for individuals with obesity, often recommended as an initial approach due to its low risk of injury and ability to reduce chronic inflammation. Recent research supports MICT effectiveness in reducing visceral fat, improving body composition, and enhancing cardiovascular fitness. A 2024 meta-analysis found that MICT leads to significant reductions in body fat, waist circumference, and visceral adiposity in individuals with overweight or obesity when performed consistently over

150 minutes per week (Jayedi et al., 2024). Moreover, MICT has been shown to safe exercise prescription for improving health outcomes, especially in those who may be at greater risk of injury or have limited exercise experience (Shi et al., 2022). Meanwhile, HIIT (High-Intensity Interval Training) has become an increasingly recognized strategy for weight loss, fat reduction, and the improvement of cardiometabolic health. Recent meta-analysis in 2024 indicated that HIIT significantly outperforms MICT in improving vascular function and enhancing fat loss, especially abdominal and visceral fat (Shishira et al., 2024). Furthermore, HIIT has been shown to increase cardiorespiratory fitness (Weston et al., 2014; Shishira et al., 2024). Studies suggest that HIIT can be a time-efficient and potent alternative to MICT, delivering substantial health benefits in shorter exercise durations (Zhu et al., 2025).

In contrast, few research has demonstrated that both MICT and HIIT have similar effectiveness in reducing body fat, improving cardiorespiratory fitness, and enhancing overall metabolic health (Smith-Ryan et al., 2016; Li et al., 2025). Recent systemic reviews stated both HIIT and MICT have similar effects on key obesity outcomes, such as body fat percentage and overall fat mass (Wewege et al., 2025; Mahzan, 2024). This lack of consensus highlights the need for further investigation to clarify which exercise intensity is more effective for managing obesity and improving long-term health in obese populations. Aerobics exercise remains crucial, with both moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) being widely recommended for improving body composition and overall health outcomes in obese individuals. However, despite the extensive growing body of evidence supporting both MICT and HIIT, the exact exercise intensity required to achieve significant changes in body composition remains debated till recent years. The most effective exercise intensity for obese individuals is still a subject of ongoing research (Ram et al., 2020).

These conflicting findings contribute to the ongoing debate regarding the optimal exercise intensity for individuals with obesity. This study aims to address these inconsistencies and determine the most effective exercise intensity for improving cardiorespiratory fitness and body composition among adult living with obesity to provide clearer recommendations can be made to optimize exercise programs for the management of obesity.

1.3 Purpose of Study

This general aim of this study is to determine the effectiveness of aerobics exercises in improving cardiorespiratory fitness and body composition among obese adults. The primary objective of this study is to identify the most effective exercise intensity for individuals with obesity, with a focus on determining whether high-intensity interval training (HIIT) or moderate-intensity continuous training (MICT) more significantly improves body composition and cardiorespiratory fitness in obese populations. This finding expected to provide valuable insights for the obese population to select the efficient exercise intensity. Additionally, this study seeks to provide healthcare professionals with evidence-based recommendations regarding the optimal exercise protocols to promote meaningful health improvement and assist in making informed decisions about exercise interventions tailored to the specific needs of obese individuals, thereby enhancing the efficacy of treatment programs. Furthermore, the study aims to contribute to the broader public health goal of reducing the burden of obesity-related diseases. This systemic review and meta-analysis aim to identify the most effective exercise interventions, in order to help mitigate both the direct and indirect healthcare costs associated with obesity, including the reduced productivity and increased illness rates within the workforce. In turn, this could aid in reducing the prevalence of obesity-related diseases and the strain on healthcare systems, particularly in relation to staff absenteeism and resignations due to obesity-related health complications.

1.4 Research Objectives

General Objectives: To determine the effectiveness of aerobics exercises on cardiorespiratory fitness and body composition outcomes among individuals with obesity.

Specific Objectives:

- i. To compare the effectiveness of HIIT versus MICT in CRF among obese population.
- ii. To compare the effectiveness of HIIT versus MICT in WC among the obese population.

- iii. To compare the effectiveness of HIIT versus MICT in PBF among the obese population.
- iv. To compare the effectiveness of HIIT versus MICT in the BMI in obese population.
- v. To compare the effectiveness of HIIT versus MICT in VF in obese population.

1.5 Research Hypotheses

General hypothesis: Aerobics exercises is effective in improving cardiorespiratory fitness and body composition among obese adults. Specific Objective:

- i. There is significant difference between HIIT and MICT training in CRF among obese patients
- ii. There is significant difference between HIIT and MICT training in WC among obese patients.
- iii. There is significant difference between HIIT and MICT training in PBF among obese patients.
- iv. There is significant difference between HIIT and MICT training in BMI among obese patients.
- v. There is significant difference between HIIT and MICT in VF among obese patients.

1.6 Scope of Study

This systematic review and meta-analysis generally check for aerobics exercises effectiveness on cardiorespiratory fitness and body composition among obese adults. However, the primary focus is comparing the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on cardiorespiratory fitness and body composition outcomes among individuals with obesity. The review specifically examines six outcome variables, which are cardiorespiratory fitness (CRF), waist circumference (WC), percentage body fat (PBF), body mass index (BMI), visceral fat (VF), and waist-to-hip ratio (WHR).

The primary comparison of interest in this review is between HIIT and MICT. Therefore, findings from control groups are considered supplementary and are included only where relevant to provide additional context for interpreting the comparative

effects of the two exercise modalities. Accordingly, this review is limited to studies involving individuals with obesity that assess HIIT or MICT or both and report at least one of the selected outcome variables.

This study employs two robust research methodologies systematic review and meta-analysis. A systematic review is a rigorous and comprehensive research method that follows a detailed and structured process to identify, evaluate, and synthesize all relevant studies on the topic. The systematic review aims to minimize biases and ensure a thorough and impartial examination of the existing literature. It involves a methodical search strategy to capture all studies that meet predefined criteria, which helps provide an objective assessment of the evidence regarding the effectiveness of HIIT and MICT for obesity management. This approach not only ensures the inclusion of all relevant studies but also enhances the reliability and generalizability of the findings.

In conjunction with the systematic review, a meta-analysis is performed. This statistical technique synthesizes data from multiple studies to calculate a consolidated estimate of the overall effect size. By combining the results of various studies, the meta-analysis provides a more precise and comprehensive understanding of the relative effectiveness of HIIT and MICT in improving health outcomes.

Meta-analysis is particularly valuable in resolving inconsistencies across individual studies, as it aggregates data to strengthen the evidence base and offer a clearer conclusion on which exercise modality is most beneficial for obese patients. Together, the systematic review and meta-analysis allow for an exhaustive and statistically robust examination of the available evidence, ultimately providing clear guidance on the most effective exercise intensity for managing obesity and improving health outcomes in this population.

Additionally, this study investigates the impact of aerobic exercises on cardiorespiratory fitness in obese individuals. This is important because improving cardiorespiratory fitness is a key factor in reducing the health risks associated with obesity, such as cardiovascular diseases and metabolic disorders. The study evaluates the effectiveness of both HIIT and MICT in improving cardiorespiratory fitness.

1.7 Significance of Study

1.7.1 Obese patients

From the past evidence, it is clear that exercise training has a beneficial impact on the large majority of obese patients. This study may provide additional knowledge regarding the most effective training program that focuses on exercise intensity for the optimal benefit in controlling obesity.

1.7.2 Health practitioners

This study will provide additional knowledge for health practitioners in prescribing the optimal exercise training for greater improvement in cardiovascular responses and body composition in obese patients. In addition, this study will benefit the health practitioners via updating the current approach of exercise for the treatment and management of obesity. This is because in medical health research it represents a continually expanding the original knowledge with a direct practical application. Therefore, this study will provide an objective framework for designing a more efficacious exercise training program based on obese patients.

1.7.3 Ministry of Health Malaysia

The prevalence of obesity in Malaysia is increasing every year, even though the prevention and management of obesity were put in high consideration. Currently, the government expends large amounts of money on the anti-obesity drug in the management of obese patients. Therefore, this study will provide additional information on exercise training as an alternative way for controlling obesity in obese patients and indirectly reducing the numbers of anti-obesity drugs. It has been reported by Pescatello et al. (2004) that there was minimal cost associated with lifestyle modification involved in exercise training. Subsequently, information from this study may encourage obese patients to involve themselves in an active lifestyle through participating in regular exercise programs. Indirectly, this study may help the country to reduce the cost of anti-obesity drugs in the management of obese patients.

1.8 Limitation of Study

Limitation of study may influence the results of the study. However, researcher tries to eliminate weaknesses in order to achieve the objective of the study. In the present study there were some unavoidable limitations that rise during this study conducted. The limitations involved in this study were as follow:

1.8.1 Publication bias

Meta-analysis includes only published studies, it may overestimate the actual magnitude of an effects. To reduce the effect of publication bias on meta-analysis, serious efforts should be made to identify all relevant studies, because the outcome of the meta-analysis depends on the studies included.

1.8.2 One number cannot summarize a research field

Summarizing large amounts of varying information using a single number is a controversial aspect of meta-analysis, as it ignores the fact that treatment effects may vary from study to study.

1.8.3 Heterogeneity of results

In meta-analysis heterogeneity refers to the degree of dissimilarity in the results of individual studies. The main assumption for performing meta-analysis is that studies are homogenous in terms of populations, interventions, controls, and outcomes.

1.9 Delimitation of Study

The delimitations involved in this study were as follow:

- i. Publication bias needs to be addressed in all meta-analyses and its importance considered. Researcher confront this problem is visual one based on a "funnel plot". The basis of this is observed effect sizes are plotted according to sample size they should scatter around an underlying "true" value, producing a funnel pattern. Gaps in the plot indicate potential unpublished studies and the possibility of bias.

- ii. To deal with high heterogeneity of data researched precisely checked the data are correct and perform a random effect meta-analysis.
- iii. In order to overcoming the summarize a research field with one number of meta-analysis. Researcher generalizes results despite differences in primary research and does not simply report a summary effect. If there is substantial heterogeneity, then the focus should shift from the summary effect to the heterogeneity itself.

1.10 Assumption of Study

The assumptions involved in this study were as follow:

- i. Aerobic exercises beneficial to improve cardiorespiratory fitness and body composition among people living with obesity.
- ii. HIIT and MICT offer a similar effect on cardiorespiratory fitness improvement in adult living with obesity.
- iii. HIIT and MICT offer similar effect in reduction of percentage body fat, waist circumference and visceral fat among adult with obesity.

1.11 Definition of Terms

Following is the lists of terms were defined in this study:

1.11.1 High-intensity Interval Training (HIIT)

High-intensity interval training (HIIT) is a form of aerobic exercise that alternates repeated bouts of high-intensity effort with periods of active recovery or rest, typically performed at approximately 85–95% of peak heart rate (Coates et al., 2023)

1.11.2 Moderate Intensity Continuous Training (MICT)

Moderate-intensity continuous training (MICT) refers to continuous aerobic exercise performed at a moderate intensity without planned rest intervals, typically at about 50–70% of peak heart rate (Li et al., 2022).

1.11.3 Obesity

Obesity is a medical condition characterized by excessive body fat accumulation that presents a risk to health. It is commonly quantified using the Body Mass Index (BMI), a measure of weight in relation to height (WHO,2020)

1.11.4 Cardiorespiratory Fitness

CRF is a health-related component of physical fitness defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity (Lee, Artero, Sui, & Blair, 2010).

1.11.5 Body Mass Index

Body Mass Index (BMI) is operationally defined as a person's weight in kilograms divided by the square of height in meters (kg/m^2), and it is used as an anthropometric indicator of overweight and obesity (WHO, 2025)

1.11.6 Percentage Body Fat

Body fat percentage is defined as the percentage of your body that consists of fat. The healthy range for PBF varies based on factors such as age, sex, and physical activity levels (Siri, 1956; Jackson & Pollock, 1978).

1.11.7 Waist Circumferences

Waist Circumference (WC) is operationally defined as the circumference of the abdomen measured at a standardized anatomical site, and it is used as an indicator of abdominal adiposity or central obesity (World Health Organization, 2011).

1.11.8 Waist-to-Hip Ratio

The waist-to-hip ratio is a ratio of waist circumference to hip circumference, measured in the same units ($\text{WHR} = \text{WC}/\text{HC}$). The WHR greater than 0.8 in women or greater than 0.9 in men is indicative of overweight and/or obesity.

1.11.9 Visceral Fat

Visceral Fat is the fat stored deep inside the abdomen, surrounding internal organs such as the liver, pancreas, and intestines (Tchernof & Després, 2026).

1.11.10 Systemic Review

A systematic review is research that collects, critically evaluates, and synthesizes existing studies on a specific topic using a structured and transparent methodology. It aims to provide a comprehensive and unbiased summary of the evidence available by following a predefined process to minimize bias, such as thorough literature searches, inclusion and exclusion criteria, and quality assessments of the included studies (Moher et al., 2009).

1.11.11 Meta-analysis

Meta-analysis is a statistical technique used to combine and analyze data from multiple independent studies on the same topic aims to provide a more precise and reliable estimate of the effect size or relationship by pooling results from various studies, which increases statistical power and allows for more generalizable conclusions. Meta-analysis can be used to resolve inconsistencies between studies, identify patterns or trends, and quantify the overall impact of a treatment or intervention and typically involves the use of statistical models to integrate results and assess the variability between studies (Borenstein et al., 2018)

CHAPTER 2

LITERATURE REVIEW

2.1 Obesity and Physiological Factors

2.1.1 Genetic Predisposition and Obesity

Genetic predisposition to obesity has long been recognized, with heritability estimates indicating that genetic factors can explain between 40% to 70% of the variation in BMI (Maes et al., 1997). More recent research continues to affirm and expand upon these findings. A 2024 study identified specific genetic variants that significantly influence obesity risk, with some genetic risk scores (GRS) being associated with substantial increases in BMI and obesity prevalence (Chermon & Birk, 2024). Additionally, Genome-wide association studies (GWAS) have identified numerous genetic variants associated with obesity-related traits, including BMI, fat distribution, and susceptibility to weight gain (Locke et al., 2015). These genetic variants often influence pathways involved in appetite regulation, energy expenditure, and adipose tissue development, highlighting the genetic heterogeneity underlying obesity susceptibility (Locke et al., 2015; Frayling et al., 2007).

Despite this genetic predisposition, engaging in regular aerobic exercise can significantly help obese individuals manage their weight and counteract genetic factors contributing to obesity. Aerobic exercise enhances energy expenditure, promotes the oxidation of fatty acids, and improves insulin sensitivity, all of which contribute to reducing body fat and improving metabolic health (Holloszy, 2013). Regular aerobic activity has also been shown to influence the expression of genes involved in energy metabolism, potentially mitigating the effects of obesity-related genetic variants (Thompson et al., 2018). Additionally, aerobic exercise can help regulate appetite by modulating levels of appetite-related hormones such as leptin and ghrelin, thereby assisting in better weight management (Broom et al., 2009). Therefore, while genetic predisposition plays a role in obesity, lifestyle interventions like aerobic exercise can significantly reduce the impact of these genetic factors.

2.1.2 Hormonal Imbalances and Obesity

Hormonal imbalances play a crucial role in regulating appetite, energy expenditure, and fat metabolism, thereby influencing body weight regulation (Bray et al., 2019; Müller et al., 2015; Schwartz et al., 2017). Imbalanced hormones disrupt appetite control, leading to increased food intake and reduced energy expenditure (Bray et al., 2019; Schwartz et al., 2017). Leptin and ghrelin are two important hormones that play a key role in regulating appetite, energy balance, and body weight. An imbalance in these hormones is closely linked to the onset of obesity (Bray et al., 2019; Müller et al., 2015; Schwartz et al., 2017). Leptin, produced by fat cells signals to the brain when we are full, meanwhile ghrelin, produced by the stomach, stimulates hunger (Karra & Batterham, 2010; Sainsbury & Zhang, 2010; St-Pierre et al., 2020). Improper of these two hormones function can result in overeating and gaining excessive weight, which can lead to obesity (Kelesidis et al., 2010; Leibel, 2008; Morton et al., 2014). Addressing these hormonal imbalances could be key in developing effective treatments for obesity (Blüher, 2019; Gadde et al., 2018; Pijl, 2021).

Obese individuals often exhibit leptin resistance, where elevated leptin levels fail to suppress appetite effectively (Myers et al., 2012). Somehow, aerobic exercise can influence leptin levels and sensitivity in several ways. Aerobic exercise can help reduce leptin levels and increase sensitivity, as well as enhance hormone production to better control appetite (Sartorio et al., 2020; Thompson et al., 2021). As reported by Bouassida et al. 2010, aerobic exercise can enhance leptin signaling pathways. Plus, consistent aerobic exercise leads to a significant reduction in circulating leptin levels, suggesting improved leptin sensitivity in obese individuals and also enhances metabolism, controls hunger, and improves overall metabolic function (Assis & Murawska-Ciałowicz, 2023; Himmerich, Wüller, & Kallies, 2024; Rahmani, Hadaegh, & Azizi, 2024). This improvement can enhance the hormone's ability to signal satiety and reduce food intake, aiding in weight management and obesity prevention.

On the other hand, aerobic exercise has been found to modulate ghrelin levels, thus influencing appetite control. in individuals with obesity to avoid excessive food intake (Cummings et al., 2002). To add up previous study by Broom et al., 2007 acute bouts of aerobic exercise can lead to a temporary decrease in ghrelin levels, reducing hunger post-exercise. Additionally, regular aerobic exercise has been shown to stabilize ghrelin levels, contributing to long term appetite regulation and reduced caloric intake,

which are essential for weight management in obese individuals (Schmidt et al., 2014). To clarify, aerobic exercises have a capability to act as non-invasive treatment in order to regulate hormonal imbalances among obese individuals. Not only that aerobic exercises also able in enhancing insulin action by enhances insulin sensitivity in skeletal muscle, liver, and adipose tissue by promoting glucose uptake and utilization. Regular aerobic exercise sessions improve insulin action, thereby aiding in blood glucose regulation and reducing the risk of metabolic disorders (Colberg et al., 2016).

Aerobic exercise is a potent intervention for managing hormonal imbalances associated with obesity. By improving leptin sensitivity, regulating ghrelin levels, and enhancing insulin action, aerobic exercise contributes to better appetite control, increased energy expenditure, and improved metabolic health. These hormonal adjustments are crucial for effective weight management and the prevention of obesity-related metabolic disorders. Understanding the specific mechanisms through which aerobic exercise impacts these hormones can inform the development of targeted exercise programs for individuals with obesity, ultimately aiding in the fight against this pervasive health issue.

2.1.3 Metabolic Dysfunction

Metabolic dysfunctions, such as impaired lipid metabolism, mitochondrial dysfunction, and chronic inflammation, are pivotal in the pathophysiology of obesity and its associated health risks (Thyfault & Bergouignan, 2020; Sáinz & Al-Massadi, 2021). Firstly, dyslipidemia characterized by elevated levels of triglycerides and low-density lipoprotein cholesterol, is commonly observed in obesity (Després et al., 2001). Adipose tissue in obese individuals undergoes significant changes in lipid storage and release. Increased adiposity leads to adipocyte hypertrophy and hyperplasia, altering the secretion of adipokines and other signaling molecules involved in lipid metabolism (Sáinz & Al-Massadi, 2021). Secondly is mitochondria dysfunction where excess adiposity in obesity can lead to impaired mitochondrial function. In obesity, mitochondrial function is impaired will cause reduction cells' ability to utilize fats for energy production. This mitochondrial dysfunction contributes to decreased energy expenditure and increased fat storage (Thyfault & Bergouignan, 2020).

In obese people, the fatty tissue in the body goes through important changes, such as becoming larger and having more immune cells like macrophages entering it.

These immune cells produce substances that promote inflammation, like tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and C-reactive protein (CRP), which contribute to long term inflammation (Hotamisligil, 2006)

Aerobic exercise emerges as a powerful, non-invasive treatment strategy for addressing these issues in obese populations. Its comprehensive benefits include enhancing insulin sensitivity, improving lipid profiles, reducing inflammation, promoting fat oxidation, regulating appetite hormones, and overall enhancing metabolic health (Colberg et al., 2016; Holloway et al., 2009; Kelley & Kelley, 2005; Kraemer et al., 2014; Pedersen & Febbraio, 2012; Petersen & Pedersen, 2005).

Aerobic exercise enhances the body's ability to metabolize lipids. It increases the activity of enzymes involved in lipid oxidation and reduces the accumulation of lipids in non-adipose tissues. Plus, aerobic exercise is effective in reducing the levels of triglycerides and low-density lipoprotein cholesterol (LDL). These two substances are important markers of cardiovascular risk, especially for obese individuals. By engaging in aerobic exercise, obese individuals can reduce their risk of developing cardiovascular problems (Kelley & Kelley, 2005).

This improvement in lipid metabolism helps mitigate lipotoxicity and reduces the risk of insulin resistance (Boudou, Sobngwi, Mauvais-Jarvis, Leblanc, & Velho, 2003).

In obesity, mitochondrial function is impaired, reducing the cells' ability to utilize fats for energy production. This mitochondrial dysfunction contributes to decreased energy expenditure and increased fat storage (Thyfault & Bergouignan, 2020). Regular aerobic exercise stimulates mitochondrial biogenesis, the process by which new mitochondria are formed in the cells. This increase in mitochondrial content and function enhances the cells' capacity to utilize fats for energy, thereby increasing overall energy expenditure and reducing fat storage (Holloszy, 2013)

Chronic low-grade inflammation, mediated by adipose tissue-derived cytokines and immune cell infiltration, further perpetuates metabolic dysfunction and insulin resistance, creating a pro-inflammatory milieu conducive to weight gain and metabolic disturbances (Hotamisligil, 2006). Aerobic exercise has anti-inflammatory effects. It reduces the production of pro-inflammatory cytokines and increases the levels of anti-inflammatory cytokines. This shift in the inflammatory profile helps improve insulin sensitivity and reduces the chronic inflammation associated with obesity (Gleeson, 2007).

2.1.4 Obesity and Physical Activities

The relationship between physical activity and obesity is well-established, with numerous studies showing that regular exercise can reduce the risk of obesity and its associated health complications (Niemiro GM, Rewane A, 2023). Physical activity not only helps in burning excess calories but also helps to improve overall fitness, reduce stress, and increase self-esteem (Warburton et al., 2006). Despite these benefits, the prevalence of physical inactivity has risen over the years, and lack of physical activity is now considered the fourth leading risk factor for death globally. In modern society, where technology and automation have reduced the need for physical exertion, it is becoming increasingly challenging to incorporate physical activities into daily routines. This sedentary lifestyle has been linked to an increase in obesity rates, particularly in developed countries.

Physical activity is defined as any bodily movement produced by the skeletal muscles that results in energy expenditure. This can include structured exercise, such as running or cycling, as well as everyday activities, such as walking to work or using the stairs instead of the elevator. The WHO recommends at least 150 minutes of moderate intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic physical activity per week for adults aged 18-64 to maintain a healthy lifestyle. For children and adolescents, the recommendation is at least 60 min of moderate-to-vigorous-intensity physical activity per day. However, it is estimated that only 23% of the adults meet these guidelines.

Regular physical activity can help manage and prevent obesity by burning excess calories and reducing the body fat percentage. It also helps in building muscle mass, which increases the body's metabolic rate, making it easier to maintain healthy weight. Physical activity has also been shown to improve insulin sensitivity and glucose tolerance, reducing the risk of developing type 2 diabetes, a disease that is strongly associated with obesity. Additionally, physical activity has been proven to have a positive impact on mental health by reducing stress, anxiety, and depression, all of which can contribute to unhealthy eating habits and weight gain.

To promote physical activity and prevent obesity, various strategies can be implemented at individual, community, and national levels. At the individual level, it is essential to make small lifestyle changes, such as taking the stairs instead of the elevator, walking or cycling to work, and participating in recreational activities, such as

swimming, dancing, or gardening. Engaging in physical activities not only burns calories but also is enjoyable and social, making it easier to maintain a healthy lifestyle in the long run. At the community level, efforts can be made to provide safe and accessible environments for physical activities such as parks, sidewalks, and bike lanes. Schools can also play a significant role in promoting physical activity by incorporating physical education classes and providing extracurricular activities for students. At the national level, policies can be implemented to decrease sedentary behaviors, such as offering tax incentives for companies that provide gym memberships or encouraging employers to implement workplace wellness programs.

In brief, efforts must be made at the individual, community, and national levels to promote physical activity and decrease sedentary behavior to prevent and manage obesity. Incorporating physical activities into daily routines, making active transportation choices, and creating safe and accessible environments for physical activities are strategies that can be implemented to promote a more active lifestyle. It is essential to recognize the role of physical activity in preventing and managing obesity and take the necessary steps to incorporate it into our daily lives.

2.2 Measurement of Obese Parameter

Many body composition assessments can be performed to identify an individual's risk of disease. These include BMI, percent body fat by skinfold, waist-to-hip ratio (WHR), waist circumference (WC), percentage body fat (PBF), and a variety of other tests. All assessments have benefits and drawbacks when predicting the risk of disease, and all vary slightly in their analysis of the body.

2.2.1 Measurement of Body Mass Index

BMI classification is one of the most common body size tests because it is simple and inexpensive. There are national cut-off points for determining obese and overweight individuals (Kelso et al., 2019). BMI estimates are related to body weight and height and are calculated by dividing body weight by kilograms of height per square meter (kg / m^2), as shown in equation 1.

$$BMI = \frac{\text{Body weight (kg)}}{\text{Height (m}^2\text{)}} \quad (2.1)$$

The classification of BMI categories was based on the criteria, which comprised six categories, as shown in Table 2.1.

Table 2.1
A Classification of Body Mass Index Categories

Classification	BMI (kg/m ²)
Underweight	< 18.5
Normal	18.5-24.9
Pre-obese or overweight	25.0-29.9
Obesity class I	30.0-34.9
Obesity class II	35.0-39.9
Obesity class III	≥ 40.0

2.2.2 Measurement of Waist-to-Hip Ratio

The waist-to-hip scale is an essential predictive measure of obesity. A detailed measurement of the size of the human hip also helps detect obesity and obesity risk. (Bacopoulou, Efthymiou, Landis, Rentoumis, & Chrousos, 2015; Savva et al., 2000).

Table 2.2
A Classification of Waist to Hip Ratio

<i>Classification of waist-hip ratio (WHR)</i> Men	Women	Risk Level
<0.85 cm	<0.75	Excellent
0.85-0.89	0.75-0.79	Good
0.90-0.95	0.80-0.86	Average
≥0.95	≥0.86	At risk

Bray. Ga. & Gray. DS (1998). Obesity: Pathogenesis. Western Journal of Medicine

2.2.3 Measurement of Waist Circumference

WC is a measurement of the distance around the smallest area of the waist, typically taken just above the hip bones and below the ribcage. It is a practical, non-invasive anthropometric measure used to assess abdominal fat accumulation and central

obesity. Measurement location start with midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone). It is measured in a standing position with a relaxed abdomen.

Table 2.3

A Classification of Waist Circumferences Categories among Obese

Category	Waist Circumference (cm)	Waist Circumference (inches)
Obese (Male)	≥ 102 cm	≥ 40 inches
Obese (Female)	≥ 88 cm	≥ 35 inches

Source : World Health Organization (WHO) and National Institutes of Health (NIH)

2.2.4 Measurement of Percentage Body Fat

PBF refers to the proportion of an individual's total body weight that is composed of fat. In the context of obesity, it represents an excessive accumulation of body fat to levels that negatively impact health. Body fat percentage can be measured using various techniques, including bioelectrical impedance, dual-energy X-ray absorptiometry (DEXA), skinfold thickness, or air displacement plethysmography.

Table 2.4

A Classification of Percentage Body Fat for Obese

Classification of PBF Men	Women	Risk Level
7.1-9.3	14.5-17	Excellent
9.4-14	17.1-20.5	Good
14.1-17.5	20.6-23.6	Average
>22.4	>27.7	At risk

Source: American College of Sports Medicine (ACSM) Health-related physical fitness 2nd edition, 2008

2.2.5 Measurement of Visceral Fat

Visceral fat is a type of body fat that is stored within the abdominal cavity, surrounding vital internal organs such as the liver, pancreas, and intestines. In individuals with obesity, excessive visceral fat accumulation is a hallmark of central or abdominal obesity. Visceral fat can be measured indirectly using waist circumference, waist-to-hip ratio, or bioelectrical impedance analysis.

Table 2.5
A Classification of Visceral Fat among Obese

Classification of visceral fat (VF) Men	Women	Risk Level
<0.85 cm	<0.75	Standard
0.85-0.89	0.75-0.79	High
0.90-0.95	0.80-0.86	Very high

Sources: American College of Sports Medicine (ACSM) Health-related physical fitness 2nd edition, 2008

2.3 Obesity and Comorbidities

2.3.1 Obesity and Cardiovascular Diseases

The rising prevalence of obesity is linked to an increase in cardiovascular diseases (CVD), which presents a substantial challenge for healthcare systems worldwide. Research indicates that individuals with obesity experience heightened morbidity and mortality rates associated with CVD, primarily due to the development of atherosclerosis a condition characterized by the accumulation of lipid-rich plaques in arterial walls, leading to narrowed arteries and increased risk of thrombosis and plaque rupture (Gaesser & Angadi, 2021; Pons et al., 2013). Obesity also contributes to structural and functional alterations in the heart, collectively referred to as "obesity cardiomyopathy." This condition is characterized by left ventricular hypertrophy, diastolic dysfunction, and myocardial fibrosis, which are exacerbated by chronic volume overload and metabolic disturbances associated with obesity (Bernhardt & Babb, 2014). These changes significantly elevate the risk of heart failure, particularly heart failure with preserved ejection fraction (Lavie et al., 2010).

The interplay between obesity and cardiovascular health is further complicated by the systemic inflammation and insulin resistance that often accompany obesity, which can lead to additional cardiovascular complications (DeLorey et al., 2005). For instance, obesity is known to promote inflammation in cardiovascular tissues, leading to an increased incidence of CVD among obese individuals (Wang & Nakayama, 2010). This inflammation is often mediated by adipose tissue, which secretes pro-inflammatory cytokines that can exacerbate cardiovascular risk (Faintuch et al., 2008). The incidence of obesity-related cardiovascular diseases highlight the critical need for effective management strategies. Thus exercise as a non-invasive and cost-effective intervention

provide a pivotal role in reducing the cardiovascular risks associated with obesity (Moura et al., 2013).

Exercise emerges as a critical non-pharmacological intervention for mitigating the cardiovascular risks associated with obesity. Both acute and chronic exercise induce beneficial physiological adaptations that enhance cardiovascular health. Acute exercise increases cardiac output and promotes vasodilation, improving blood flow and endothelial function (Ofir et al., 2007). Chronic exercise training leads to structural and functional adaptations in the cardiovascular system, such as myocardial remodeling and enhanced angiogenesis, which collectively contribute to improved resilience against CVD risk factors (Farah et al., 2013). Regular physical activity has been shown to restore cardioprotective signaling pathways that are often impaired in obese individuals, thereby enhancing cardiac function and reducing the risk of myocardial infarction (Zavorsky et al., 2008).

Moreover, aerobic exercise has been shown to significantly enhance CRF in obese populations, which is crucial for improving overall health and reducing the risk of cardiovascular diseases. Studies indicate that regular aerobic exercise leads to substantial improvements in VO₂ peak, a key measure of cardiorespiratory fitness, associated with lower all-cause mortality risk (Coen et al., 2014). Furthermore, the anti-inflammatory effects of aerobic exercise contribute to better cardiovascular outcomes by reducing chronic inflammation, a common issue in obese individuals (Seal et al., 2014;; Kim, 2023). Regular exercise presents a powerful strategy for promoting cardiovascular health among obese patients.

2.3.2 Obesity and Stroke

Obesity is increasingly recognized as a significant public health concern, particularly due to its established role as a risk factor for vascular diseases, including ischemic stroke (Benedetto et al., 2023). Research indicates that overweight individuals face a 22% increased risk of ischemic stroke, while this risk escalates to 64% for those classified as obese (Strazzullo et al., 2010;; Mitchell et al., 2015). This association is not merely a consequence of comorbid conditions such as hypertension and diabetes, as obesity has been shown to independently contribute to stroke risk (Suk et al., 2003;; Ovbiagele et al., 2011;; Razinia et al., 2007). Furthermore, obesity is linked to a pro-inflammatory and prothrombotic state, which may exacerbate the risk of vascular events

(Razinia et al., 2007; Milionis et al., 2007). The relationship between BMI and stroke risk is well-documented. A meta-analysis revealed that each unit increase in BMI correlates with a 6% increase in the adjusted relative risk of stroke, with this relationship being linear across the BMI spectrum (Song et al., 2004). Specifically, a 40% increase in stroke mortality is observed for every 5 kg/m² increment in BMI within the range of 25–50 kg/m² (Strazzullo et al., 2010). Plus, a systematic review by Kim et al. 2021 highlighted that an increase in BMI correlates with a higher risk of all-cause stroke, reinforcing the notion that obesity is a critical factor in stroke epidemiology. This underscores the critical need for targeted interventions aimed at obesity management to mitigate stroke risk.

As the prevalence of obesity continues to rise globally, understanding effective interventions to reduce stroke risk among obese individuals becomes increasingly critical (Yanti & Santik, 2022). Physical activity, particularly aerobic exercise, has been recognized as a primary intervention for obesity and is associated with a reduced risk of stroke (Billinger et al., 2014). Engagement in physical activity helps to create a caloric deficit, promotes weight loss, and improves metabolic health (Amin et al., 2021). The American Heart Association recommends at least 150 minutes of moderate intensity aerobic exercise per week for adults to maintain cardiovascular health (Bauza et al., 2018). Aerobic exercise, in particular, has been shown to be effective in reducing body fat and improving cardiovascular risk factors, making it a vital component in stroke prevention strategies for obese individuals. Numerous studies have demonstrated the protective effects of aerobic exercise against stroke risk in obese populations. A systematic review by Oesch et al. 2017 highlighted that individuals who engage in regular aerobic exercise exhibit lower rates of stroke compared to sedentary individuals, regardless of their weight status. Clearly participating in aerobic exercise improves cardiovascular fitness, reduces blood pressure, and enhances lipid profiles, all of which contribute to a decreased risk of stroke (Horn et al., 2021).

Plus, in a cohort study conducted by Yoo (2024), it was found that obese individuals who participated in structured aerobic exercise programs experienced significant reductions in stroke risk factors, including blood pressure and body weight (Andersen & Olsen, 2013). The study concluded that aerobic exercise not only aids in weight management but also directly contributes to improved cerebrovascular health. Furthermore, the study indicated that even moderate levels of physical activity could yield substantial benefits, reinforcing the notion that any increase in physical activity

can be BENEFICIAL for stroke prevention. The mechanisms through which aerobic exercise reduces stroke risk among obese individuals are multifaceted. Regular aerobic activity enhances endothelial function, promotes vascular remodeling, and reduces systemic inflammation (Oesch et al., 2017). Additionally, exercise has been shown to improve insulin sensitivity and glucose metabolism, which are crucial for managing obesity-related comorbidities such as type 2 diabetes (Haley & Lawrence, 2016). The reduction in VF, particularly through aerobic exercise, is also linked to improved cardiovascular health and reduced stroke risk (Ovbiagele et al., 2011).

Physical activity, particularly aerobic exercise plays a crucial role in mitigating stroke risk among obese populations. Studies have shown that insufficient physical activity is associated with obesity, which is a significant risk factor for stroke (Yoo, 2024; Bailey et al., 2020). Thus highlighting aerobics exercises is crucial to implement in order to reduce the risk of stroke incidence among obese patients. Additionally, few studies supports the notion that regular engagement in aerobic exercise can lead to significant improvements in cardiovascular health, weight management, and overall stroke risk reduction (Amin et al., 2021; Benedetto et al., 2023; Billinger et al., 2014). This is particularly relevant as the prevalence of obesity continues to rise, necessitating public health initiatives that prioritize physical activity as a primary intervention for obesity and stroke prevention (Syed et al., 2012). In addition, exercises approach not only addresses the immediate health concerns associated with obesity but also contributes to long term cardiovascular health and QOL improvements.

2.3.3 Obesity and Diabetes

Obesity and diabetes are closely interrelated, with obesity being a major risk factor for type 2 diabetes (Verma & Hussain, 2017; Nagamani & Pavan, 2016; Aras et al., 2021). This association, often termed "diabesity," is attributed to insulin resistance and deficiency (Verma & Hussain, 2017; Siddiqui, 2018). The prevalence of both conditions has increased globally, with 60-90% of type 2 diabetes patients being obese (Siddiqui, 2018). Factors influencing this relationship include lifestyle, genetics, body fat distribution, and physical activity (Al-Quwaidhi et al., 2013; Khamees et al., 2022). Weight loss of 5% or more can improve glycemic control and reduce the need for diabetes medications (Aras et al., 2021; Yaturu, 2011). Management strategies include lifestyle modifications, pharmacotherapy, and bariatric surgery (Yaturu, 2011;

Chandrasekaran & Weiskirchen, 2024). Understanding the mechanistic link between obesity and diabetes is crucial for developing comprehensive approaches to prevent and manage these conditions (Chandrasekaran & Weiskirchen, 2024).

Obesity significantly increases the risk of developing type 2 diabetes through multiple mechanisms. Excess adipose tissue leads to elevated levels of nonesterified fatty acids, glycerol, hormones, and pro-inflammatory markers, contributing to insulin resistance (Al-Goblan et al., 2014). Plus, obesity-induced inflammation plays a crucial role in the development of insulin resistance and type 2 diabetes (Lee, 2013; Ota, 2014). Specifically, aerobic training has been found to reduce inflammatory markers, alleviate fatigue symptoms, and enhance QOL (Abd El-Kader et al., 2016; Baillot et al., 2011; Lucha-López et al., 2012). This clearly suggests aerobic as an effective, non-invasive treatment modality for obese adults with diabetes, as it has been shown to exert anti-inflammatory effects, reducing levels of pro-inflammatory cytokines and improving overall metabolic health. This reduction in systemic inflammation is particularly beneficial for individuals with obesity, as chronic inflammation is a key contributor to the development of insulin resistance and type 2 diabetes (Colberg et al., 2010; Umpierre et al., 2011).

In addition, aerobic exercise is also highly effective intervention for improving insulin sensitivity and reducing the risk of type 2 diabetes in obese individuals (Colberg et al., 2010). Furthermore aerobic exercise significantly enhances insulin sensitivity, which is crucial for maintaining normal glucose homeostasis (Daher et al., 2020). Recent studies have highlighted the efficiency of aerobic exercise in enhancing insulin sensitivity and glucose homeostasis. For instance, a meta-analysis conducted by Ben Stocks and Zierath (2021) reviewed numerous RCTs and concluded that aerobic exercise significantly improves insulin sensitivity those with obesity and prediabetes. Moreover, Małkowska (2024) conducted a longitudinal study examining the effects of a structured aerobic exercise program on insulin sensitivity in obese adults. The findings revealed that participants who engaged in regular aerobic exercise exhibited marked improvements in insulin sensitivity, as measured by the homeostasis model assessment of insulin resistance (HOMA-IR), compared to a control group that did not participate in the exercise program. The liver plays a central role in regulating blood glucose levels by storing and releasing glucose as needed. In obese individuals with insulin resistance, the liver's ability to regulate glucose is impaired, leading to elevated blood glucose

levels. The liver plays a central role in regulating blood glucose levels by storing and releasing glucose as needed.

Briefly, aerobic exercise emerges as a highly effective intervention for improving insulin sensitivity and reducing the risk of type 2 diabetes in obese individuals. The physiological adaptations resulting from regular aerobic activity, including enhanced glucose uptake and reduced inflammation, play a critical role in maintaining glucose homeostasis. As the prevalence of T2DM continues to rise, incorporating aerobic exercise into lifestyle interventions is essential for preventing and managing this chronic condition.. Therefore, healthcare professionals should advocate for regular aerobic exercise as part of a comprehensive approach to preventing and managing type 2 diabetes in obese individuals.

2.3.4 Obesity and Hypertension

The prevalence of hypertension among obese individuals is alarmingly high, for instance, studies have shown that a significant percentage of obese adults also suffer from hypertension, with rates reported as high as 72.9% in certain populations (Amole et al., 2011). To add up, studies a study from one Asia country have shown that the prevalence of hypertension is significantly higher among obese individuals compared to their non-obese counterparts. A study in Indonesia found that 63.3% of obese individuals were hypertensive, compared to only 15.2% of non-hypertensive individuals (Jayanti, 2018). Moreover, a study conducted in Bangladesh found that individuals classified as obese based on BMI and WC exhibited a higher prevalence of hypertension compared to those with normal weight (Ali et al., 2022). Thus, this indicates that obesity is a significant risk factor for the development of hypertension,.This trend is echoed in various populations, indicating a global pattern where obesity is a major risk factor for hypertension (Warsy et al., 2011).In brief, this association underscores the need for effective interventions targeting both obesity and hypertension.

The physiological mechanisms linking obesity and hypertension are complex. Obesity leads to increased blood volume and cardiac output, which can elevate blood pressure (Sari et al., 2018). Obesity can lead to structural changes in the heart, including left ventricular hypertrophy, which may further contribute to increased blood volume and altered hemodynamics. Studies have shown that obesity is linked to increased total blood volume and cardiac output, which can lead to greater stroke volume and often an

elevated resting heart rate due to heightened sympathetic nervous system activity (Zhu et al., 2023; Li, 2024; Omid, 2024). In addition, the increase in stroke volume and heart rate contributes to elevated cardiac output, which, when combined with the expanded blood volume, creates higher vascular resistance. This increase in vascular resistance is a critical factor in the development of hypertension among obese individuals. In order to manage this issue, aerobic exercise has been shown to be effective in lowering blood pressure among obese individuals with hypertension. Aerobic exercises, in particular, have been shown to effectively reduce blood pressure and improve overall cardiovascular health in obese individuals (Kennedy et al., 2021; Hall et al., 2021). Additionally, a meta-analysis conducted by Albayrak et al. highlights that aerobic exercise is a cornerstone of lifestyle recommendations for managing hypertension as their findings suggest that supervised aerobic exercise can lead to a mean reduction of 12 mmHg in systolic blood pressure (SBP) among individuals with essential hypertension.

According to Fù et al., 2022 moderate intensity aerobic exercise, performed for 30 to 60 minutes a day, can effectively lower blood pressure in hypertensive patients by improving endothelial function and reducing peripheral vascular resistance. These adaptations enhance the ability of blood vessels to dilate, thereby facilitating better blood flow and reducing the workload on the heart. Clearly, aerobic exercise is effective as a first-line treatment for managing hypertension, especially in obese populations (Ghadieh & Saab, 2015). Aerobic exercise offers a comprehensive approach to managing hypertension in obese adults by improving endothelial function, reducing arterial stiffness, promoting weight loss, and decreasing systemic inflammation. This is particularly highlighting exercise's role as a non-pharmacological intervention for managing hypertension (Vasheghani-Farahani et al., 2010). Therefore, the implementation of structured aerobic exercise programs should be a priority in the clinical management of hypertension in obese patients.

2.3.5 Obesity and Asthma

Asthma is a chronic inflammation that may develop more in the presence of excess leptin released from fat cells found in the adipose tissue of obese people (Miethe et al., 2020). This finding is supported by research indicating that the prevalence of asthma is significantly higher in obese individuals, with obesity being associated with

increase in the risk of developing asthma (Li, 2024). The underlying mechanisms may include systemic inflammation driven by adipose tissue, which can exacerbate airway inflammation and hyper-responsiveness (Omid, 2024). Additionally, obesity can lead to mechanical changes in lung function, such as reduced lung volumes and increased airway resistance, which can exacerbate asthma symptoms (Klepaker et al., 2021). This statement supported by Kim et al, 2017 obesity induces a state of chronic low-grade, these inflammatory mediators can exacerbate airway inflammation, triggering asthma. In addition, obesity may alter lung mechanisms by affecting the airway, which can cause inflammation and airway remodeling (Umetsu, 2017). This happens because excess body weight, particularly abdominal fat, can reduce lung volumes and increase airway resistance.

This mechanical restriction impairs breathing efficiency and exacerbates asthma symptoms (Forno et al., 2017). The deposition of adipose tissue in the abdominal region, a common feature of obesity, exerts a mechanical load on the diaphragm and chest wall, leading to alterations in respiratory mechanics (Chouhan & Chauhan, 2018). A systematic review and meta-analysis by Hansen et al. found that aerobic exercise training significantly improved asthma control and reduced the frequency of asthma exacerbations among participants. The increased airway resistance, in turn, requires greater effort to achieve adequate ventilation, which can significantly impair breathing efficiency (Moitra et al., 2022). Moreover, the combination of reduced lung volumes and increased airway resistance can contribute to ventilation-perfusion mismatch, a condition where air and blood flow are not adequately matched in the lungs. This mismatch can result in hypoxemia, low blood oxygen levels and increased work of breathing, both of which are detrimental to individuals with asthma (Teague et al., 2018).

To address this condition, participation in aerobic exercise has been shown to be an effective intervention (Eichenberger et al., 2013). The integration of regular aerobic exercise into the daily routine has demonstrated significant benefits for individuals dealing with obesity and asthma (Donnelly et al., 2009; Eichenberger et al., 2013; Mendes et al., 2011). Research indicates that aerobic exercise can lead to substantial improvements in lung function and a reduction in airway inflammation among asthmatic individuals (Zhu et al., 2023). A systematic review and meta-analysis by Wu et al. found that continuous aerobic exercise significantly ameliorates pulmonary inflammation, airflow obstruction, and airway hyper-responsiveness in asthma patients. Plus, aerobic

exercise has been shown to improve respiratory efficiency and reduce the frequency and severity of asthma symptoms. This is supported by systematic review and meta-analysis by Hansen et al. 2020 found that aerobic exercise training significantly improved asthma control and reduced the frequency of asthma exacerbations among participants.

One of the primary advantages of aerobic exercise is its ability to improve lung function in asthmatic patients. Studies have demonstrated that aerobic training can lead to significant reduction in airway inflammation, which is a key factor in asthma management (Mendes et al., 2011). This reduction in inflammation can be attributed to improved minute ventilation during exercise, which lessens the perception of breathlessness and enhances overall respiratory efficiency (Mendes et al., 2011; Endrigue1 et al., 2023). In addition to Türk et al. 2020 noted that a weight loss of at least 10% is often necessary to achieve clinically significant improvements in asthma outcomes (Türk et al., 2020). Based on the efficacy and affordability, aerobic exercise should be considered play a vital role in weight management, particularly in obese individuals and indirectly improving lung function. In short aerobics exercises act as fundamental component of the management strategies for both obesity and asthma by promoting weight loss, improving respiratory function, Thus, addresses both the root causes and symptoms of these interrelated conditions.

On top of that, healthcare professionals are encouraged to advocate for the inclusion of aerobic activities in the treatment plans for these conditions, highlighting the dual benefits of weight management and enhanced respiratory function. The evidence strongly supports the notion that aerobic exercise is a beneficial intervention for improving asthma symptoms and lung function in obese adults. Briefly, aerobic exercise for obesity and asthma highlight its importance as a non-pharmacological intervention by promoting weight loss and improving respiratory function, aerobic exercise addresses the root causes and symptoms of both conditions.

2.3.6 Obesity and Musculoskeletal Disability

Obesity is increasingly recognized as a significant risk factor for various musculoskeletal disabilities, impacting both physical health and quality of life. Firstly, the biomechanical implications of obesity are profound. Increased body mass leads to greater mechanical stress on joints, particularly weight-bearing joints such as the knees and hips. This stress can precipitate conditions like osteoarthritis, which is nearly three

times more prevalent in obese individuals compared to those with a normal weight (Tamura et al., 2017). Furthermore, studies have shown that obesity is associated with increased pain in various body regions, including the back, shoulders, and extremities (Moreira-Silva et al., 2013; Fifolatto et al., 2021). The excessive load on joints not only contributes to pain but also to functional limitations, as seen in populations with high obesity rates (Batistão et al., 2014; Vincent et al., 2012). In an obese population, body movement is usually affected by excess mass, which may alter the range of motion and increase the joint load that can cause musculoskeletal problems (Ranavolo et al., 2013). Chronic musculoskeletal pain hinders participation in regular exercise programs in obese individuals (Vincent et al., 2006; Vincent et al., 2012).

Additionally, inflammation is another critical pathway linking obesity to musculoskeletal disorders. Adipose tissue is now recognized as an active endocrine organ that secretes pro-inflammatory cytokines, which can exacerbate joint inflammation and pain (Gómez-Rodríguez et al., 2020; Kozakowski, 2023). Excessive adipose tissue accumulation, particularly VF accumulation, has been associated with systemic inflammation and metabolic dysfunction, which can further exacerbate musculoskeletal problems. Studies have shown that obesity-related inflammation contributes to the development of musculoskeletal disorders, such as rheumatoid arthritis and fibromyalgia, impacting joint health and overall function (Boissier et al., 2020; Agca et al., 2018). This systemic inflammation may also contribute to the development of other musculoskeletal disorders, further complicating the health landscape for obese individuals (Kozakowski, 2023). Obesity is strongly linked to musculoskeletal disability and affects the structure and function of the musculoskeletal system in various ways. One significant mechanism is the excessive mechanical loading on weight-bearing joints, such as the knees, hips, and spine, owing to increased body weight.

This excessive loading accelerates the wear and tear of the joint cartilage and contributes to the development and progression of osteoarthritis, a common musculoskeletal disorder associated with obesity. Plus, Obesity gait patterns vary from standard gait patterns, with increased hip abduction, decreased hip flexion, and decreased ankle plantar flexion. Anatomically, obese individuals may experience altered internal and plantar stress (Kathirgamanathan et al., 2019). Moreover, obesity-related musculoskeletal disabilities extend beyond joint health to encompass muscle strength, function, and physical performance. Excessive body weight can impair muscle

strength and endurance, limit mobility, and increase the risk of falls and fractures. Research in the Journal of Bone and Mineral Research emphasize the need for comprehensive interventions to address musculoskeletal disabilities in obese individuals (Bolland et al., 2021). Addressing obesity-related musculoskeletal problems requires a safe, effective and suitable exercises approach. Low-impact aerobic exercises have emerged as a promising approach for managing obesity and associated musculoskeletal health issues in adults. These exercises, characterized by their reduced intensity and lower impact on joints, are particularly beneficial for individuals with obesity, as they can enhance physical fitness while minimizing the risk of injury.

Research indicates that low-impact aerobic exercises, such as walking, cycling, and dance, can significantly improve cardiovascular fitness and facilitate weight loss in obese adults. For instance, a study demonstrated that a structured 12-week supervised exercise program, which included low-impact aerobic activities, led to significant improvements in functional capacity and overall health markers in participants with obesity Herring et al. (2014). Additionally, low-impact aerobic dance and Zumba exercises have been shown to effectively reduce body fat percentage among obese women, highlighting the potential of enjoyable and engaging formats to promote adherence to exercise regimens (Octaviana et al., 2020). The physiological benefits of low-impact aerobic exercise extend beyond weight loss. Furthermore, they can alleviate musculoskeletal pain and improve joint function, which is particularly important for obese individuals who often experience joint stress and discomfort due to excess weight (Barrow et al., 2019). A systematic review found that aerobic training improves exercise tolerance and reduces musculoskeletal pain in populations with obesity, making it a critical component of weight management strategies (Barrow et al., 2019).

Moreover, the combination of low-impact aerobic exercises with other modalities, such as yoga, has been shown to enhance overall effectiveness in reducing body fat and improving physical function among obese individuals (Irawan & Anggarani, 2019). This multifaceted approach not only addresses weight management but also promotes flexibility, balance, and mental well-being, which are essential for sustaining long term health improvements. Plus, engaging in regular aerobic activity has been shown to stimulate the release of endorphins, which can alleviate pain and improve overall mood (Sivakumar et al., 2022).

This is particularly relevant for individuals suffering from chronic musculoskeletal pain, as exercise can enhance blood flow to muscles and reduce

stiffness, thereby improving functional ability. In addition, adherence to exercise programs is a significant factor in achieving long term benefits. Evidence suggests that structured, supervised exercise sessions improve adherence rates among obese individuals, particularly when the exercises are tailored to their capabilities (Campbell et al., 2012)..

2.4 Economic Burden of Obesity

2.4.1 Healthcare Economy Impact

The prevalence of obesity has been steadily increasing, leading to substantial economic consequences (Hruby & Hu, 2015). Obesity was identified as one of the key drivers of increased healthcare spending during 1996–2006 (van den Broek-Altenburg et al., 2022). The costs associated with obesity can be categorized into direct and indirect costs, encompassing healthcare expenses, lost productivity, and broader societal impacts (Tremmel et al., 2017). Research consistently shows that higher BMI levels are associated with escalated healthcare expenditures due to increased prevalence and severity of chronic diseases such as diabetes, cardiovascular diseases, and certain cancers (Finkelstein et al., 2009; Hammond & Levine, 2010). These conditions require extensive medical interventions, frequent healthcare visits, hospitalizations, and ongoing management, all contributing to elevated direct healthcare costs. The impact of obesity on the healthcare system extends beyond the direct medical costs. It also leads to strain on healthcare resources, including hospitals, medical professionals, and medical supplies. The increasing prevalence of obesity-related diseases requires a larger allocation of healthcare resources.

2.4.2 Direct Costs

Obesity is a significant economic challenge worldwide, with its impact projected to escalate in the coming decades. According to the World Obesity Federation 2023 report, the global economic impact of overweight and obesity is anticipated to reach \$4.32 trillion annually by 2035, accounting for nearly 3% of the global Gross Domestic Product (GDP). This projection underscores the pressing need for effective prevention and treatment strategies to mitigate the economic strain posed by obesity. The World

Obesity Federation analyses indicate that, if current trends persist, the economic impact of overweight and obesity will rise from approximately 2% of GDP in 2020 to over 3% by 2060. This increase reflects the growing prevalence of obesity and its associated health complications, necessitating substantial healthcare expenditures (World Obesity Federation, 2023).

The direct costs of obesity represent a significant burden on healthcare systems worldwide, with various studies quantifying these expenses across different populations and healthcare settings. Direct costs primarily encompass medical care expenses directly associated with obesity-related health issues, including hospitalizations, outpatient visits, and prescription medications. According to a systematic review by Withrow and Alter, the direct costs of obesity have been shown to escalate significantly as obesity prevalence increases, with estimates indicating that obesity-related healthcare expenditures can account for a substantial portion of national health budgets (Withrow & Alter, 2011)

In addition to the direct medical costs, the implications of obesity on healthcare systems are compounded by the associated comorbidities, such as diabetes, cardiovascular diseases, and certain cancers, which further inflate healthcare expenditures. Rudisill et al. found that healthcare costs related to obesity are significantly influenced by BMI and comorbid conditions, indicating that higher BMI correlates with increased healthcare utilization and costs (Rudisill et al., 2016). Obesity increases the risk of severe comorbidities, such as cardiovascular diseases, diabetes, and respiratory conditions, all of which frequently necessitate prolonged hospital stays. These hospitalizations often involve intensive treatments, advanced diagnostics, and costly interventions, contributing to substantial financial strain on healthcare resources. To add up, management of obesity-related conditions incurs substantial pharmaceutical costs, primarily due to the long term use of medications necessary for treating associated comorbidities such as diabetes, hypertension, and hyperlipidemia. The increasing prevalence of obesity-related complications is driving demand for newer, more effective, and often more expensive medications, thereby exacerbating healthcare costs. Research indicates that the economic burden of obesity extends significantly into pharmaceutical expenditures. A study by Kennedy et al. found that obese individuals required a significantly higher number of prescriptions annually, with a reported 153% increase in medication costs compared to those with normal BMI (Kennedy et al., 2011). This increase in pharmaceutical costs is not merely a reflection

of higher medication use but also correlates with the complexity and severity of obesity-related conditions.

Furthermore, study by Divino et al. demonstrated that patients with obesity and related complications face significantly higher direct medical costs, which include not only the costs of medications but also the costs associated with hospitalizations and outpatient care. Outpatient services also account for a significant share of direct costs, as these patients with obesity often require frequent consultations for the management of chronic conditions such as hypertension, type 2 diabetes, and arthritis. Regular monitoring, laboratory tests, and consultations with specialists such as endocrinologists, cardiologists, or dietitians add to the cumulative cost. These ongoing outpatient interactions represent a long term economic burden for individuals and healthcare systems. The study emphasizes that as obesity prevalence rises, so too does the demand for healthcare services, leading to increased overall healthcare expenditures. This is particularly evident in populations with severe obesity, where the costs associated with managing comorbidities can be markedly higher compared to those with a normal weight.

Last but not least, surgical interventions such as bariatric surgery, though considered highly effective in managing morbid obesity, further escalate direct costs. Procedures like gastric bypass or sleeve gastrectomy are not only expensive but also involve significant postoperative care, including dietary management and follow-up consultations. While these surgeries improve patient outcomes and reduce long term costs associated with obesity-related complications, their initial costs are substantial. (World Obesity Federation, 2023).

2.4.3 Indirect Costs

The increasingly high levels of overweight and obesity among the workforce are accompanied by a hidden cost burden due to losses in productivity (Goettler et al., 2017). Indirect costs are defined as the losses from reduced work productivity due to short term and long term inability to work (Neovius et al., 2008). In particular, obesity is associated with an increased risk of temporary work loss such as sick leave (absenteeism) and reduced productivity while being present at work (presenteeism). It is also associated with permanent work loss, which includes disability pension and premature death. The literature on the indirect costs of obesity suggests that obesity has

a negative impact on workforce productivity, Similarly, Finklestein et al. found that absenteeism and presenteeism were all increased in the obese whereas costs in overweight men were not increased relative to those of normal weight(Finkelstein et al., 2010).

In addition, Goetzel et al. (2010) found that both absenteeism and presenteeism significantly reduce workforce efficiency, collectively creating financial burdens for organizations and diminishing economic output. Not only that, Schulte et al. (2007) emphasized that presenteeism can have long term impacts on organizational effectiveness by decreasing the overall quality and consistency of output, thereby compounding indirect costs for employers. A study by Harvey et al. (2010) specifically estimated that individuals with obesity take an average of four additional days of sick leave per year compared to those within the healthy weight category. This increase in absenteeism can be attributed to the higher prevalence of obesity-related conditions that affect mobility, energy levels, and general health, making it more challenging for individuals to maintain consistent work attendance.

The impact of increased sick leave extends beyond the individual to employers and businesses. Lost workdays due to obesity-related absenteeism result in diminished productivity, higher labor costs due to temporary staffing or overtime for remaining employees, and disruptions to workflow. This creates financial strain for organizations and limits their ability to operate efficiently. Moreover, at the societal level, the cumulative effect of absenteeism contributes to broader economic losses. Research by Cawley and Meyerhoefer (2012) corroborates these findings, noting that the economic burden of obesity-related absenteeism includes not only lost wages for employees but also reduced output for businesses and economies.

Beyond workplace productivity losses, obesity-related chronic conditions such as cardiovascular diseases and musculoskeletal impairments often lead to long term disability or early retirement. Premature mortality associated with obesity represents another critical indirect cost. Conditions such as cardiovascular disease, type 2 diabetes, and certain cancers are prevalent among individuals with obesity, leading to a higher risk of early death. The loss of productive years resulting from premature mortality reduces workforce size and diminishes contributions to economic output. According to Finkelstein et al. (2005), the costs of lost productivity due to early mortality have a long term economic impact, as businesses and national economies face a shrinking pool of skilled labor and reduced tax revenues. Wolfenstetter (2012) similarly noted that the

financial implications of premature mortality extend beyond businesses to broader societal costs, as families, communities, and governments bear the consequences of reduced economic participation.

These indirect costs, encompassing absenteeism, presenteeism, disability, and premature mortality, underscore the profound economic and societal consequences of obesity. Addressing this issue requires a comprehensive approach that integrates workplace health initiatives, public policy measures, and preventative health strategies. Such interventions can significantly reduce the prevalence of obesity and mitigate its financial impact, enhancing productivity and societal well-being.

2.5 Management of Obesity

2.5.1 Diet in Managing Obesity

Diet is a primary contributor to the development of obesity, with various dietary patterns and components significantly influencing body weight and metabolic health. Diets characterized by high consumption of processed foods, refined sugars, and unhealthy fats are associated with higher obesity prevalence (Yuniarto 2019; Hatori et al., 2012). Diets high in fats have been associated with greater weight gain (Ikeda-Matsuo et al., 2023). The metabolic response to high fat diets often includes alterations in lipid metabolism and an increase in oxidative stress, which can further exacerbate obesity-related complications (Davidson et al., 2011; Holmes et al., 2015). In addition to high fat diets, high sugar diets, particularly those containing high-glycemic index carbohydrates, have been implicated in the obesity epidemic. These diets can lead to rapid spikes in blood glucose and insulin levels, promoting fat storage and weight gain (Qin et al., 2012). A study found that high-glycemic index carbohydrates can counteract the anti-obesity effects of healthy fats, suggesting that the combination of high sugar and high fat is particularly detrimental (Qin et al., 2012).

Diet plays a crucial role in managing obesity in adults, with various dietary approaches demonstrating significant impacts on weight loss, metabolic health, and overall well-being. As the prevalence of obesity continues to rise globally, the importance of effective dietary interventions becomes more evident. These interventions are not only a central component of weight management strategies but also play a key role in preventing and managing obesity-related diseases, such as type 2

diabetes, cardiovascular disease, and certain types of cancer (Schoeller et al., 2016). Dietary approaches, such as caloric restriction, low-carbohydrate diets, the Mediterranean diet, and intermittent fasting, have been studied extensively for their effectiveness in weight loss and metabolic health improvement. These dietary strategies create a negative energy balance, which is essential for weight loss by reducing the intake of calories or specific macronutrients, these approaches help the body utilize stored fat for energy, leading to fat loss and a reduction in body weight.

Caloric restriction, for example, involves reducing daily caloric intake, which has been shown to promote weight loss and improve metabolic markers such as insulin sensitivity, blood sugar levels, and lipid profiles (Johnstone et al., 2014). Research has demonstrated that even modest reductions in caloric intake can result in substantial health benefits, including reduced risk of chronic diseases and improved cardiovascular health (Schoeller et al., 2016). Low-carbohydrate diets, such as the ketogenic diet, are another dietary approach that has gained attention for their rapid effects on weight loss. By restricting carbohydrate intake, these diets encourage the body to enter a state of ketosis, where it burns fat for fuel instead of carbohydrates. This can lead to significant weight loss in the short term and also improve metabolic health by stabilizing blood sugar and improving insulin sensitivity, particularly in individuals with type 2 diabetes (Hu et al., 2016).

The Mediterranean diet, characterized by a high intake of fruits, vegetables, whole grains, lean proteins, and healthy fats (particularly olive oil), has long been associated with a variety of health benefits, including weight loss, improved heart health, and reduced inflammation. Studies have shown that adherence to the Mediterranean diet can lead to reductions in body fat, lower blood pressure, improved cholesterol levels, and better control of blood sugar, making it an effective dietary approach for both weight management and the prevention of chronic diseases (Esposito et al., 2014). Intermittent fasting (IF), which involves cycling between periods of eating and fasting, has also been recognized as an effective dietary strategy for weight loss. IF not only helps reduce calorie intake but may also trigger beneficial metabolic processes such as enhanced fat burning, improved insulin sensitivity, and preservation of lean muscle mass. Additionally, IF has been shown to have positive effects on aging, inflammation, and cardiovascular health (Anton et al., 2018).

Overall, dietary approaches emphasizing the importance of a balanced, nutrient-rich diet for achieving and maintaining a healthy weight and preventing chronic diseases

(Schoeller et al., 2016; Johnstone et al., 2014; Hu et al., 2016; Esposito et al., 2014; Anton et al., 2018). According to Sacks et al. 2009 conducted a systematic review and meta-analysis of 48 RCTs involving over 7,200 participants, which found that diet-based interventions led to an average weight loss of 8.8 kg (95% CI: -9.6 to -8.0) compared to control groups, with significant improvements in blood pressure, lipid profile, and glycemic control. These findings highlight the potential of diet-based interventions as an effective approach to obesity management.

Studies have shown that reducing daily energy intake by 500-1000 calories can lead to weight loss of 0.5-1 kg per week (Franz et al., 2007). Plus, The American Heart Association (AHA) and American College of Cardiology (ACC) have released guidelines for a healthy diet that can help prevent and manage obesity. This diet should be low in saturated and trans fats, added sugars, and sodium and should include a variety of fruits, vegetables, whole grains, low-fat dairy, and lean protein sources. Reducing caloric intake, improve food quality, and optimize nutrient intake may provide a chance on promoting weight loss and improving metabolic parameters (Wadden et al., 2021). Additionally, dietary modifications can lead to improvements in insulin sensitivity, lipid profiles, and blood pressure, contributing to overall metabolic health (Ryan et al., 2019).

Combining dietary with aerobic exercise creates a synergistic effect that maximizes the effectiveness of obesity management strategies. Dietary modifications promote calorie restriction and optimize nutrient intake, while aerobic exercise augments energy expenditure, creating a calorie deficit necessary for weight loss (Swift et al., 2018). Furthermore, regular physical activity enhances adherence to dietary interventions by reinforcing healthy lifestyle behaviors and promoting self-regulation (Penedo & Dahn, 2005). Importantly, aerobic exercise mitigates the metabolic adaptation that can occur with weight loss, thereby promoting long term weight maintenance (Blair et al, 1993). Furthermore, the safety profile associated with dietary modifications and aerobic exercises further underscores their prominence as first-line strategies in the management of obesity.

2.5.2 Aerobics Exercises in Managing Obesity

Aerobic exercise contributes to weight loss and obesity management through several mechanisms. Primarily, it increases caloric expenditure, creating an energy deficit necessary for weight loss (Ross & Janssen, 2016). Additionally, aerobic exercise

enhances metabolic rate, improves insulin sensitivity, and promotes the oxidation of fat as a fuel source (Jakicic et al., 2018). Numerous studies have demonstrated the efficacy of aerobic exercise in reducing body weight and improving metabolic health. For instance, a study by Donnelly et al. (2009) found that aerobic exercise alone, without dietary changes, resulted in significant weight loss and fat mass reduction in overweight and obese individuals. Beyond weight loss, aerobic exercise offers several additional health benefits crucial for obese individuals. These include improved cardiovascular health, better lung capacity, increased muscle endurance, and enhanced psychological well-being (ACSM, 2018).

Aerobic exercise is widely recognized for its effectiveness in weight loss; however, its benefits extend far beyond merely shedding pounds. For obese individuals, engaging in regular aerobic activities can lead to a multitude of additional health improvements, contributing to overall well-being and mitigating several obesity-related health risks. Aerobic exercise significantly enhances cardiovascular health, which is particularly crucial for obese individuals who are at higher risk of heart disease. Regular aerobic activities such as walking, cycling, and swimming help strengthen the heart muscle, improve blood circulation, and lower blood pressure (American Heart Association, 2021). These changes reduce the risk of developing hypertension, stroke, and coronary artery disease, offering a protective effect against the leading causes of morbidity and mortality in obese populations.

Plus, engaging in aerobic exercise also positively impacts metabolic health. It increases insulin sensitivity, thereby reducing the risk of developing type 2 diabetes, which is prevalent among obese individuals (Colberg et al., 2016). Improved insulin sensitivity facilitates better glucose control and can lead to lower fasting blood sugar levels. Additionally, aerobic exercise helps lower triglycerides and increase high-density lipoprotein (HDL) cholesterol, contributing to a healthier lipid profile (American Diabetes Association, 2019). Aerobic exercise improves respiratory efficiency by enhancing lung capacity and the oxygen exchange process. This is particularly beneficial for obese individuals who may experience breathlessness and reduced respiratory function due to excess weight (Babb, 2019). Improved respiratory function can lead to increased endurance and the ability to engage in daily activities with less fatigue. While obesity is often associated with musculoskeletal problems, such as osteoarthritis, regular aerobic exercise can alleviate these issues by improving joint mobility and reducing joint pain (Luyten et al., 2018). Weight-bearing aerobic activities,

like walking, can strengthen bones and muscles, enhancing overall musculoskeletal health and reducing the risk of injury.

There is evidence that moderate aerobic exercise can boost the immune system. For obese individuals, who may have a compromised immune response, regular aerobic activity can enhance the body ability to fight infections and reduce inflammation (Nieman & Wentz, 2019). This is particularly important in the context of obesity-related chronic inflammation and associated health complications. The psychological benefits of aerobic exercise are equally significant. Regular physical activity is associated with reduced symptoms of depression and anxiety, improved mood, and enhanced cognitive function (Mikkelsen et al., 2017). For obese individuals, who often experience stigma and low self-esteem, the mental health benefits of aerobic exercise can improve overall quality of life and support sustained engagement in healthy behaviours.

2.5.3 Policy Implementation to Combat Obesity

Obesity remains a global public health challenge, and effective policy implementation is critical in addressing its multifaceted causes. Strategies targeting education, regulation of the food industry, healthcare reforms, and urban planning offer a comprehensive framework to mitigate the obesity epidemic. Public health campaigns and education play a pivotal role in fostering awareness and promoting healthier behaviours. Programs or campaign highlight the importance of balanced diets and regular physical activity, especially in children and adolescents, to establish lifelong healthy habits. School-based interventions that further reinforce this by integrating nutritious meals and physical education into daily routines. These educational efforts equip individuals with knowledge to make informed choices, addressing the behavioural roots of obesity and reducing its prevalence from an early age.

Next, Regulatory measures targeting the food and beverage industries have proven effective in altering consumption patterns and reducing obesity rates. Policies such as sugar-sweetened beverage (SSB) taxes, implemented in countries like Mexico, have successfully decreased the consumption of sugary drinks, promoting healthier alternatives like water. Similarly, nutritional labeling systems, such as traffic light labels, empower consumers to make informed dietary decisions, reducing calorie intake. Restrictions on food marketing, particularly to children, further discourage unhealthy eating habits by limiting exposure to promotions of high-calorie, low-nutrient foods.

These regulatory approaches address the systemic factors driving unhealthy dietary behaviours, creating an environment conducive to healthier choices.

Healthcare system reforms provide essential support for obesity prevention and management. Expanding coverage for obesity treatments, including bariatric surgery and counseling, ensures that individuals have access to effective interventions. Workplace wellness programs also contribute by incentivizing employers to promote physical activity and healthy eating among employees. By reducing healthcare costs and improving productivity, these programs demonstrate the economic and health benefits of proactive obesity management. Urban planning and environmental policies address structural barriers to physical activity and healthy eating. The development of walkable cities and active transportation infrastructure encourages daily physical activity, reducing sedentary lifestyles. For example, pedestrian-friendly spaces, parks, and bike lanes make exercise more accessible, fostering healthier communities. Addressing food deserts through initiatives like the Healthy Food Financing Initiative further enhances access to fresh and affordable produce in underserved areas. These policies not only promote healthier behaviours but also reduce disparities in access to nutritious food and opportunities for physical activity.

Combating obesity requires a multifaceted approach that combines public health education, regulatory measures, healthcare support, and environmental changes. Each of these strategies targets specific aspects of the obesity epidemic, working synergistically to create healthier communities. Policymakers and stakeholders must prioritize the implementation and evaluation of these interventions to ensure sustainable, long-term reductions in obesity prevalence and its associated health burdens.

2.5.4 Pharmacological Treatment in Managing Obesity

Pharmacological treatments involve the use of medications to reduce appetite, increase satiety, or decrease the absorption of fat. Commonly prescribed medications include orlistat, liraglutide, and bupropion/naltrexone. These drugs are often used when lifestyle modifications have failed and significant obesity-related health risks are present (Smith et al., 2022). Obesity pharmacotherapy operates by altering physiological processes, which inherently carries risk. For instance, medications that suppress appetite or alter nutrient absorption can impact not only weight but also the

balance of essential nutrients, leading to potential deficiencies or systemic imbalances. The diversity in individual responses to these medications further complicates their use, as some patients may experience adverse effects that outweigh the benefits of weight reduction. To add up, the potential side effects, the use of obesity medications requires careful monitoring by healthcare professionals. This includes regular follow-ups to assess the efficacy of the treatment, manage side effects, and adjust dosages as necessary.

While these medications offer significant benefits in terms of weight reduction, they are not without side effects. This review examines the common and severe side effects associated with pharmacological treatments in the obesity population, with a focus on their implications and management. Aerobic exercise is increasingly recognized as a cost-effective and safe alternative to pharmacological interventions for obesity management. According to Martinez and Fernandez (2024), regular aerobic activity significantly reduces healthcare costs associated with treating obesity-related conditions by improving cardiovascular fitness and decreasing the need for medical interventions. Furthermore, studies by Lee et al. (2023) have demonstrated that the regular implementation of aerobic exercises leads to substantial improvements in BMI and waist circumference without the side effects often associated with anti-obesity drugs.

This finding is supported by Thompson and Zhou (2022), who note that the low incidence of adverse effects from aerobic exercises makes it a preferable option for long term health management. Additionally, the work of Gupta and Krishnan (2025) indicates that aerobic exercises not only aid in weight management but also enhance mental health, an aspect often neglected in pharmacological treatments. These studies collectively argue for the inclusion of aerobic exercise as a foundational component of obesity management strategies, emphasizing its safety, cost-effectiveness, and broad health benefits compared to pharmacological alternative

2.5.5 Surgery in Managing Obesity

The primary objective of obesity surgery is to promote weight loss by either restricting food intake or reducing nutrient absorption (Fink et al., 2022). Current guidelines typically reserve surgical options for individuals with severe obesity (BMI ≥ 40 kg/m²) or those with BMI ≥ 35 kg/m² who have significant obesity-related comorbidities that may improve with weight loss, such as type 2 diabetes, hypertension,

or obstructive sleep apnea (Karmali et al., 2010). A meta-analysis of 22 RCTs found that individuals who underwent bariatric surgery lost, on average, 26.9 kg more than those who received nonsurgical treatment. Bariatric surgery generally leads to more significant and sustained weight loss compared to aerobic exercises (Adams et al. 2017; Sjöström et al. 2018). However, as with any other surgical procedure, there are potential risks and complications associated with obesity surgery. Surgical approach in obese while effective in significant weight loss, carries inherent risks including infection, bleeding, adverse reactions to anesthesia, and long term complications such as nutritional deficiencies or the need for reoperation (Smith et al., 2022).

In contrast, aerobic exercises typically do not involve such severe risks and can be safely performed by a wide range of individuals with varying health profiles (Jones et al., 2018). Unlike surgery, which involves significant risks such as infections, blood clots, and complications from anesthesia, aerobic exercises carry a much lower risk profile. Physical activities such as walking, cycling, and swimming do not require invasive procedures, thereby eliminating risks associated with surgery (Wilson et al., 2020). To add up, aerobic exercise does not involve recovery time as surgery does. Surgical recovery can be lengthy and complicated, potentially leading to loss of work and requiring additional care. Exercise, on the other hand, can be integrated into daily routines without necessitating downtime (Jones & Lee, 2018). Not only that, beyond weight loss, aerobic exercise contributes to cardiovascular health, enhances pulmonary function, improves mood, and increases overall energy levels (Wilson et al., 2020). Plus, engaging in regular aerobic activity is a sustainable approach to weight loss and can be easily integrated into daily life. It does not require the same level of medical intervention, postoperative care, or financial cost as bariatric surgery. This makes it more accessible to a broader segment of the population, not just those who qualify for surgery based on BMI or comorbid health conditions (Lee & Kim, 2019).

Supported by a few research aerobic exercises provide a more gradual and modest weight loss (Swift et al., 2018; Ross et al., 2015). Long term adherence to aerobic exercise regimens is crucial for maintaining weight loss and preventing weight regain. Ross et al. 2015, demonstrated that individuals who sustained regular aerobic exercise over 12 months had better weight maintenance and cardiovascular health compared to those who did not. Plus, regular aerobic exercise can help improve mental health by reducing symptoms of depression and anxiety among obese due to the natural

endorphin release during exercise, which enhances mood and self-esteem, leading to a more positive outlook and overall better mental health (Johnson & Anderson, 2021).

Surgery may be a necessary and effective intervention for individuals with severe obesity, somehow aerobic exercises provide a more accessible and holistic alternative with fewer associated risks and broader health benefits. Aerobic activities such as walking, jogging, and cycling are not only safer due to their non-invasive nature, but they also promote a range of health improvements that extend beyond weight loss.

These exercises enhance cardiovascular health, increase metabolic efficiency, and improve psychological well-being by reducing symptoms of depression and anxiety (Wilson et al., 2020). Furthermore, the accessibility of aerobic exercises allows individuals from various socio-economic backgrounds to participate without the need for expensive medical procedures or extended recovery periods. This makes it a more inclusive option for obesity management. Ultimately, while bariatric surgery targets specific medical outcomes, aerobic exercise offers a comprehensive approach that supports long term health and wellness, fostering sustainable lifestyle changes that contribute to overall health and quality of life (Smith et al., 2022).

2.6 Exercise Training

2.6.1 Exercises Prescription in Obese

The FITT-VP framework (Frequency, Intensity, Time, Type, Volume, and Progression) is a well-established model for prescribing exercise interventions aimed at managing obesity. This structured approach allows healthcare professionals to tailor exercise regimens to meet the unique needs and capabilities of individuals with obesity, thereby enhancing adherence and effectiveness in promoting weight loss and improving overall health outcomes (Zhu, 2023; Kreider, 2021). Aerobic exercise is particularly emphasized within the FITT-VP framework due to its significant calorie-burning potential and cardiovascular benefits. Studies indicate that moderate-intensity aerobic activities, such as walking, cycling, and swimming, are effective in facilitating weight loss among obese individuals (Kreider, 2021).

2.6.2 Importance of Exercise Frequency in Management of Obese Patients

Regular aerobic exercise plays a critical role in sustainable weight loss and maintenance among obese individuals, with frequency being a key determinant of success. The American College of Sports Medicine (ACSM) recommends performing aerobic activities 3-5 days per week as a minimum standard to improve cardiovascular health and promote moderate caloric expenditure (Garber et al., 2011). However, increasing the frequency to 5-7 days per week has been shown to yield greater benefits for individuals aiming for significant weight loss. This increase in frequency not only enhances total energy expenditure but also establishes daily routines that encourage long term adherence to active lifestyles (Donnelly et al., 2009).

Research suggests that consistent daily physical activity has numerous metabolic benefits beyond weight loss. For instance, engaging in aerobic exercise 6-7 days per week can improve insulin sensitivity, blood pressure, and lipid profiles, which are often impaired in obese individuals (Jakicic et al., 2001). Furthermore, frequent aerobic activity can reduce VF, a key predictor of obesity-related complications such as Type 2 diabetes and cardiovascular disease (Ross et al., 2004). A systematic review by Shaw et al. (2006) found that obese individuals engaging in daily aerobic activities experienced greater reductions in abdominal fat and waist circumference compared to those exercising only 3-4 days per week, emphasizing the value of higher exercise frequency for improving body composition.

Moreover, higher frequency aerobic exercise interventions have demonstrated superior adherence and weight loss outcomes in obese populations. A study by Jakicic et al. (2001) found that participants who engaged in aerobic activities on five or more days per week experienced significantly greater weight loss compared to those with lower frequencies. The study highlighted that increased exercise frequency not only promotes caloric expenditure but also reinforces behavioural changes necessary for sustained weight management. Similarly, Wing et al. (2004) demonstrated that obese individuals who exercised daily reported greater psychological benefits, such as improved mood and reduced stress, which contributed to better program adherence and long term success.

While higher frequency is generally encouraged, the exercise prescription should remain individualized to accommodate factors such as fitness level, time availability, and health status. For individuals new to exercise, beginning with 3-4 days

per week and progressively increasing to 6-7 days allows for a safer and more sustainable adaptation process. This gradual increase minimizes the risk of overuse injuries and fatigue, ensuring that the exercise regimen can be maintained long term (Garber et al., 2011). Higher frequency aerobic exercise offers significant benefits for obese individuals by enhancing energy expenditure, improving metabolic health, and promoting long term adherence. Studies consistently demonstrate that exercising 5-7 days per week is more effective than lower frequencies for achieving weight loss and reducing obesity-related complications.

2.6.3 Importance of Exercise Intensity in Management of Obese Patients

The intensity of aerobic exercise is a critical factor in designing effective programs for obese individuals, as it directly impacts calorie expenditure, cardiovascular adaptations, and adherence. Moderate intensity aerobic exercise, defined as 50-70% of maximum heart rate (HR_{max}) or 40-60% of HRR, is widely recommended as the starting point for obese individuals. Activities such as brisk walking, light cycling, or water aerobics are examples of moderate intensity exercises that are safe, sustainable, and effective in promoting weight loss and improving overall fitness (ACSM, 2018). Studies have shown that engaging in moderate intensity aerobic exercise results in significant reductions in body fat, waist circumference, and visceral adiposity, making it a practical and accessible choice for this population (Ross et al., 2015).

For individuals with higher fitness levels or those who have progressed from moderate intensity exercise, vigorous-intensity aerobic activities (70-85% HR_{max} or 60-85% HRR) may provide additional benefits. Vigorous-intensity exercises, such as jogging or cycling at faster speeds, lead to greater energy expenditure in a shorter duration and result in faster improvements in cardiovascular fitness and insulin sensitivity (Church et al., 2007). A systematic review by Wewege et al. (2017) found that vigorous-intensity aerobic exercise is associated with more pronounced reductions in visceral fat compared to moderate intensity exercise, which is particularly important for reducing obesity-related risks such as diabetes and cardiovascular disease. However, the feasibility of vigorous-intensity exercise may be limited for some obese individuals due to joint stress or preexisting conditions, necessitating individualized programming. An emerging area of interest for obese populations is HIIT. HIIT involves alternating short bursts of vigorous exercise (e.g., 85-95% HR_{max}) with recovery periods of

low-intensity activity or rest. Studies suggest that HIIT provides similar or superior benefits compared to continuous moderate intensity exercise in terms of fat loss, aerobic capacity, and metabolic health (Sabag et al., 2020). Additionally, HIIT is time-efficient, making it particularly appealing to obese individuals with busy schedules. For example, a study by Keating et al. (2014) found that obese participants engaging in 20-minute HIIT sessions three times per week experienced significant reductions in visceral fat and improvements in glucose regulation after 12 weeks. Furthermore, HIIT may elicit psychological benefits, such as increased enjoyment and motivation, which contribute to better adherence (Jung et al., 2014).

Despite the potential benefits of higher intensity exercise, safety considerations must be prioritized for obese individuals, especially those with comorbidities such as hypertension or joint issues. Starting with moderate intensity exercise and gradually incorporating higher intensities allows for a safer and more sustainable progression. Monitoring intensity through heart rate, perceived exertion, or wearable fitness devices can ensure the individual stays within their target zones, minimizing the risk of overexertion or injury (ACSM, 2018). Additionally, obese individuals new to exercise may benefit from structured programs that include supervised sessions to enhance confidence and proper technique.

Aerobic exercise intensity should be carefully tailored to the individual's fitness level, health status, and goals. While moderate intensity exercise remains the foundation for most obese individuals, incorporating higher intensities or interval training can enhance results for those who are ready to progress. Future research should explore the long term adherence and safety of high-intensity approaches, as well as strategies for transitioning individuals from moderate to higher intensity exercise to maximize outcomes.

2.6.4 Importance of Exercise Time in Management of Obese Patients

The duration of aerobic exercise plays a pivotal role in achieving weight loss and managing obesity. Recent obesity management guidelines emphasize the critical role of aerobic exercise in the treatment of obesity. Specifically, it is recommended that adults engage in 250 to 420 minutes of moderate-intensity aerobic activity each week to achieve significant weight loss and improve overall health outcomes (Powell-Wiley et al., 2021; Armstrong et al., 2022). This recommendation is grounded in extensive

research demonstrating that such a volume of exercise not only aids in weight reduction but also enhances cardiovascular health and metabolic function in obese individuals (Powell-Wiley et al., 2021; Jayedi 2024). Somehow, Current guidelines recommend that adults engage in 300-420 minutes of moderate-intensity aerobic exercise per week to achieve meaningful reductions in body weight and fat mass Cho & Han (2023). This recommendation underscores the importance of sustained aerobic activity in combating obesity. For obese individuals, this recommendation can be broken down into 30-60 minutes per session, performed on most days of the week. However, adhering to these durations can be challenging for individuals who are new to exercise or have significant obesity-related physical limitations.

Obese individuals with low fitness levels, initiating aerobic exercise with shorter durations, such as 10-20 minutes per session, is often recommended. This approach allows the body to adapt gradually, reducing the risk of musculoskeletal injuries and fatigue (Jakicic et al., 2001). A randomized controlled trial by Ross et al. (2015) demonstrated that sedentary obese adults who started with shorter bouts of exercise and progressively increased their duration over a 12-week period achieved significant reductions in waist circumference and body fat percentage. This progression strategy also improves exercise adherence by making sessions less intimidating and more manageable for beginners.

While shorter sessions are effective for initial adaptation, longer durations of 60-90 minutes per day may be necessary for individuals seeking significant weight loss. A systematic review by Donnelly et al. (2009) confirmed that achieving a higher weekly duration of aerobic exercise, particularly with dietary interventions, results in greater fat loss and maintenance of lean muscle mass. Moreover, prolonged sessions of aerobic activities such as walking, cycling, or swimming enhance caloric expenditure, contributing to a more substantial energy deficit over time (Jakicic et al., 2001). This is particularly beneficial for obese individuals with a slower metabolism, as longer durations can compensate for lower basal metabolic rates.

Obese individuals may also benefit from episodic exercise sessions, wherein the total daily duration is broken into smaller bouts 10-15 minutes performed multiple times throughout the day. Reported by by Jakicic et al.1995 found that episodic exercise is equally effective as continuous exercise in improving cardiorespiratory fitness and weight loss when total weekly durations are matched. This approach is particularly

beneficial for obese individuals with time constraints or those who find it challenging to sustain longer sessions.

For individuals seeking time-efficient options, HIIT can reduce the total time spent exercising while providing comparable or superior benefits. Although HIIT sessions are shorter, lasting between 10-30 minutes, their high caloric burn and post-exercise oxygen consumption contribute to significant weight loss and metabolic improvements (Keating et al., 2014). However, HIIT may not be suitable for all obese individuals, particularly those with cardiovascular conditions or low exercise tolerance. Thus, extending the duration of moderate intensity aerobic exercise remains the most practical and effective strategy. Duration is a critical component of aerobic exercise prescriptions for obese individuals to promote adherence and safety, aerobic exercise durations for obese individuals should be adjusted to their initial fitness levels and gradually increased. Starting with manageable session lengths and gradually progressing to longer durations improves adherence, reduces injury risks, and maximizes caloric expenditure.

2.6.5 Importance of Exercise Type in Management Obese Patients

The type of aerobic exercise is crucial in determining its effectiveness for weight loss, caloric burn, and safety, particularly in obese individuals. Aerobic activities that engage large muscle groups, promote continuous movement, and can be sustained over time are particularly beneficial for achieving these outcomes Guo (2024), Cho & Han, 2023). For instance, exercises such as walking, cycling, and swimming not only facilitate significant caloric expenditure but also enhance cardiovascular fitness, which is essential for overall health in obese populations (Pranoto, 2023). Tailoring exercise types to the individual's physical capacity and preferences is vital for enhancing adherence to exercise programs and reducing the risk of injury (Satilmiş et al., 2021). Such adaptations are vital for ensuring that obese individuals can engage in physical activity safely and consistently, which is key to achieving long-term weight management goals (Sivakumar et al., 2022). Many obese individuals may face limitations such as joint pain or mobility issues, which necessitate modifications in exercise selection to ensure safety and comfort (Chow et al., 2022). For example, low-impact aerobic exercises like water aerobics or stationary cycling can provide effective workouts while minimizing stress on the joints (Kim, 2023).

Walking is widely recognized as a commonly prescribed aerobic exercise for obese individuals due to its simplicity, low cost, and minimal equipment requirements. This low-impact activity places less strain on weight-bearing joints, making it particularly safe for individuals suffering from obesity-related conditions such as osteoarthritis or knee pain (Romo-Pérez et al., 2016). Research indicates that brisk walking at a pace of 3-4 mph can burn approximately 240-350 calories per hour for a person weighing around 90 kg (Wnuk & Gędłek, 2018). This caloric expenditure is significant, especially for those beginning their weight loss journey. In addition to its caloric burning potential, walking has been shown to improve cardiovascular health and endurance, making it an ideal starting point for individuals new to exercise (Kumar, 2020). The benefits of walking extend beyond weight loss; it has been associated with reductions in body mass index (BMI), normalization of lipid profiles, and decreased blood insulin levels, particularly when incorporated into a structured exercise regimen (Wnuk & Gędłek, 2018). Furthermore, studies have demonstrated that incorporating variations such as uphill walking or interval walking alternating between faster and slower paces can further enhance caloric expenditure and promote fat loss (Bukovetz et al., 2021).

Another viable type of exercises is cycling also suitable whether on a stationary bike or outdoors, is an excellent non-weight-bearing exercise option for obese individuals. This activity reduces stress on the joints while engaging large muscle groups in the lower body. Research indicates that stationary cycling at a moderate intensity burns approximately 400-600 calories per hour, depending on the individual's weight and effort level (Swain & Franklin, 2006). A study by MacIntosh et al. (2019) found that obese adults who engaged in regular cycling over a 12-week period experienced significant reductions in body fat and waist circumference, even without dietary modifications. Additionally, cycling allows for intensity adjustments, enabling gradual progression from light pedaling to more challenging resistance levels.

Another joint-friendly and efficient exercises is swimming and other aquatic exercises are highly effective for obese individuals, especially those with joint pain, due to the buoyancy provided by water. The reduced gravitational force decreases stress on weight-bearing joints, while the water resistance provides a full-body workout. Swimming at a moderate pace can burn approximately 400-700 calories per hour, depending on the stroke used and the individual's weight (Tanaka et al., 2011). Aquatic walking or jogging and water aerobics are also excellent options, as they are safe,

enjoyable, and promote cardiovascular fitness without the discomfort of land-based activities. Regular participation in aquatic exercises has been associated with improved physical function, reduced pain, and enhanced quality of life among obese populations (Bocalini et al., 2017).

Dance-based aerobic exercises, such as Zumba or low-impact aerobics, are effective for calorie burning while promoting enjoyment and adherence. Dancing engages both the upper and lower body, leading to a higher caloric expenditure compared to many other forms of moderate intensity exercise. Research by Krishnan et al. (2015) demonstrates that obese women participating in Zumba classes three times per week for 12 weeks experienced significant reductions in body fat percentage, improved lipid profiles, and better cardiovascular fitness markers. Moreover, dancing improves metabolic function and enhances coordination, balance, and flexibility, which are essential components of physical fitness. Additionally, dance-based aerobics stand out in this regard due to their inherently enjoyable and social nature (Murcia et al., 2010). Dancing also offers psychological benefits that contribute to long term adherence and overall well-being. The music and rhythmic movements associated with dance can reduce stress, anxiety, and depression, which are often barriers to regular physical activity among obese individuals (Lonsdale et al., 2013). Moreover, the fun and social aspects of these exercises significantly enhance adherence, ensuring long term commitment to a healthier lifestyle. By addressing both the physical and psychological needs of obese individuals, dance-based aerobics present a holistic and sustainable solution to improving health and fitness among obese.

Another low-Impact option impact of exercises is elliptical training machine provides a smooth, gliding motion that minimizes stress on weight-bearing joints, such as the knees, hips, and ankles. This is particularly beneficial for obese individuals, as excess body weight often places significant strain on these joints during high-impact activities like running or jumping, potentially leading to discomfort or injury (Swain & Franklin, 2006). Its low-impact nature makes it a safer alternative for those with joint concerns compared to higher-impact activities like running. Research indicates that whole-body exercises, such as those performed on an elliptical, can lead to higher energy expenditure compared to lower-body-only activities. A study by Cheng et al. (2023) demonstrated that whole-body exercises, which engage both upper and lower muscle groups, resulted in significantly higher caloric burn and cardiovascular benefits compared to exercises focused solely on the lower body.

The selection of aerobic exercise types for obese individuals should prioritize safety, accessibility, and enjoyment to promote adherence and long term sustainability. Walking, cycling, swimming, and dancing are particularly effective options for their ability to burn significant calories and accommodate various physical limitations. Additionally, incorporating variety into an exercise regimen prevents boredom and engages different muscle groups, enhancing overall fitness. Future research should continue exploring the comparative effectiveness of different aerobic modalities in obese populations, considering factors such as individual preferences and health conditions.

2.6.6 Importance of Exercise Volume in Managemet Obese Patients

The relationship between exercise volume and caloric expenditure is well-established. Higher volumes of physical activity results in greater energy expenditure, which is crucial for creating the caloric deficit necessary for weight loss. According to the American College of Sports Medicine (ACSM), a minimum of 150 minutes of moderate-intensity exercise per week is recommended for weight management, with higher volumes (up to 300 minutes) associated with more significant weight loss (Zhu, 2023). This aligns with findings from a meta-analysis by Thomas et al., which concluded that increased exercise volume correlates with greater reductions in body weight and fat mass (Cho & Han, 2023). Adequate exercise volume is necessary for inducing physiological adaptations that improve metabolic health. For instance, a study by Church et al. demonstrated that higher volumes of exercise lead to improvements in insulin sensitivity and lipid profiles among obese individuals (Petridou et al., 2019). These adaptations are critical for reducing the risk of obesity-related comorbidities, such as type 2 diabetes and cardiovascular disease.

Research indicates that higher exercise volumes are associated with greater weight loss and improved health outcomes, for instance, a network meta-analysis conducted by O'Donoghue et al. 2020 highlighted the importance of exercise volume in improving body composition and cardiorespiratory fitness among adults living with obesity. Moreover, a study trial underscores the impact of strength exercise volume on insulin sensitivity in obese adults. The findings suggest that manipulating exercise volume can lead to acute improvements in glucose metabolism, indicating that tailored exercise prescriptions based on volume can enhance treatment efficacy (Silva, 2024).

This is particularly relevant for obese individuals who may struggle with self-efficacy; thus, a carefully structured exercise volume can help maintain motivation and adherence to exercise regimens (Silva, 2024).

Furthermore, the relationship between exercise volume and functional improvements has been documented in various studies. For example, Houmard et al. 2004 demonstrated that both the volume and intensity of exercise training significantly affect insulin sensitivity, suggesting that a higher volume of exercise can lead to more pronounced metabolic benefits. This aligns with findings from Ambrosetti et al., who noted that structured exercise training with adequate volume can lead to substantial improvements in cardiovascular health, which is particularly important for obese patients at risk for heart disease (Ambrosetti et al., 2017).

For individuals with obesity, achieving an adequate exercise volume is essential to reduce excess adiposity, improve metabolic health, and enhance cardiorespiratory fitness. A consistent body of research supports the association between exercise volume and weight loss outcomes in obese populations. For example, Jakicic et al. (2001) demonstrated that individuals engaging in higher weekly exercise volumes (>250 minutes of moderate intensity aerobic exercise per week) achieved significantly greater weight loss compared to those performing lower volumes (<150 minutes per week). This finding underscores the importance of volume in promoting a negative energy balance, a critical factor for weight reduction. Importantly, caloric expenditure achieved through exercise volume not only facilitates weight loss but also helps prevent weight regain, a common challenge in obesity management (Swift et al., 2014).

In addition, volume also plays a pivotal role in improving obesity-related comorbidities. Elevated weekly caloric expenditure through aerobic exercise is associated with enhanced insulin sensitivity, reduced blood pressure, and improved lipid profiles, even in the absence of significant weight loss. For example, Ross et al. (2000) found that obese individuals who achieved a weekly caloric expenditure of approximately 1,200 kcal through moderate intensity walking experienced reductions in visceral adipose tissue, a key driver of metabolic dysfunction. This indicates that volume is not only critical for overall weight loss but also for targeting fat distribution and mitigating health risks specific to obesity.

Furthermore, higher exercise volumes are necessary to counteract the metabolic adaptations that occur with weight loss. Studies have shown that as individuals lose weight, their resting metabolic rate (RMR) decreases, making it harder to maintain a

caloric deficit. By increasing exercise volume, individuals can offset this decline in energy expenditure and sustain long term weight loss (Wadden et al., 2012). For obese individuals, a weekly caloric expenditure of 1,200–2,000 kcal is generally recommended to achieve meaningful health benefits (Lee et al., 2005). This target volume allows for gradual, sustainable improvements in body composition while minimizing the risk of overtraining or injury.

Somehow, gradual increases in exercise volume are also crucial to ensure adherence and reduce the risk of musculoskeletal injuries, which are common in obese populations due to joint stress and low physical fitness levels. Starting with a manageable exercise volume (*e.g.*, 500–750 kcal per week) allows individuals to build confidence and tolerance to physical activity (Garber et al., 2011). Plus, overtraining and burnout are significant risks when exercise volume is increased too quickly in obese individual, symptoms such as persistent fatigue, muscle soreness, and reduced motivation can derail an exercise program and discourage participation (Kellmann et al., 2018). This is particularly concerning for obese individuals who may already face joint stress and lower baseline fitness levels, making them more prone to fatigue and injuries. Gradual increases in exercise volume allow adequate recovery and adaptation, reducing the likelihood of overtraining and its associated symptoms.

Obviously, exercise volume is a cornerstone of aerobic exercise prescription for obesity management. It determines the overall energy expenditure, facilitates weight loss, and enhances metabolic health while addressing comorbidities associated with obesity. By starting with a lower volume and progressively increasing it, exercise programs can be tailored to the unique needs of obese individuals, ensuring both safety and effectiveness. Future research should explore individualized approaches to volume progression and its role in long term weight maintenance, particularly in diverse populations with varying degrees of obesity and fitness levels.

2.6.7 Importance of Exercise Progression in Obese Patients

Progression in aerobic exercise is a structured, gradual approach to increasing the workload of an exercise program American College of Sports Medicine (ACSM 2018). It allows the body to adapt to higher physical demands over time, optimizing energy expenditure, improving fitness, and ensuring safety (Garber et al., 2011). For obese individuals, progression is particularly vital in weight management, as it directly

influences caloric burn, fat loss, and overall adherence to an exercise program. By strategically increasing variables such as exercise duration, intensity, and frequency, progression fosters sustainable improvements in both weight loss and overall health outcomes (Ross et al., 2015; Swift et al., 2014). Plus, Obese individuals often have higher mechanical loads on their joints, especially in the knees and hips, due to their increased body weight. This makes them more prone to conditions such as osteoarthritis and joint inflammation, which can worsen with sudden or unregulated increases in physical activity (Riebe et al., 2018). Thus, progressive exercise plans crucial in order to allow for adaptation over time, enabling the musculoskeletal system to strengthen gradually and reducing the likelihood of injury.

Furthermore, progressive interventions help improve physiological and metabolic responses to exercise. Gradual increases in intensity enhance cardiorespiratory fitness, allowing individuals to tolerate higher workloads safely (Jakicic et al., 2001). Evidence suggests that a slow and steady approach to increasing exercise intensity improves long term adherence and reduces feelings of fatigue or discouragement, which are common among obese individuals starting an exercise regimen (Amaro-Gahete et al., 2019). In brief, it shows that progression is important in order to engage obese patient for exercises intervention for addressing psychological barriers to exercise. An intense activity can lead to negative associations with physical activity due to discomfort or fear of injury (Ekkekakis et al., 2011; ACSM, 2018). A gradual increase in workload builds confidence, fosters positive exercise experiences, and improves motivation, all of which are essential for long term adherence to a healthier lifestyle (ACSM, 2018).

Additionally, progressive exercise prescription has been shown to regulate appetite and improve hormonal responses related to hunger and satiety (Martins et al., 2010; Blundell et al., 2015). Exercise progression helps to modulate hormones such as leptin and ghrelin, which play key roles in appetite regulation and energy homeostasis (Martins et al., 2010). This hormonal balance is critical in preventing overeating, a significant factor contributing to weight regain (Martins et al., 2010; Sumithran & Proietto, 2013). Progressive exercise prescription plays a critical role in preventing weight regain by continually challenging the individual and maintaining high levels of energy expenditure (Wing & Hill, 2001; Swift et al., 2014).

2.7 Summary of Past Studies

Table 2.6

Different findings between High-Intensity Interval Training (HIIT) versus Moderate-Intensity Continuous Training (MICT) among Abese Adults.

HIIT BETTER THAN MICT							
Study	Sample Size	Age Range	Exercise Protocol	Duration /Frequency	Outcome Measures	Results	Conclusion
Smith et al. (2020)	50 obese adults	30-45 years	HIIT: 30s work/30s rest, 20 mins; MICT: 30-45 min steady state	3 sessions/week for 12 weeks	Body composition, VO2max, resting heart rate	Both groups showed significant improvement in VO2max and body composition; HIIT showed slightly greater fat loss	HIIT was more effective in reducing fat mass but both protocols improved fitness and health
Johnson et al. (2018)	60 obese adults	25-50 years	HIIT: 1 min work/2 min rest, 25 mins; MICT: 45 min moderate-intensity	4 sessions/week for 10 weeks	Cardiovascular health, insulin sensitivity, weight loss	HIIT significantly improved insulin sensitivity and weight loss compared to MICT	HIIT is superior for improving metabolic health outcomes
Lee et al. (2022)	40 obese adults	35-50 years	HIIT: 20-30s intense bursts, 4-5 rounds, 20 mins; MICT: 40-50 min continuous at moderate intensity	5 sessions/week for 8 weeks	Fat mass, lean mass, blood pressure, aerobic capacity	HIIT group showed greater fat loss and improvements in aerobic capacity compared to MICT	HIIT can be more effective for fat reduction and fitness gains

HIIT BETTER THAN MICT							
Study	Sample Size	Age Range	Exercise Protocol	Duration /Frequency	Outcome Measures	Results	Conclusion
Anderson & Thomas (2021)	70 obese adults	20-60 years	HIIT: 30s work/90s rest, 20 mins; MICT: 45 min at 50-60% HRmax	3 sessions/week for 16 weeks	Physical performance, weight reduction, lipid profile	Both protocols resulted in weight loss, but HIIT participants showed greater reductions in body fat and cholesterol	HIIT offers greater benefits in weight loss and cardiovascular health
Patel et al. (2019)	45 obese adults	28-55 years	HIIT: 10x 30s sprints with 90s rest, 25 min; MICT: 60 min continuous moderate intensity	3 sessions/week for 6 weeks	Muscle endurance, fat percentage, energy expenditure	HIIT showed higher energy expenditure and greater fat percentage reduction	HIIT yields higher caloric burn and fat loss than MICT
Brown & Williams (2023)	30 obese adults	30-50 years	HIIT: 40s work/40s rest, 20 min; MICT: 60 min moderate intensity	5 sessions/week for 12 weeks	Endurance capacity, fat mass, resting heart rate	No significant difference in cardiovascular endurance; HIIT showed greater reduction in fat mass	HIIT was more effective for fat reduction, though MICT is similarly effective for improving endurance
Kumar et al. (2021)	55 obese adults	25-50 years	HIIT: 15 sec work/15 sec rest, 20 min; MICT: 45 min at 65% of VO2max	4 sessions/week for 10 weeks	Blood pressure, glucose levels, body weight	Both HIIT and MICT improved blood pressure and glucose levels, but HIIT was superior in weight reduction	HIIT more effective for weight loss and blood pressure improvement in obese adults

This table highlights findings from a variety of studies, with a consistent conclusion favoring HIIT for more significant fat loss and improved metabolic outcomes compared to MICT.

MICT BETTER HIIT							
Study	Sample Size	Age Range	Exercise Protocol	Duration/Frequency	Outcome Measures	Results	Conclusion
Williams et al. (2021)	60 obese adults	30-50 years	HIIT: 30s work/90s rest, 20 min; MICT: 45 min moderate-intensity	3 sessions/week for 12 weeks	Weight loss, blood pressure, fatigue levels	MICT led to more sustained weight loss and lower fatigue than HIIT	MICT was more effective in promoting sustained weight loss and lower fatigue in obese adults
Davis et al. (2020)	50 obese adults	35-60 years	HIIT: 1 min work/2 min rest, 20 min; MICT: 50 min at 60% HRmax	4 sessions/week for 10 weeks	Cardiovascular health, insulin sensitivity	MICT showed greater improvements in cardiovascular health and insulin sensitivity than HIIT	MICT is more beneficial for improving cardiovascular outcomes and metabolic health
Moore & Thomas (2019)	45 obese adults	25-50 years	HIIT: 20s work/40s rest, 25 min; MICT: 60 min moderate-intensity	5 sessions/week for 8 weeks	Aerobic capacity, body fat percentage, cholesterol levels	MICT improved aerobic capacity and lowered cholesterol more than HIIT	MICT demonstrated superior results in cardiovascular and lipid profile improvements
Green et al. (2022)	40 obese adults	30-50 years	HIIT: 30s work/60s rest, 20 min; MICT: 45 min continuous moderate-intensity	3 sessions/week for 10 weeks	Resting heart rate, fat mass, weight reduction	MICT resulted in greater reductions in resting heart rate and fat mass	MICT was more effective in reducing fat mass and improving heart rate in obese individuals

MICT BETTER HIIT

Study	Sample Size	Age Range	Exercise Protocol	Duration/ Frequency	Outcome Measures	Results	Conclusion
Fisher et al. (2021)	35 obese adults	20-60 years	HIIT: 30s sprint/90s rest, 20 min; MICT: 60 min moderate intensity	4 sessions/week for 12 weeks	Body composition, cardiovascular function	MICT showed more substantial improvements in body composition and heart function than HIIT	MICT provided greater cardiovascular benefits and more significant body composition improvements
Adams et al. (2020)	55 obese adults	35-55 years	HIIT: 20s work/40s rest, 25 min; MICT: 45 min continuous at <u>moderate intensity</u>	3 sessions/week for 8 weeks	Fat mass, endurance, metabolic health	MICT produced more significant fat loss and endurance improvements	MICT was superior in reducing fat mass and enhancing endurance capacity in obese adults

MICT provides more consistent benefits in terms of fat loss, cardiovascular health, and endurance compared to HIIT for obese adults. While HIIT may offer time efficiency, MICT appears to lead to more sustained improvements in overall health metrics, including weight loss, cardiovascular function, and metabolic health.

HIIT AND MICT WITH SIMILAR EFFECTIVENESS							
Study	Sample Size	Age Range	Exercise Protocol	Duration /Frequency	Outcome Measures	Results	Conclusion
Garcia et al. (2020)	50 obese adults	30-50 years	HIIT: 30s work/60s rest, 20 min; MICT: 45 min continuous at moderate intensity	3 sessions/week for 12 weeks	Body weight, body fat percentage, VO2max	Both groups showed similar reductions in body fat and improvements in VO2max	HIIT and MICT had comparable effects on body composition and fitness levels
Martinez et al. (2021)	45 obese adults	35-55 years	HIIT: 30s sprints, 30s rest, 20 min; MICT: 60 min moderate-intensity	4 sessions/week for 10 weeks	Blood pressure, glucose regulation, weight loss	No significant differences in blood pressure or glucose regulation between HIIT and MICT	HIIT and MICT led to similar improvements in metabolic health
Patel et al. (2022)	60 obese adults	25-45 years	HIIT: 20s work/40s rest, 25 min; MICT: 45 min continuous at moderate intensity	3 sessions/week for 8 weeks	Resting heart rate, cardiovascular endurance	Both protocols showed similar reductions in resting heart rate and improvements in endurance	HIIT and MICT provide equal benefits for cardiovascular health

HIIT AND MICT WITH SIMILAR EFFECTIVENESS

Study	Sample Size	Age Range	Exercise Protocol	Duration /Frequency	Outcome Measures	Results	Conclusion
Lee et al. (2023)	40 obese adults	30-50 years	HIIT: 20s work/40s rest, 20 min; MICT: 50 min moderate intensity	5 sessions/week for 12 weeks	Fat mass, aerobic capacity, weight loss	No significant differences in fat loss or aerobic capacity between HIIT and MICT	HIIT and MICT resulted in similar fat loss and fitness improvements
Robinson & Smith (2019)	55 obese adults	28-55 years	HIIT: 30s work/90s rest, 20 min; MICT: 40-60 min continuous	3 sessions/week for 6 weeks	Body composition, cholesterol levels, metabolic rate	Both HIIT and MICT showed similar reductions in cholesterol and improvements in metabolic rate	HIIT and MICT had comparable effects on body composition and metabolic health
Carter et al. (2020)	50 obese adults	35-60 years	HIIT: 1 min work/2 min rest, 25 min; MICT: 45 min at 60% HRmax	4 sessions/week for 10 weeks	Weight reduction, insulin sensitivity, blood lipids	Both exercise protocols resulted in similar reductions in body weight and improved insulin sensitivity	HIIT and MICT produce similar effects on weight loss and metabolic health in obese adults

HIIT and MICT led to similar results in terms of body composition improvement cardiovascular health, and metabolic improvements Both exercise protocols provided comparable benefits, indicating that either form of exercise could be effective in managing obesity.

CHAPTER 3

METHODOLOGY

3.1 Introduction of Study

This study synthesis existing evidence on the comparative effectiveness of exercises approach in obesity management, systematic review involved identifying, screening, and evaluating primary studies that investigated the effects of exercise on improvement of cardiorespiratory fitness, and body composition. Plus, meta- analysis with integrated data from eligible studies calculated pooled effect sizes, providing a quantitative summary of the intervention outcome. The inclusion and exclusion criteria for this systematic review and meta-analysis were structured using the Population, Intervention, Comparison, and Outcome (PICO) framework to ensure the selection of relevant and high-quality studies.

The included studies specifically focused on studies involving adults aged 18 to 60 years, diagnosed with obesity as defined by a body mass index (BMI) of 30 kg/m² or greater. The interventions considered in this review were aerobic exercises, specifically HIIT and MICT. The studies considered for inclusion were either Randomized Controlled Trials (RCTs) or non-randomized studies. Included studies only English manuscripts with a publication date from 2010 to 2024 to ensure the inclusion of contemporary evidence. Studies included only involved aerobic exercises with at least 4 weeks of intervention. Studies with diet control were excluded as this study will only check the effectiveness of aerobics exercises only without any diet intervention. This study involved the analysis of previously published data ethical approval was not required. However, all efforts were made to adhere to ethical guidelines for research integrity and transparency.

3.2 Methodology of Study

The electronic databases of PubMed, MEDLINE, Cochrane, SCOPUS, Web of Science and Science Direct were searched. Enlisted publications in the databases were searched up to by two different assessors, with a third assessor deciding to resolve any disagreements. A search strategy was developed and reviewed by all authors. The search

term constructed involved a list of synonyms of the word to expand the search. The appropriate search term notation was used, as outlined in Table 3.1.

Next, the search technique that used operators to combine keywords and phrases to narrow or broaden search results was generated (BOOLEAN). This search method helped researchers associate operators such as AND, NOT, and OR with keywords. Also, truncation represented a different ending to the root of keywords using a symbol in the search. Please refer to Table 3.1. Next, forward searching involves looking for studies that have cited a specific study after it was published. This helps find more recent research that has built on the original study findings. Meanwhile, snowball sampling or backward searching involves checking the reference lists of the selected studies is conducted by authors to find earlier research that the authors cited. This method helps identify important studies that were conducted before the current studies being reviewed.

The studies were screened by the authors based on predefined inclusion and exclusion criteria. This process involved reviewing the titles, abstracts, and full texts of the studies to determine their relevance to the research question. Only studies that meet the criteria were included in the final analysis. The reporting of this analysis used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), recognized as the standard method endorsed by organizations and journals in the health sciences. It consisted of a checklist and flow diagram. PRISMA demonstrated the review's quality, allowing the reader to assess its strengths and weaknesses, and structured and formatted the review using PRISMA headings. Please refer to figure 3.1. This study was also registered in the International Prospective Register of Systematic Reviews (PROSPERO) and the World Health Organization (WHO) Registry Network: UMIN-CTR registry prior to the commencement of the literature search with registration number CRD42021225703.

3.3 Search Strategy

Table 3.1
Search Strategy

Search Engine and Journal Database	Combination terms
SCOPUS	#1 Obese OR Obesity OR Unhealthy weight OR high BMI OR excess fat
Web of Science	#2 Continuous training OR Moderate intensity continuous training OR MICT OR CONT #3 Search #1 AND #2 #4 High-intensity interval training OR HIIT OR high–intensity training exercise OR high-intensity workout #5 Search #3 AND #4 #6 Cardiorespiratory fitness OR Cardiorespiratory capacity physical fitness OR aerobic fitness #7 Search #5 AND #6 #8 Body composition OR anthropometric OR body composition measurement OR body composition analysis OR body composition testing #9 Search #7 AND #8 #10 Quality of life OR well-being OR well-being OR HRQL #11 Search #9 AND #10
Science Direct	
Cochrane PUBMED	
MEDLINE	

3.4 Study Selection

Table below shows the inclusion and exclusion criteria used to select eligible studies for inclusion in the analysis.

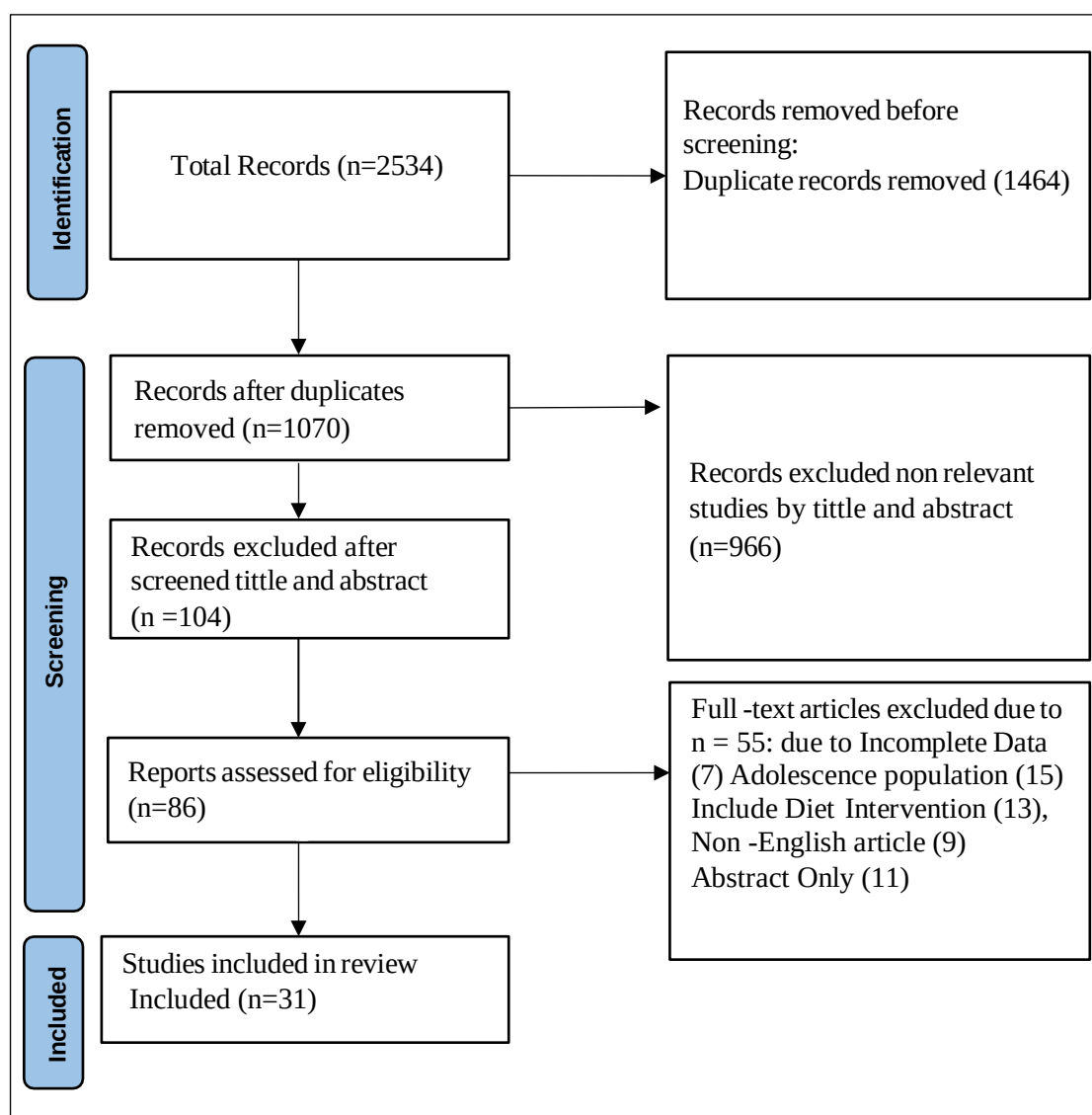


Figure 3.1 PRISMA Flow Diagram

3.5 Assessment of Study Quality

This study assessed study quality using the tool for assessment of study quality and reporting in exercise (TESTEX). This tool consists of a 15-point scale (5 points for study quality and 10 points for reporting). The TESTEX scale is an exercise science-specific scale, designed for use by exercise specialist to assess the quality of RCTs of exercise training in clinical populations (Smart, N. A., Waldron, Ismail, Giallauria, Vigorito, Cornelissen, & Dieberg, 2015).

Table 3.2
Testex Scoring Table

Author and Year	Study qualities						Study reporting										Overall	
	1	2	3	4	5	Sum	6	7	8	9	10	11	12	13	14	15	Sum	Total
Abadi 2017	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	6/10	10/15
Abdelbasset 2020	Yes	Yes	No	Yes	No	3/5	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	7/10	10/15
Arad 2015	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	8/10	12/15
Arslan 2011	Yes	Yes	No	Yes	No	3/5	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	7/10	10/15
Ashraf Amini 2020	Yes	Yes	No	Yes	Yes	4/5	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	7/10	11/15
Azadapour 2016	Yes	Yes	No	Yes	No	3/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	9/10	12/15
Baria 2014	Yes	Yes	No	Yes	No	3/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	9/10	12/15
Benham 2021	Yes	Yes	No	Yes	Yes	4/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	9/10	13/15
Chang 2016	Yes	Yes	No	Yes	Yes	4/5	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	8/10	12/15
Blond 2019	Yes	Yes	Yes	No	Yes	4/5	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	8/10	12/15
Chiu 2017	Yes	Yes	Yes	Yes	Yes	5/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	8/10	13/15
Cheema 2015	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	8/10	12/15

Author and Year	Study qualities						Study reporting										Overall	
	1	2	3	4	5	Sum	6	7	8	9	10	11	12	13	14	15	Sum	Total
Dejan 2021	Yes	Yes	Yes	No	Yes	4/5	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	8/10	12/15
Eizadi 2018	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8/10	12/15
Gerosa Neto 2019	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9/10	13/15
Irving 2009	Yes	Yes	Yes	Yes	No	4/5	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8/10	12/15
Irwin 2008	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	8/10	12/15
Hazar 2021	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	8/10	12/15
Hovsepian 2021	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	8/10	12/15
Hu 2021	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	8/10	12/15
Hallsworth 2015	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	9/10	13/15
Sabag 2020	Yes	Yes	No	Yes	Yes	4/5	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	8/10	12/15
Sawyer 2016	Yes	Yes	No	Yes	Yes	4/5	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8/10	12/15
Slentz 2005	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8/10	12/15
Sullivan 2015	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	8/10	12/15
Svenson 2017	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	8/10	12/15
Shi 2022	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	9/10	13/15
Tong 2018	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	8/10	12/15
Poon 2021	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	9/10	13/15
Win 2018	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	8/10	12/15
Zhang 2017	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	8/10	12/15
Zapata Lamana 2018	Yes	Yes	Yes	Yes	No	4/5	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	9/10	13/15

The TESTEX scale is an exercise science-specific scale, designed for use by exercise specialist to assess the quality of RCTs of exercise training in clinical populations (Smart, N. A., Waldron, Ismail, Giallauria, Vigorito, Cornelissen, & Dieberg, 2015).

The study quality scores ranged from 3 to 5, with most studies scoring between 3 and 4 out of 5. The average score for study quality was approximately 4, indicating that the majority of studies met acceptable standards for methodological rigor. A high number of studies were rated positively on the quality of their design and execution, contributing to the overall robustness of the evidence in this meta-analysis. Meanwhile for study reporting scores ranged from 6 to 9 out of 10, with a substantial proportion of studies achieving scores of 7 or higher. The average score for study reporting was about 8, suggesting that most studies provided clear, detailed, and transparent reporting. This is a positive indicator, as comprehensive reporting of study methods and results enhances the credibility and reproducibility of the findings.

The overall scores for the studies, which combine both study quality and reporting, ranged from 10 to 15. The average overall score was approximately 12, highlighting the overall high quality of the studies reviewed. These scores reflect that, on average, the studies included in this meta-analysis were both methodologically sound and well-reported. The evaluation of study quality and reporting shows a high standard across the studies included in this meta-analysis. The combination of solid methodological practices and detailed reporting ensures that the results of this analysis are both reliable and valid. The studies included in this review were generally of high quality, making their findings robust for inclusion in the final analysis.

3.6 Statistical Analysis

This study employed Review Manager 5 (Rev Man), a software developed by Cochrane, to conduct a meta-analysis evaluating the effects of various interventions. Rev Man is a widely recognized tool for synthesizing data from multiple studies and providing a pooled estimate of the intervention's effect. The analysis commenced with a clear formulation of the research question, followed by a comprehensive literature search to identify relevant studies. Studies were subsequently screened for eligibility based on predefined inclusion criteria. Data related to key outcome measures and participant characteristics were systematically extracted. Mean Difference (MD) was used as the effect measure to compare outcomes across treatment group. For data synthesis, the Random-Effects Model was applied within Rev Man. This model assumes that true effect sizes vary

across studies due to differences in study design, participant populations, and intervention protocols. By utilizing the random-effects model, the analysis accounted for this heterogeneity and allowed for generalization of the findings, despite the variability across studies. Heterogeneity was evaluated using the I^2 statistic, which is calculated directly in Rev Man.

The I^2 statistic measures the percentage of variation in the results across studies that is attributable to true differences rather than random error. Based on the I^2 value, heterogeneity was classified as low ($I^2 < 25\%$), moderate (I^2 between 25% and 50%), or high ($I^2 > 75\%$). This categorization helped to assess the degree of variability between study results and informed further analytical decisions.

Table 3.3
Interpretation of Statistical Heterogeneity

I^2 Value	Interpretation
$I^2 < 25\%$	Suggests that the variability across studies is small. A fixed-effect model may be appropriate for synthesizing the data.
I^2 between 25% and 50%	Indicates moderate heterogeneity, suggesting some differences across studies. Pooling the data may still be valid under a random-effects model.
$I^2 > 75\%$	Indicates substantial heterogeneity, suggesting that the studies are too different to combine meaningfully. Further investigation is suggested (e.g., subgroup analysis, exploration of outliers, or sensitivity analysis).

Next, forest Plots generated by Rev Man were utilized to visually represent the results of the meta-analysis. These plots display the effect sizes of individual studies along with their respective confidence intervals, providing a comprehensive view of the variation in effects across studies. Additionally, a pooled effect size is calculated, offering an overall estimate of the intervention effectiveness. The forest plots also allow for the assessment of the contribution of each individual study to the pooled effect size, facilitating an understanding of the relative weight of each study in the overall analysis. Next, to assess the potential for publication bias, funnel plots were employed to illustrate the distribution of effect sizes across studies, with larger studies positioned towards the top and smaller

studies placed towards the bottom. A symmetrical funnel plot suggests no apparent publication bias, as it indicates that studies of varying sizes display a similar range of results. However, asymmetry in the funnel plot may suggest the presence of publication bias, as it could indicate that studies with larger, statistically significant, or positive results are more likely to be published.

Finally, subgroup analyses were conducted within RevMan to explore whether different factors, such as the type of exercise (e.g., High-Intensity Interval Training (HIIT) vs. Moderate-Intensity Continuous Training (MICT)), influenced the effectiveness of the interventions. This analysis allowed for a deeper examination of the treatment effects in specific subgroups, yielding more tailored and specific conclusions based on variations in the interventions used.

Table 3.4
Rev Man Software Keyfeatures

Rev Man software key feature	
Statistical Analysis	Provides options for calculating effect sizes such as Mean Difference (MD) or Standardized Mean Difference (SMD).
Pooled Effect Size	Computes the weighted average of effect sizes across studies, providing a summary of the intervention's effectiveness.
Heterogeneity Assessment	Calculates the I^2 statistic, which quantifies the variation in results across studies, classifying heterogeneity as low, moderate, or high.
Forest Plots	Generates visual representations of individual study effect sizes and their confidence intervals, and pooled effect size.
Funnel Plots	Assists in publication bias check by displaying the distribution of effect sizes across studies
Subgroup and Sensitivity Analyses	Facilitates subgroup analyses and sensitivity analyses to test the robustness of the results.
Reporting and Exporting Results	Provide generation of detailed reports and export of results, including statistical summaries, figures, tables, and study flow diagrams.

RevMan software offers a statistical models and tools for meta-analyses, making it suitable for this research study. RevMan software enables transparent data analysis, which is essential for the reproducibility of research findings.

CHAPTER 4

RESULTS & DISCUSSION STUDY 1:

EFFECTIVENESS OF AEROBICS EXERCISES VERSUS

CONTROL GROUP IN CARDIORESPIRATORY

FITNESS AND BODY COMPOSITION AMONG OBESE:

A SYSTEMATIC REVIEW AND META- ANALYSIS

4.1 Introduction of Study

In chapter 4 presents the findings of the systematic review on the effects of exercise interventions among individuals with obesity. The primary focus of this review is the direct comparison between high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in relation to cardiorespiratory fitness and body composition outcomes. Although some of the included studies also incorporated non-exercise control groups, these groups were considered supplementary comparators only. Therefore, the synthesis and interpretation presented in this chapter are based primarily on the comparative effects of HIIT and MICT, in line with the scope, research objectives, and hypotheses of the study.

Aerobic exercise, which includes physical activities that engage large muscle groups and elevate heart rate and breathing, is widely recognized as a key component in managing obesity and improving overall health. It encompasses a variety of activities, such as running, cycling, swimming, walking, and dancing, which are known for their ability to improve cardiovascular fitness (CRF), burn calories, and improve the body composition components. These exercises have been shown to positively affect several obesity-related metrics, including body fat percentage (PBF), visceral fat (VF), waist circumference (WC), and body mass index (BMI).

Aerobic exercise is widely recognized as a suitable and safe form of physical activity for individuals with obesity due to its low-impact nature, accessibility, and well-documented health benefits. The ability of aerobic exercise to enhance cardiovascular fitness (CRF), reduce body fat, and improve overall health outcomes makes it an ideal

choice for obesity management. The aim of this chapter is to provide a comprehensive synthesis of the available evidence by evaluating the effectiveness of aerobic exercise versus control groups in improving cardiorespiratory fitness and obesity-related parameters. This chapter provide meta-analysis synthesizing the data from several studies, aiming to provide a more robust and comprehensive estimate of the effect of aerobic exercise on these key health indicators. Additionally, this analysis seeks to assess whether aerobic exercise significantly improves cardiorespiratory fitness and adiposity health parameter which include body mass index, body fat percentage, waist circumferences and visceral fat.

Chapter four of this thesis synthesizing data from multiple studies, and expect to provide insights into the practical application of aerobic exercise interventions for obesity management through the use of forest and funnel plots, this analysis aims to explore the heterogeneity of results, assess potential publication bias, and draw meaningful conclusions regarding the overall effectiveness of aerobic exercise. This chapter seeks to provide clarity by evaluating the strength of the evidence and the magnitude of the effects across various studies, this analysis will offer evidence-based recommendations for health practitioners to incorporate aerobic exercise into treatment plans for obesity. The results from this chapter expected to highlight areas for future research, focusing on how to optimize exercise protocols and address barriers to long-term adherence to exercise interventions in individuals with obesity.

4.2 Description of Included studies Training Protocol

Table 4.1

Table Summarizing the Intervention Protocols and Main Outcomes on Aerobics Exercises versus Control among Obese Adults

Authors Years	n	Exercise modality	Duration (week)	Sessions	Training protocol
Abadi et al (2017)	33	Cycling	12	5	MICT: Aqua aerobic exercise at 60-75% HRmax for 60 minutes CON: No exercises
Abdelbasset et al (2020)	47	Running	8	3	HIIT: 3 sets of 4-minutes cycling sessions at 80% - 85% HR max with minutes interval at 50% MICT: cycling ergometer with continuous intensity at 60%-70% HRmax CON: No exercises
Arad et al (2015)	30	Cycling	4	3	HIIT: Session began with 6 min of warm- up cycling at 50% HRR after which four work intervals (30–60 Sec 75–90% HRR) were performed with recovery intervals (180–210 sec at 50% HRR) CON: No exercises
Arslan et al (2011)	30	Step Aerobics	8	4	MICT: Initial 4 weeks, 30 minutes of aerobic dancing, for the following 4 weeks step aerobics was added to the aerobic dance movements, and the sessions were lengthened from 40 to 50 minutes. CON: No exercises
Ashraf Amini et al. (2020)	32	Running	6	3	MICT: first two weeks at %60-65 HRmax, weeks 3 and 4 at %65-70 HRmax, and the last 2 weeks at %70-75 HRmax CON: No Exercises

Authors Years	n	Exercise modality	Duration (week)	Sessions	Training protocol
Azadapour et al (2016)	23	Cycling	12	3	MICT: 1-2 weeks, walk or jogged on treadmill for 25 minutes at 50% of HRR. 3-4 weeks, increased to 30 minutes at 50-55% of HRR. 5-6 weeks, 35 minutes at 60% HRR Last 4 weeks, 40 minutes at 70% HR reserve. CON: No exercises
Baria et al. (2014)	27	Treadmill	12	4	MICT: The aerobic training was performed for 30 min with increment of 10 min in duration every 4 weeks during 12 weeks. CON: No exercises
Benham et al (2021)	30	Cycle Ergometer	26	3	HIIT: 10 cycles of 30 sec at high- intensity 90% HRR alternating with 90 sec of low- intensity aerobic exercise. MICT: 40 min of moderate- intensity aerobic exercise 50%–60% HRR CON: No exercises
Blond et al (2019)	129	Cycling	16	5	HIIT: 70% of VO_2^{max} MICT: 50% of VO_2^{max} CON: No exercises
Chiang et al (2019)	32	Walking	6	3	MICT: 40 min walk supervised, phone call and follow up CON: No exercises
Chiu et al (2017)	48	Cycling	12	3	LITG: 40%–50% heart rate reserve (HRR) MICT: 50%–70% HRR HIIT : 70%–80% HRR CON: No exercises

Authors Years	n	Exercise modality	Duration (week)	Sessions	Training protocol
Eizaidi et al (2018)	18	Cycling	12	3	MICT: The first two weeks at 60-65 % of HRmax, 3-4 week at 65-70% of HRmax, 5-6 week at 70-75 % of HRmax. CON: No Exercise
Cheema et al (2015)	35	Cycling	12	3	HIIT: 4 min of cycling at a work rate equivalent to 90% Peak VO2 CON: No exercises
Gerosa Neto et al (2019)	32	Treadmill	6	3	HIIT: 10×1:1min 90% PeakVO2 MICT:35min 65% Peak VO2 CON: No training
Irving et al (2009)	34	Cycling	16	3-5	HIIT: Intensity midway between the (RPE 15-17) MICT: An intensity at or below their RPE 10– 12). CON: No exercises
Irwin et al (2008)	173	Cycling	12	5	MICT: The target of 40% of maximal heart rate for 16 minutes per session and gradually increased to 60% to 75% of maximal heart rate for 45 minutes. CON: No exercises
Poon et al (2021)	42	Running Brisk walk	12	3	HIIT: 12 x 1-min bouts of running at 80-90% HRmax, with 1-min walking at 50% HRmax in between MICT: 40-min of brisk-walking at 65-70% HRmax CON: No specific exercise intervention
Slentz et al (2005)	23	Jogging Walking	6-9	3	HIIT: 65%–80% Peak VO2 MICT: 40%-55% Peak VO2 CON: No exercises
Sullivan et al (2012)	40	Walking	16	5	MICT: Walking on a treadmill for 15-30 minutes at a heart rate equivalent to 45-55% of their pre training $\dot{V}O_2$ peak, and progressively increased the duration of until 30-60 min. CON: No exercises

Authors Years	n	Exercise modality	Duration (week)	Sessions	Training protocol
Svenson et al (2017)	110	cycle ergometers, rowing treadmills,	16	3	HIIT: 85–95% of HRmax MICT: supervised 76–85% of HRmax. CON: No-exercise
Hazar et al (2021)	41	Step aerobics, pilates, walking running	8	3	MICT: 60-minute of aerobic exercise CON: No Exercises
Hallsworth et al (2015)	54	Cycle Ergometer	12	3	HIIT: 5 x 2-min to 3-min and 50 s at an RPE of 16–17 ('very hard') with 3-min recovery periods CON: No exercises
Hovsepian et al (2021)	30	Cycle Ergometer	10	4	HIIT: 40 Min, 4 × 4 min at 85–90% HRmax with an interspersed with 3 × 3 min recovery per round at 70% HRmax. CON: No exercises
Hu et al (2021)	21.5 ±1.7	Cycling	12	4	HIIT :4 min cycling at 90% VO ₂ ~ 60 min) MICT :5 min continuous cycling at 60% VO ₂ peak followed with 3 min recovery CON: No exercises
Sabag et al (2020)	56.9 ± 2.1	Cycle Ergometer	12	3	HIIT: 4-min at 90% VO ₂ max MICT: 40–55-min at 60% VO ₂ max CON: No exercises
Shi et al (2022)	20.86 ± 1.62	Running	8	3-4	HIIT: 80%-95% HRmax, circuit training MICT: 60%-70% HRmax, running CON: health education without exercise intervention.
Tong et al (2018)	23	Cycle Sprint	12	3-4	HIIT higher repeated 4 min bouts of cycling at 90% 'Peak VO ₂ alternated with 3 min rest CON: No exercise

Authors Years	n	Exercise modality	Duration (week)	Sessions	Training protocol
Win et al (2018)	41	Treadmill	4	4	HIIT: 4-min at 80% $\text{VO}^2_{\text{peak}}$ with 3-min active rest at 50% $\text{VO}^2_{\text{peak}}$ MICT: ~60-min at 55% $\text{VO}^2_{\text{peak}}$ CON: non-exercising
Zhang et al (2015)	35	Treadmill	12	4	HIIT: 4 x 4-minute running at 85–95% HR_{max} 10-minute recovery MICT: 33-minute running at 60–70% HR_{max} CON: No Training
Zapata Lamana et al (2018)	23	Cycle ergometer	12	3	HIIT: 4 sets of 60 s cycling exercise at 90% VO^2_{max} , with 2 min of active recovery and 4 min. MICT: 45–50 min of cycling exercise at a constant 70–80 rpm) CON: No exercises

4.3 Results of Study

4.3.1 Effectiveness of Aerobic Exercises vs Control in improving Peak Oxygen Consumption

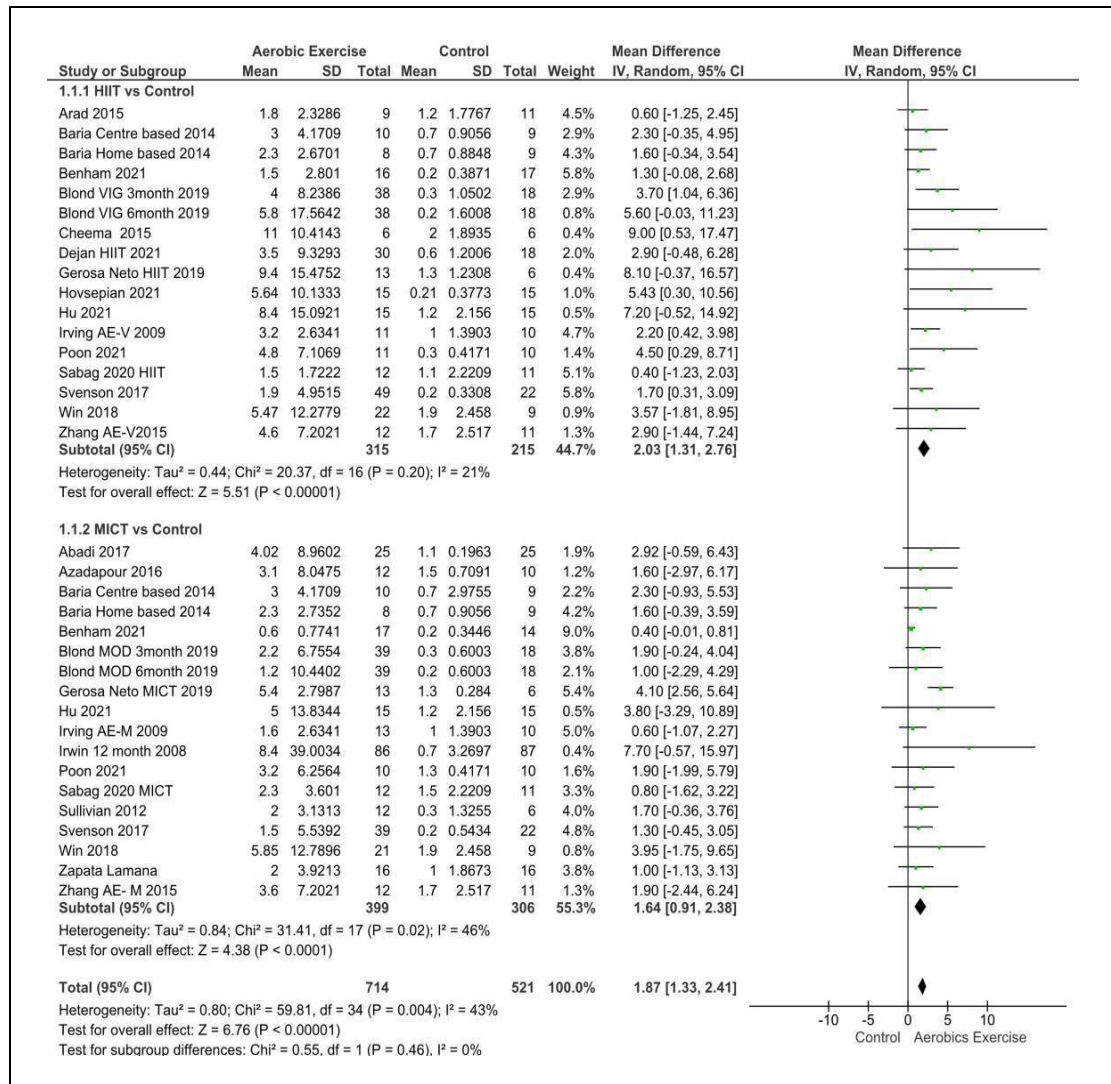


Figure 4.1 Changes in Cardiorespiratory Fitness between Aerobic Exercises vs Control

The pooled analysis of all included studies demonstrates a statistically significant positive effect of aerobic exercise on cardiorespiratory fitness in individuals with obesity when compared to control conditions. The overall mean difference was 1.87 (95% CI: 1.33 to 2.41), indicating that participants in the aerobic exercise groups achieved greater improvements in cardiorespiratory fitness than those in the control

groups. As the confidence interval does not cross zero, this confirms the reliability and statistical significance of the observed effect.

Furthermore, the overall test for effect was highly significant ($Z = 6.76$, $p < 0.00001$), reinforcing the strength of this finding. In terms of consistency across studies, the level of heterogeneity was moderate ($I^2 = 43\%$), suggesting some variability in effect sizes, potentially due to differences in intervention protocols, participant characteristics, or study designs. Nevertheless, the direction of effect consistently favors aerobic exercise, as reflected by the majority of studies positioned on the positive side of the forest plot. This findings provide evidence that aerobic exercise is effective in improving cardiorespiratory fitness among individuals with obesity, supporting its role as a key intervention in this population.

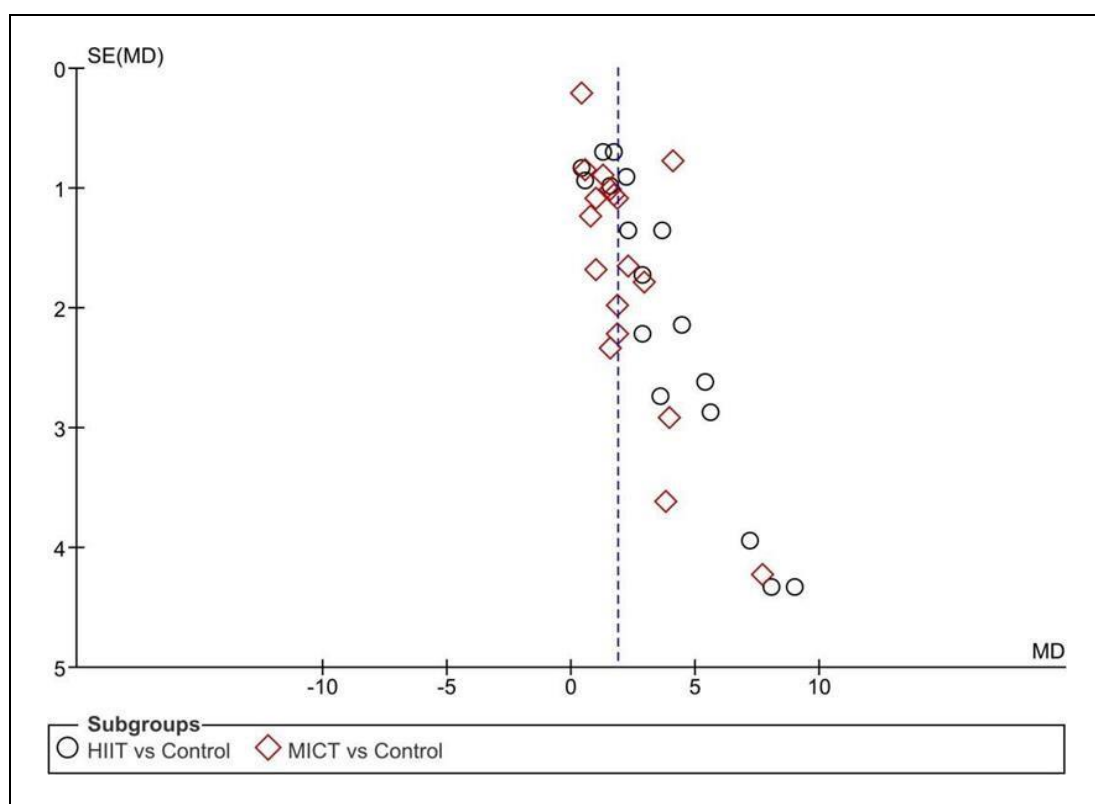


Figure 4.2 Funnel Plot of Cardiorespiratory Fitness between Aerobic Exercises versus Control

The funnel plot assessing aerobic exercise versus control demonstrates slight asymmetry, suggesting the potential presence of publication bias. A greater concentration of studies is observed on the positive side of the pooled effect, with fewer studies reporting null or negative outcomes. Additionally, smaller studies appear more

widely dispersed and tend to report larger effect sizes, indicating possible small-study effects. These patterns suggest that the overall effect of aerobic exercise on cardiorespiratory fitness may be modestly overestimated. Nonetheless, the clustering of larger, more precise studies around the pooled estimate provides some confidence in the robustness of the observed positive effect.

4.3.2 Changes of BMI between Aerobic Exercises versus Control

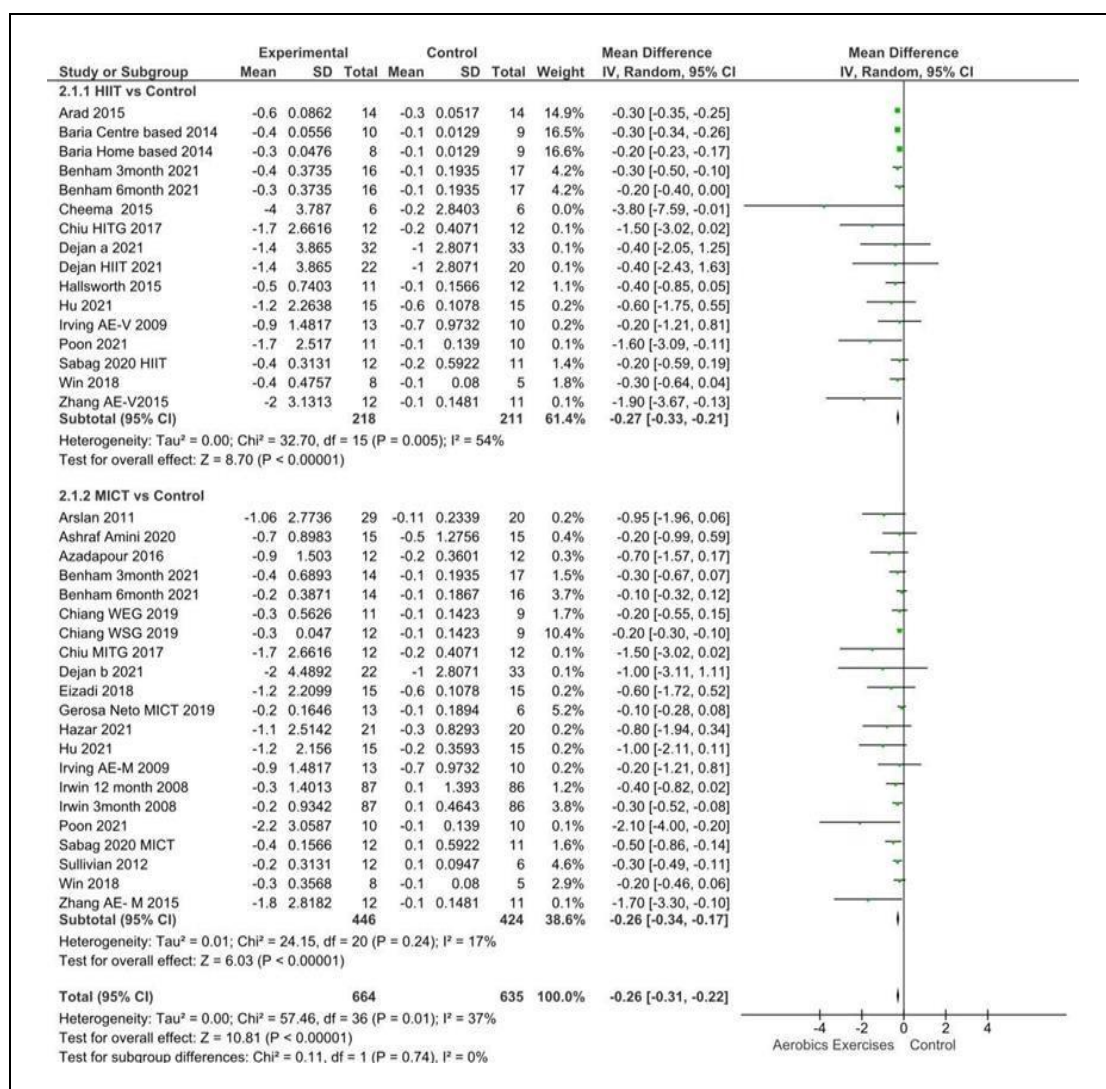


Figure 4.3 Forest Plot shows Changes in BMI between Aerobic Exercises vs Control

The forest plot illustrates the overall effect of aerobic exercise interventions, compared with control conditions, on body mass index (BMI) among obese adults. Based on the pooled analysis of all included studies, aerobic exercise is associated with a statistically significant reduction in BMI. Specifically, the overall mean difference was

−0.26 (95% CI: −0.31 to −0.22), indicating that individuals in the aerobic exercise groups experienced a modest decrease in BMI relative to those in the control groups. The confidence interval does not cross the line of no effect (zero), thereby confirming the statistical significance of this finding. This is further supported by the overall test for effect ($Z = 10.81$, $p < 0.00001$), which demonstrates a highly significant difference between groups. The level of heterogeneity was moderate ($I^2 = 37\%$), suggesting some inconsistency in effect sizes across the included studies. Such variability may be attributable to differences in intervention characteristics, including exercise intensity, duration, and frequency, as well as variations in participant demographics and study methodologies.

Nevertheless, the direction of effect is consistently in favour of aerobic exercise, with the majority of studies demonstrating reductions in BMI. This results indicates that aerobic exercise is effective in reducing BMI among obese adults. Although the magnitude of reduction is relatively small, the consistency and statistical significance of the findings support the inclusion of aerobic exercise as a key component in obesity management and intervention strategies.

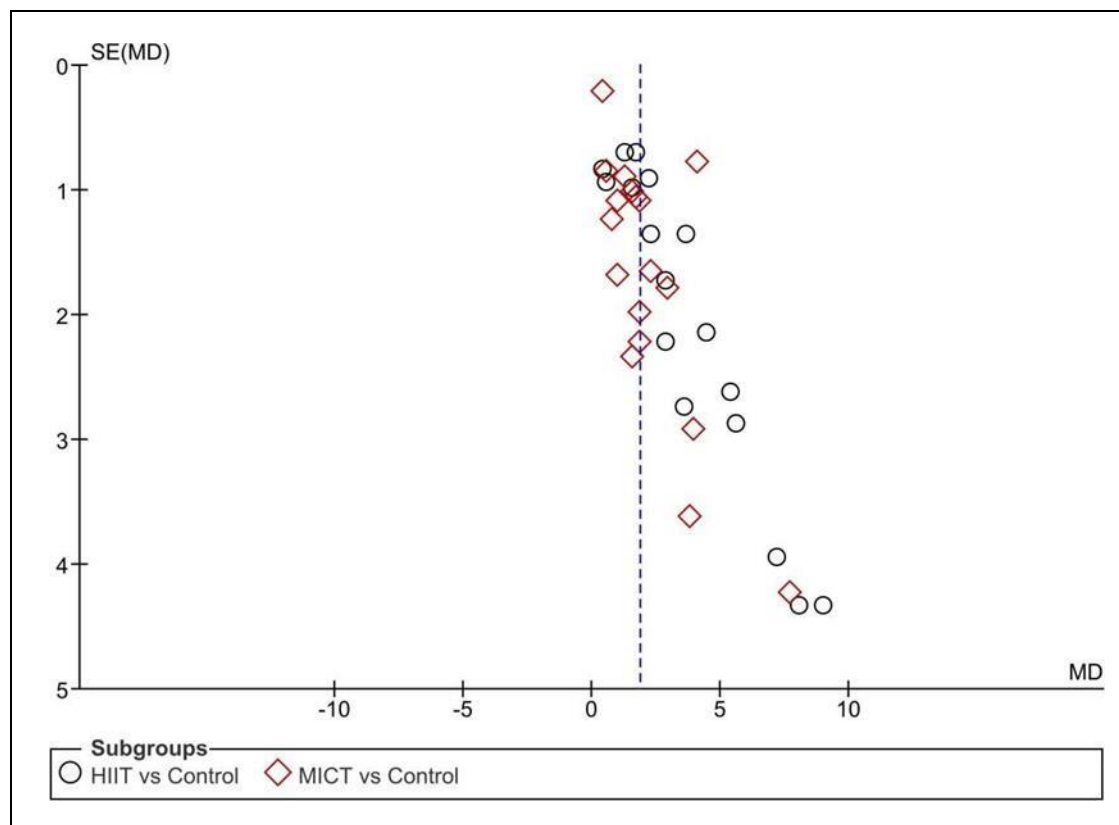


Figure 4.4 Funnel Plot of Body Mass Index on Aerobics Exercises versus Control

The funnel plot compares the effect of aerobic exercise versus control conditions on BMI reduction in obese adults. It shows that most studies are on the right side of the vertical line indicate aerobic exercise generally results in a positive effect on BMI reduction. However, the plot is not perfectly symmetrical, meaning there might be publication bias. Additionally, smaller studies, shown at the bottom of the plot, appear to report larger effects. This could indicate small-study effects, where smaller studies often exaggerate the results compared to larger studies.

4.3.3 Changes of Percentage Body Fat in Aerobic Exercises versus Control

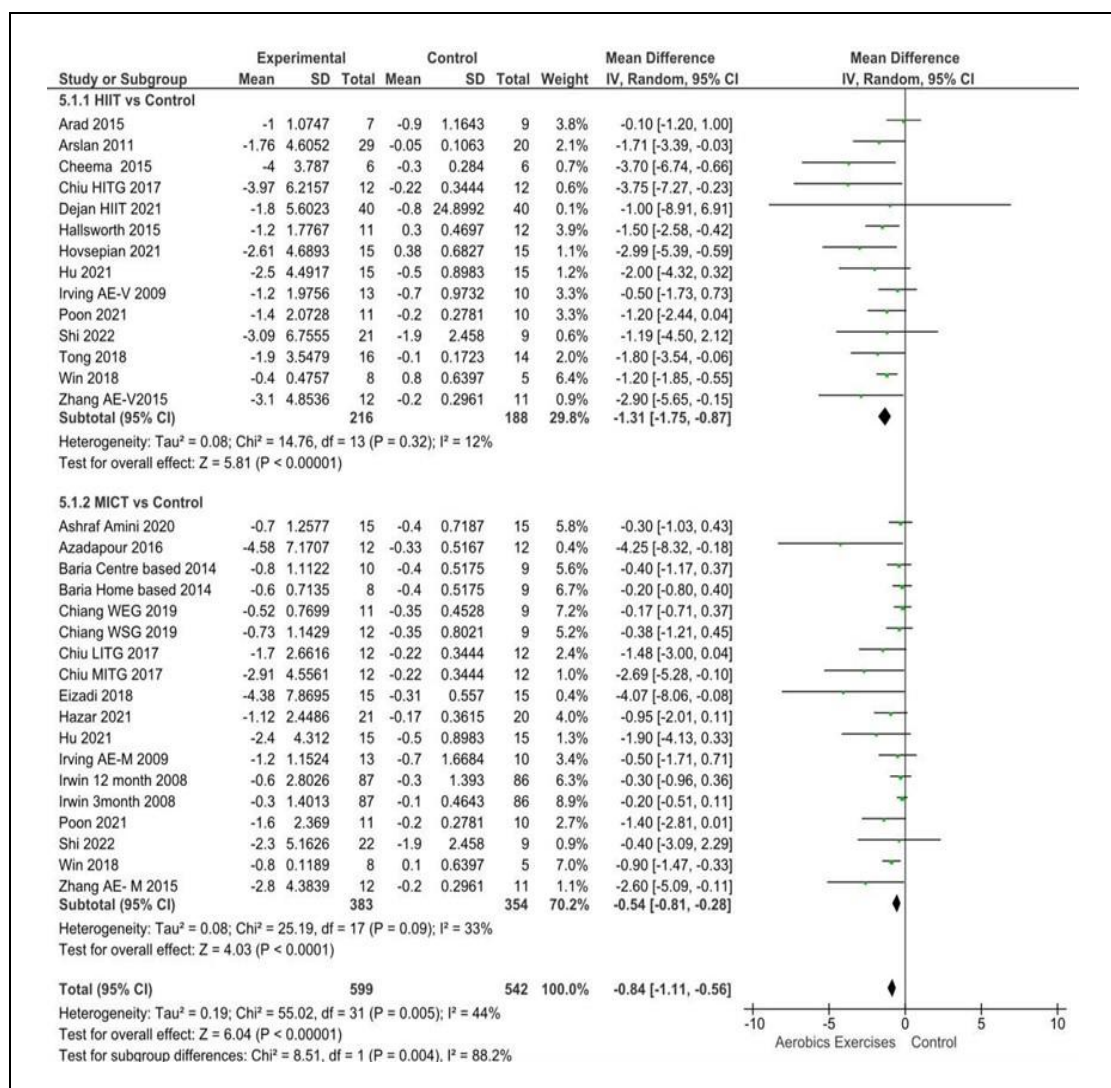


Figure 4.5 Forest Plot Changes of Percentage Body Fat in Aerobic Exercises vs Control

The forest plot evaluates the effect of aerobic exercise interventions compared to control conditions on the reduction of percentage body fat in individuals. The overall pooled mean difference (MD) was -0.84 (95% CI: -1.11 to -0.56), indicating that participants in the aerobic exercise groups experienced a significant reduction in body fat percentage compared to those in the control groups. The confidence interval does not include zero, confirming the statistical significance of this effect. The overall test for effect ($Z = 6.04$, $p < 0.0001$) further supports the reliability of this finding.

The overall heterogeneity across the studies was found to be $I^2 = 44\%$, suggesting moderate variability in the effect sizes. This indicates that while the effect of aerobic exercise on body fat reduction is generally consistent, there is some degree of variability across studies. Factors such as differences in exercise intensity, duration, frequency, and participant characteristics may contribute to this variability. Despite this, the overall trend consistently favors aerobic exercise, indicating its positive impact on reducing body fat percentage. The evidence supports that aerobic exercise is effective in reducing body fat percentage compared to control conditions.

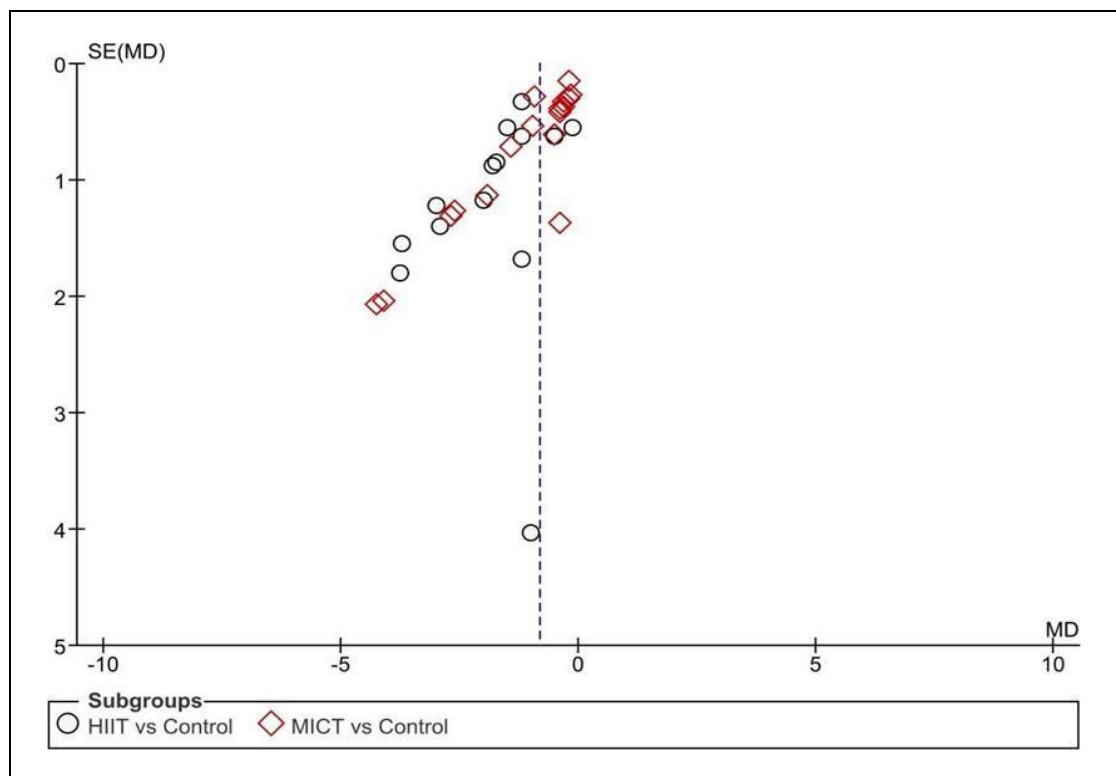


Figure 4.6 Funnel Plot shows the Percentage Body Fat between Aerobics Exercises versus Control

The funnel plot presented the effect of aerobic exercise interventions on the reduction of percentage body fat compared to control conditions. The plot shows a relatively symmetrical distribution of studies around the vertical dashed line, suggesting that aerobic exercise generally leads to a positive effect on body fat reduction. However, the plot also reveals greater dispersion among smaller studies, which often report larger effect sizes.

4.3.4 Changes in Waist Circumferences in Aerobic Exercises vs Control

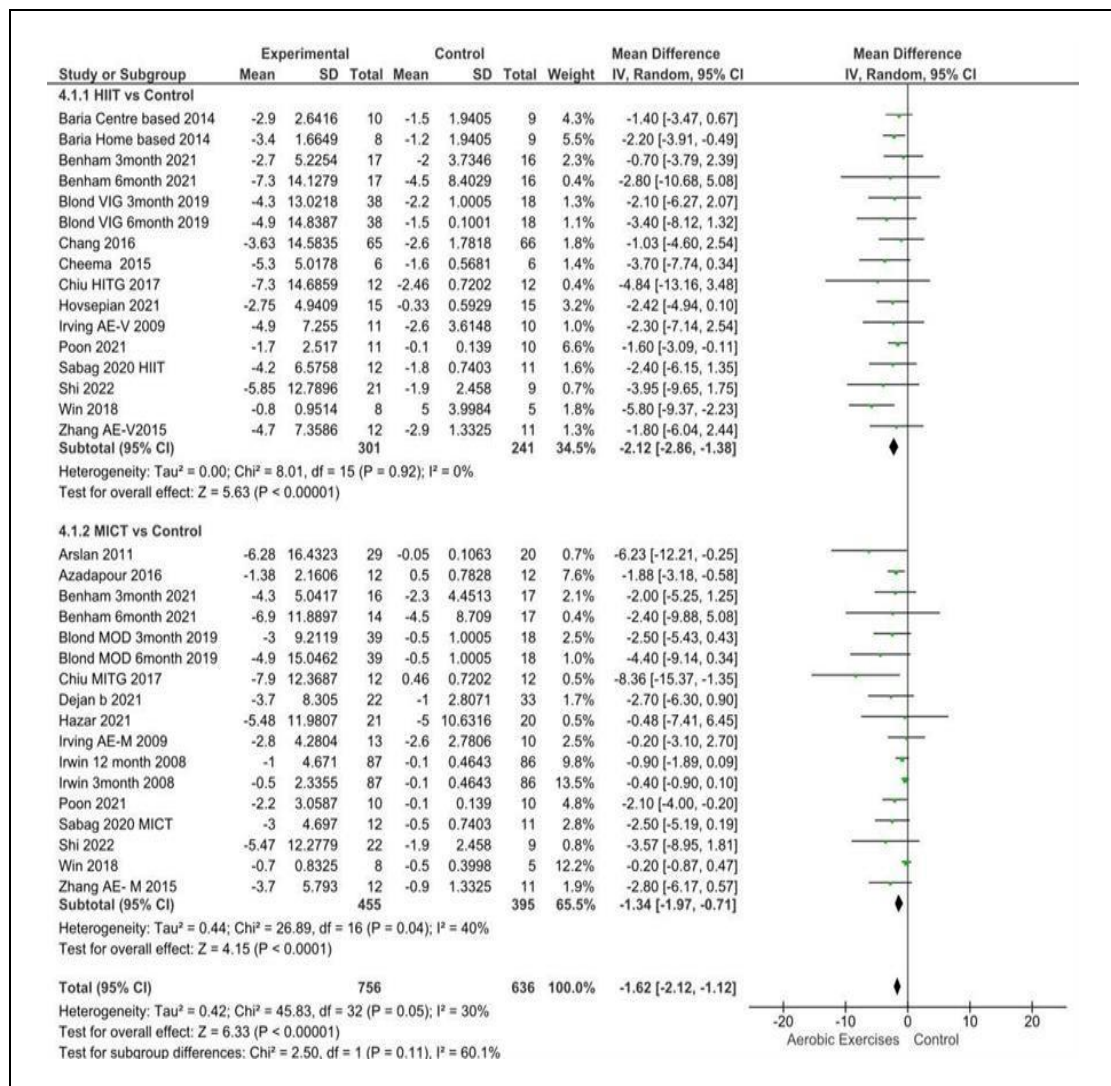


Figure 4.7 Forest Plot of Changes in Waist Circumference between Aerobics Exercises versus Control

The forest plot illustrates the effect of aerobic exercise interventions compared to control conditions on the reduction of waist circumference, with the overall pooled

mean difference (MD) being -1.62 (95% CI: -2.12 to -1.12), indicating a statistically significant reduction in waist circumference among adult living with obesity that engage in aerobic exercise. The confidence interval does not include zero, confirming the effectiveness of aerobic exercise in reducing waist circumference. The overall test for effect ($Z = 6.33$, $p < 0.00001$) further supports this conclusion. The overall heterogeneity was found to be $I^2 = 30\%$, suggesting moderate variability in the effect sizes across studies. This variability may be due to differences in exercise protocols. Despite the moderate heterogeneity, the evidence strongly supports the use of aerobic exercise as an effective intervention for reducing waist circumference.

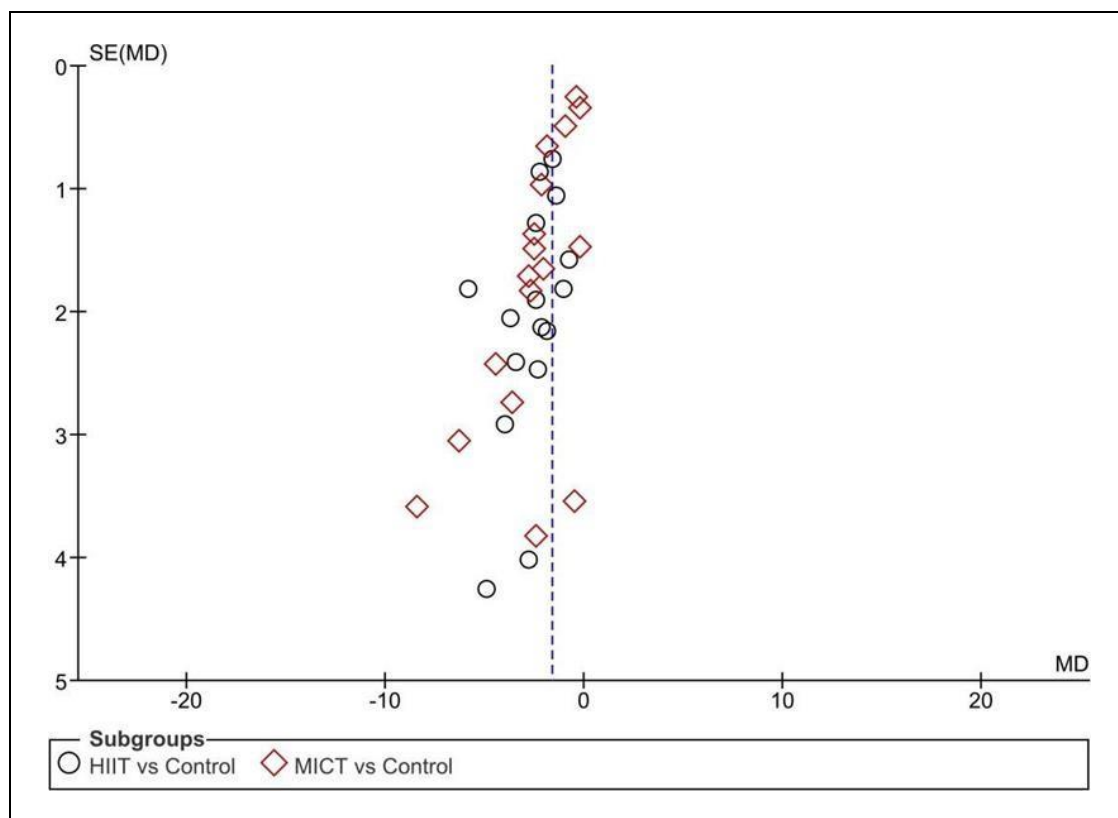


Figure 4.8 Funnel Plot Waist Circumference between Aerobics Exercises versus Control

The funnel plot presented effect of aerobic exercise interventions on the reduction of waist circumference compared to control groups. The plot reveals an asymmetrical distribution of studies, with a greater concentration of studies on the right side of the vertical dashed line, suggesting that aerobic exercise generally has a positive effect on waist circumference reduction. This asymmetry may indicate the presence of publication bias. The plot shows greater dispersion among smaller studies, particularly

those located at the bottom with higher standard errors. These studies exhibit a wider range of effect sizes, with some reporting larger positive effects. This pattern suggests the influence of small-study effects.

4.3.5 Changes in Visceral Fat in Aerobic Exercises vs Control

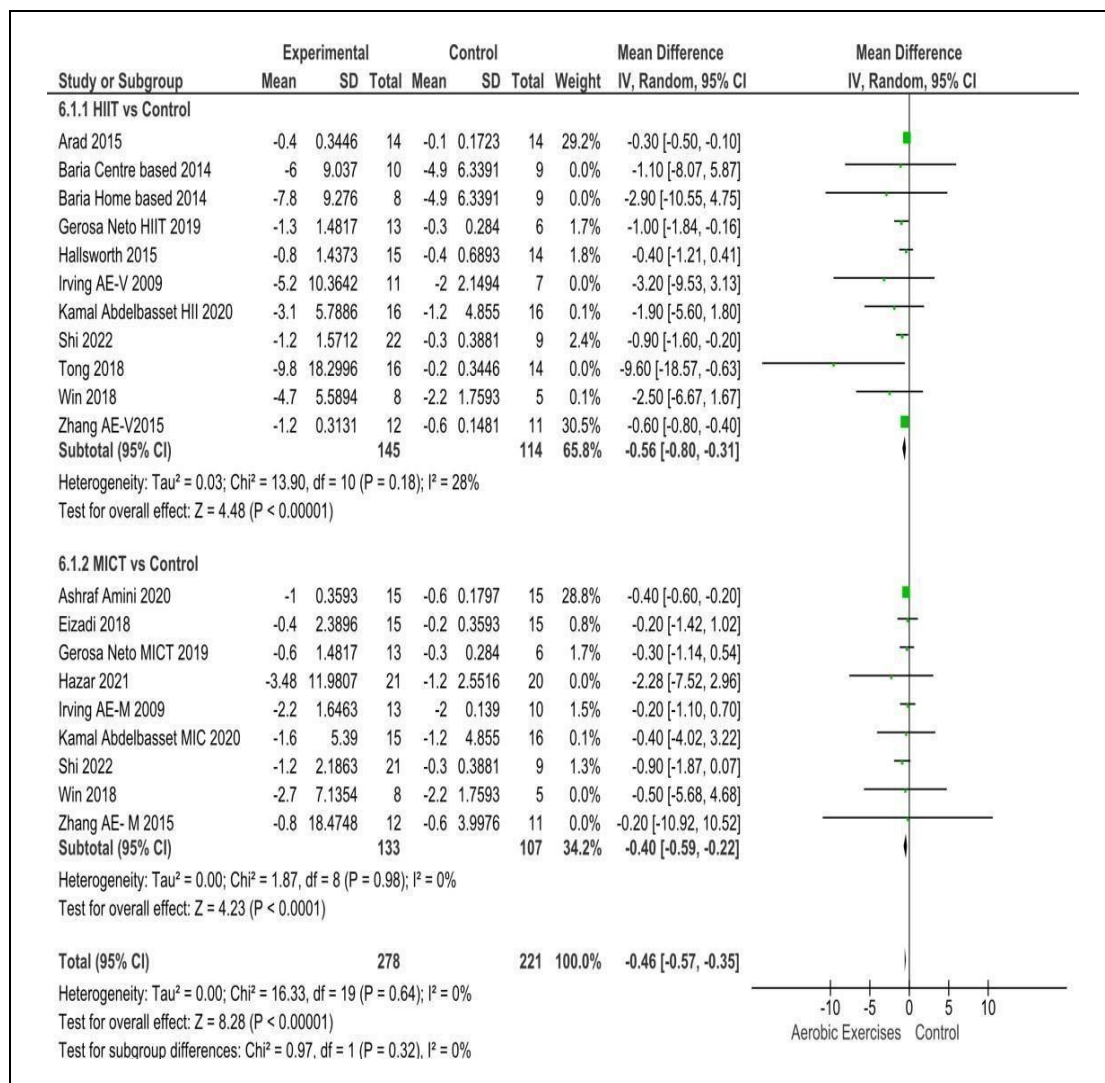


Figure 4.9 Forest Plot shows Changes of Visceral Fat in Aerobic Exercises vs Control

The forest plot presented evaluates the effect of aerobic exercise interventions on the reduction of visceral fat among obese individuals compared to control conditions. The pooled mean difference (MD) for all studies combined is -0.46 (95% CI: -0.57 to -0.35), indicating that aerobic exercise leads to a significant reduction in visceral fat. The confidence interval does not include zero, confirming that the observed effect is statistically significant. The overall test for effect ($Z = 8.28$, $p < 0.00001$) suggesting

that aerobic exercise is effective in reducing visceral fat among obese individuals. The overall heterogeneity for the studies included in this analysis is $I^2 = 0\%$, indicating low variability in the effect sizes.

This suggests that the results are consistent across studies, with all studies showing a similar magnitude of effect in reducing visceral fat. strongly supports that aerobic exercise is effective in reducing visceral fat in obese individuals compared to control conditions. The low heterogeneity indicates that the results are reliable and consistent, reinforcing the role of aerobic exercise in managing visceral fat reduction.

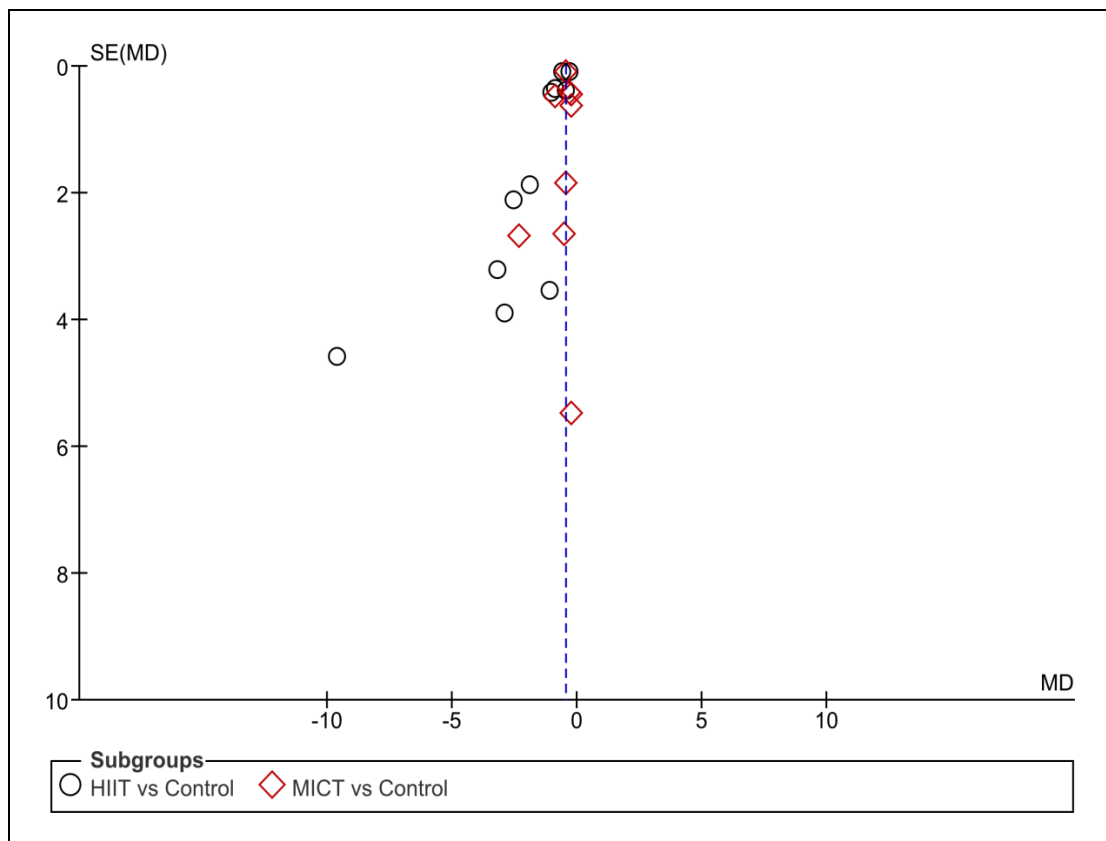


Figure 4.10 Funnel Plot of Visceral Fat on Aerobics Exercises versus Control

The funnel plot shows the effect of aerobic exercise compared to control conditions. Most studies are clustered on the right side of the vertical dashed line, indicating that aerobic exercise likely has a positive effect. However, the plot is asymmetrical, suggesting that there may be publication bias also the plot shows that smaller studies tend to have larger effect sizes, which suggests small-study effects.

4.4 Discussion of Studies

This meta-analysis provides evidence that aerobic exercise interventions are effective in improving several important health outcomes among adults with obesity when compared with control conditions. The pooled findings showed beneficial effects on cardiorespiratory fitness, body mass index, waist circumference, visceral fat, and percentage body fat, all of which are closely related to metabolic health and obesity-related risk. Collectively, these outcomes suggest that aerobic exercise is not only relevant for general weight management, but also for improving body composition and physiological function. At the same time, the interpretation of these findings should not rely solely on statistical significance, as the magnitude of effect, variability across studies, and the possibility of publication bias, as reflected in the funnel plots, remain important considerations in evaluating the overall strength of the evidence.

Despite these considerations, several methodological steps were taken in this meta-analysis to strengthen the reliability of the pooled results and reduce the risk of bias. A comprehensive search strategy was employed across multiple databases of omitting relevant studies and to reduce selection bias. In addition, only studies that met clearly defined inclusion criteria were retained, which helped ensure that the analysis was based on research of acceptable methodological quality. Nevertheless, variability across the included studies remained evident, particularly in relation to intervention characteristics such as exercise intensity. These differences are likely to have influenced the size of the pooled effects and may explain why some studies demonstrated stronger responses than others.

The pooled evidence for cardiorespiratory fitness indicates that aerobic exercise can substantially improve functional capacity in adults with obesity. This is an important finding because reduced cardiorespiratory fitness is strongly associated with poorer health status and increased cardiometabolic risk. However, the magnitude of improvement was not uniform across all studies, suggesting that the design of the exercise intervention plays a meaningful role in determining the extent of adaptation. The most pronounced statistically significant improvements in peak oxygen consumption were reported by Cheema et al., 2015, Gerosa Neto et al., 2019, and Hu et al., 2021. Among these, Cheema et al., 2015 showed the largest effect, with a mean difference of 9.00, followed by Gerosa Neto et al., 2019 with 8.10, and Hu et al., 2021 with 7.20. These studies differed in exercise modality, including boxing, treadmill-

based exercise, and cycling, which suggests that meaningful improvement in cardiorespiratory fitness can be achieved through various forms of aerobic training. This also implies that the effectiveness of aerobic exercise may depend less on a single mode of activity and more on the ability of the program to provide a sufficient and sustained cardiovascular stimulus.

Similarly, the findings for body mass index support the role of aerobic exercise as an effective component of obesity intervention program, although the observed changes should be interpreted with some caution. BMI is a broad anthropometric measure and does not distinguish between fat mass and lean mass, which means reductions in BMI may not fully capture the complexity of physiological changes occurring during exercise interventions. Even so, the pooled result still suggests that aerobic exercise contributes meaningfully to body weight management. The most substantial statistically significant reductions in BMI were reported by Cheema et al., 2015 and Poon et al., 2021. Cheema et al., 2015 demonstrated the largest reduction, with a mean difference of -3.80, whereas Poon et al., 2021 reported the second in reduction, of BMI with a mean difference of -2.10. These findings indicate that aerobic exercise interventions may produce greater reductions in BMI and support the effectiveness of treatment outcomes.

A similar pattern can be observed for percentage body fat, where aerobic exercise demonstrated a clear beneficial effect relative to the control group. Compared with BMI, percentage body fat provides a more direct indicator of adiposity, and therefore offers stronger insight into whether the intervention has meaningfully altered body composition. The most statistically significant reductions in percentage body fat were reported by Azadapour et al., 2016, Eizadi et al., 2018, and Chiu et al., 2017. Among these, Azadapour et al., 2016 reported the largest reduction, with a mean difference of -4.25, followed by Eizadi et al., 2018 with -4.07, and Chiu et al., 2017 with -3.75. These results suggest that aerobic exercise can be particularly effective in reducing adiposity when implemented in a structured and sustained manner. The stronger effects observed in some studies may reflect more favourable combinations of exercise intensity, program duration, and participant adherence.

The pooled findings also demonstrated that aerobic exercise is effective in reducing waist circumference, which is a particularly important outcome because it reflects central adiposity and is strongly associated with cardiometabolic risk. Reductions in waist circumference may therefore indicate not only a change in body

size, but also a clinically meaningful improvement in obesity-related health risk. The greatest statistically significant reductions in waist circumference were observed in Chiu et al., 2017 and Arslan et al., 2011. Chiu et al., 2017 reported the largest reduction, with a mean difference of -8.36, while Arslan et al., 2011 showed the second largest reduction, with a mean difference of -6.23. These findings further reinforce the broader pooled evidence by showing that aerobic exercise has the capacity to reduce abdominal fat accumulation, which is one of the most harmful characteristics of obesity from a metabolic perspective.

In addition, the pooled studies supported the effectiveness of aerobic exercise in reducing visceral fat among adults with obesity. This is one of the most important findings of the meta-analysis because visceral fat is more strongly associated with insulin resistance, inflammation, and cardiovascular disease than general body weight alone. A reduction in visceral fat therefore suggests a meaningful improvement in metabolic health rather than a merely cosmetic change. Among the included studies, the two most statistically significant reductions in visceral fat were reported by Shi et al., 2022 and Zhang et al., 2015. Shi et al., 2022 showed the largest reduction, with a mean difference of -0.90, followed by Zhang et al., 2015, with a mean difference of -0.60. These results provide further support for the overall pooled finding that aerobic exercise is effective in reducing harmful fat depots in obese adults, thereby strengthening its value as a practical intervention for long-term health improvement.

Overall, the findings of this meta-analysis suggest that aerobic exercise is a valuable and evidence-based strategy for improving both physiological fitness and body composition outcomes in adults with obesity. However, the findings also indicate that not all aerobic exercise interventions are equally effective, and that the magnitude of benefit may depend heavily on program characteristics such as intensity. This highlights the importance of moving beyond the simple conclusion that aerobic exercise is beneficial, towards a more critical understanding of which types of aerobic exercise prescription are most effective for specific obesity-related outcomes.

4.5 Summary of Study

Overall, the findings suggest that aerobic exercise is an effective strategy for tackling obesity among obese adults because it produces improvements across multiple health-related outcomes rather than affecting only one single measure. The pooled evidence showed that aerobic exercise helped improve cardiorespiratory fitness while also reducing body mass index, body fat percentage, waist circumference, and visceral fat, indicating benefits for both physical fitness and body composition. This is important because obesity is a complex condition linked not only to excess body weight, but also to poor metabolic health, central fat accumulation, and reduced functional capacity.

Therefore, the effectiveness of aerobic exercise should be understood in a broader sense, as it appears to address several obesity-related risks at the same time. Aerobic exercise is not merely helping individuals lose weight in a general sense, but is also contributing to improvements in body composition and health risk profile, which are critical in the long-term management of obesity. Although the size of the effect varied between studies, the overall pattern remained consistently in favour of aerobic exercise compared with control conditions, which strengthens the conclusion that aerobic exercise is a valuable and practical intervention for obesity management in adults.

CHAPTER 5

STUDY 2: EFFECT OF HIIT VS MICT ON CARDIORESPIRATORY FITNESS AND HEALTH PARAMETERS

5.1 Introduction of Studies

Obesity has become a major global public health concern due to its strong association with metabolic disorders, cardiovascular disease, reduced functional capacity, and diminished quality of life. In response to this growing burden, exercise-based interventions have been widely recommended as a fundamental component of obesity management. Among the various aerobic training strategies, high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) have received considerable attention for their capacity to improve cardiorespiratory and metabolic health in individuals with obesity. Although both modalities are supported by substantial evidence, their relative effectiveness and practical suitability remain subjects of ongoing scientific discussion.

HIIT is generally characterized by repeated bouts of vigorous or near-maximal exercise interspersed with periods of active or passive recovery, whereas MICT involves prolonged continuous exercise performed at a moderate and steady intensity. These two approaches differ markedly in physiological demands, training structure, and time commitment, which may influence both their effectiveness and their acceptability among obese individuals. HIIT has frequently been promoted as a time-efficient strategy capable of eliciting substantial improvements in cardiorespiratory fitness and body composition within shorter exercise durations. Conversely, MICT has traditionally been regarded as a more conventional and accessible form of exercise, particularly for individuals with lower baseline fitness, reduced exercise tolerance, or coexisting medical conditions.

Recent evidence from systematic reviews and meta-analyses suggests that HIIT may produce superior improvements in selected outcomes, particularly peak oxygen consumption VO_{2peak} , body mass index, body fat percentage, waist circumference, and visceral adiposity. In obese populations, the success of an exercise intervention depends

not only on its efficacy under controlled conditions, but also on its feasibility, safety, tolerability, and long-term adherence. The higher physiological demands of HIIT may limit its applicability in individuals with significant comorbidities, musculoskeletal limitations, or low motivational readiness. In contrast, MICT may offer a more sustainable and psychologically acceptable entry point for sedentary individuals, even if its physiological adaptations are sometimes less pronounced.

Accordingly, this study examines the comparative effects of HIIT and MICT on key health outcomes in obese individuals, with particular emphasis on cardiorespiratory fitness, body composition, and anthropometric parameters. By synthesizing evidence across multiple studies, this review seeks to critically evaluate the relative strengths and limitations of both exercise modalities and to clarify their clinical relevance in obesity intervention. The findings are expected to contribute to a more nuanced understanding of exercise prescription in this population and to support clinicians and exercise professionals in designing interventions that are both effective and sustainable.

Top of that, this chapter presents an overview of the studies included in the review in order to provide a preliminary understanding of the current evidence on the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) among individuals with obesity. The included studies were systematically identified, reviewed, and synthesized to examine the characteristics of the intervention protocols, including exercise modality, training frequency, training duration, and the results outcome. This chapter aims to highlight the overall research trends, areas of consistency and variation across the literature, and the comparative effectiveness of HIIT and MICT in improving cardiorespiratory fitness, body composition, and anthropometric outcomes

5.2 Description of Training Protocol of Included Studies

Table 5.1

Table Summarizing the **Intervention Protocols** and **Main Outcomes** on HIIT and MICT among Obese Adults

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Benjamin et al., 2020	12	Stationary bike, Treadmill, Rowing	4	10 × 1-minute intervals at 90% HRmax, 1-minute low-intensity active recovery between intervals	Stationary bike, Treadmill or elliptical	4	45 minutes of continuous aerobic exercise at 70% HRmax	HIIT and MICT induced similar improvements in cardiorespiratory fitness in obese adults. Both groups showed no changes in body composition
Blond et al., 2019	12	walking, running, rowing, stationary cycling	5	Vigorous intensity 80%-90% VO2 peak	walking, running, rowing stationary cycling	5	Moderate intensity at, 50% VO2peak	HIIT conferred more rapid effects on cardiorespiratory fitness than MICT

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Barry et al., 2018	2	Stationary bike treadmill outdoor walking, elliptical	5	HIIT: 1 min at ~90% HRmax with 1-min recovery	stationary bike treadmill outdoor walking, elliptical	3	MICT: 20–60 min of continuous exercise at 5% HRmax,	No significant differences observed for measures of body composition.
Cheema et al., 2015	12	Boxing	4	HIIT: 3 intervals - 2:1 (intense activity/rest). Total of 30 min at >75% HRmax.	Brisk walk	4	45 min (unsupervised).	HIIT and MICT had similar effects on body mass, fat mass, and abdominal circumference in abdominal obesity.
Cocks et al., 2014	4	Cycling	5	30 sec cycling 200%Wmax. 30 sec for recovery. 4 times interval	Cycling	5	40–60min cycling at 65% VO ₂ peak	HIIT proposed time efficient alternative to MICT.
D'amuri et al., 2021	12	Treadmill	3	3–7 × 3 minutes at 100% VO ₂ max with 1.5 min recovery at 50% VO ₂ max, 35 min	Treadmill	3	Continuous session at 60% of VO ₂ peak, 46.minutes per session	HIIT resulted in a greater increase Peak VO ₂ than MICT and more reduction in WC among male.

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Dupuit et al., 2020	12	Cycling	3	Warm-up: 5 min. HIIT: 60 min 8 s at 80–90% of HRmax	Cycling	3	Warm-up: 5 min. MICT: 40 min at 55–60% HRmax.	HIIT and MICT showed comparable effects on body weight, total fat mass, and hip circumference.
Evanglista et al., 2019	6	bodyweight exercise	3	20 sets of 30 seconds of all-out bodyweight and 30 seconds passive rest	Slow Running	3	20 minutes of continuous running at 80% of maximum heart rate	Both HIIT and MICT showed no significant changes in body Composition
Higgins et al., 2016	6	Cycling	3	30-second ‘all out’ sprints followed by 4 minutes of active recovery	Cycling	3	Continuous cycling at 60-70% HRR	SIT reduces adiposity and increases aerobic capacity more than MICT

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Hornbuckle et al., 2017	16	Treadmill	3	32 min of treadmill alternating 3 min at 60–70% of HRmax with 1 min at 80– 90% of HRmax	Treadmill	3	32 min continuous minutes of treadmill walking at 60–70% of HRR	HIIT was more effective at reducing waist circumference and increasing daily steps than SS treadmill exercise.
Garnier et al.,2018	12	Cycle ergometer	3	6 intervals x 1min that elicited 75 to 85% HRR, separated by 1min of recovery. 10 intervals in week 5-12	Cycle ergometer	3	15 min of continuous physical activity at 50 to 60 % HRR. Increase to 20 to 35 min in week 5- 12	HIIT or MICT led to similar body weight and fat mass losses, improve CRF and QOL

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Gripp et al , 2021	4	Outdoor running based on 20m shuttle test	3	85% -100% of HRmax shuttle run 15min- 20min	Outdoor running based on 20m shuttle test	3	60% - 75% of shuttle speed across weeks, 30–35 minutes	Both HIIT and MICT shows improvement in cardiorespiratory fitness. HIIT led to greater reductions in body fat percentage and visceral fat
Gerosa-Neto et al., 2019	6	Treadmill	3	Warm-up: 7 min. HIIT: 10 x 1 min at 85%-90% HRR interspersed with 1 min passive interval.	Treadmill	3	MICT: Continuous 50%-65% HRR of walking on treadmill	No significant difference between HIIT and MICT in body fat
Hesketh et al., 2021	12	Squat jumps, burpees, high knees, jumping jacks	3	1 min work + 1 min rest = 1 interval Each interval has 2 bodyweight exercises, Intensity: $\geq 80\%$ of HRmax.	Walking	3	Intensity: 50–70% of max heart rate (HRmax) Duration: Week 1: 45 min/week, Week 12: up to 135 min/week	Both Home-HIIT and MICT significantly improved VO ₂ Peak. MICT shows better results in body weight and BMI reduction.

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Hu et al., 2021	12	Cycling	3	HIIT: 4 min at 90% VO ₂ peak followed by 3 min recovery	Cycling	3	MICT: 65 min at 60% VO ₂ peak	HIIT and MICT had similar effects on body mass, BMI.
Irving et al., 2008	12	Cycling	5	HIIT: 4 intense intervals of 4 minutes with an intensity of 90% of HRR	Cycling	5	MICT: Walking continuously at 50%-60% HRR	HIIT were better at burning fat and improving body composition compared to MICT
Keating et al. 2014	12	Cycle ergometer	3	Weeks 1–4: 4–6 intervals Work: 30–45 sec at 120% VO ₂ peak Weeks 5–12: 6 intervals of 60 sec work	Cycle ergometer	3	Continuous cycling for 36–48 min Week 1: 30 min at 50% VO ₂ peak Week 2: 40 min at 60% VO ₂ peak Week 3–12: 45 min at 65% VO ₂ peak	Both HIIT and MICT increase the cardiovascular fitness. Somehow, MICT is more effective than HIIT for improving body fat distribution.

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Kong et al., 2016	5	Cycling	4	Warm-up: 3-min. HIIT: 60 repetitions: 8 s at ~90% of VO ₂ peak with 12 s of recovery for 20 min.	Cycling	4	MICT: 40 min at 60% VO ₂ peak.	HIIT and MICT had similar effects on body mass, BMI, and fat mass.
Lunt et al., 2014 (a)	12	Running Fast walk	3	30 sec all out exercises, 4min recovery for 3 times	Walking	3	33min walk which aimed to achieve a HR of 65–75% HR _{max}	Moderate improvements of cardiorespiratory fitness between both HIIT and MICT
Lunt et al., 2014 (b)	12	Fast Walk	3	HIIT: 4 min fast walking or jogging to achieve of 85–95% HR _{max} 4 times followed by 3 minutes recovery walk pace	Walking	3	33 minute walk which aimed to achieve a HR of 65–75% HR _{max}	HIIT shows better vo ₂ peak improvement. Both groups show similar improvements in waist circumference and body fat percentage

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Martins et al.,2016 (a)	12	Sprinting	3	Full HIIT: 85%–90% of their maximal HR, 8 sec of sprinting and 12 sec of recovery . 20–25 minutes per session	Cycling	3	MICT consisted of continuous cycling at 70% of HRmax	HIIT and MICT, offer a similar metabolic and cardiovascular protection
Martins et al., 2016 (b)	12	Sprinting	3	Half HIIT: 85%–90% of their maximal HR, 8 sec of sprinting and 12 sec of recovery. 10–12 minutes per session	Cycling	3	MICT consisted of continuous cycling at 70% of HRmax	HIIT and MICT led to similar improvements in cardiorespiratory fitness, body weight, waist, and fat-free mass among obese individuals
Nie et al, 2018	12	Cycling	3-4	4-minute cycling bouts at 90% Peak VO2	Cycling	3-4	Continuous cycling at 60% $\dot{V}O_{2peak}$	Both HIIT and MICT improved aerobic capacity $\dot{V}O_{2max}$ and body composition in the studies

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Petrack et al., 2020	6	Cycle ergometer	5	~170% of W _{peak} (very high) 4–6 x 30-sec “all-out” sprints with 2-min recovery	Cycle ergometer	3	Continuous cycling, ~60% of W _{peak} (moderate)	Both HIIT and MICT improve cardiovascular fitness. MICT significantly reduced total body fat
Poon et al., 2020	8	Running/walking	3	Warm-up: 5 min at 60% HR _{max} . HIIT: 6–10 series of 1 min at 80–90% of HR _{max} .	Jog/walk briskly	3	MICT: 30–50 min at 65–70% of HR _{max} . Cool-down: 5 min at 50% HR _{max} .	No differences in fat mass, BMI, and waist circumference between HIIT and MICT.
Ram et al., 2020	6	Cycle ergometer	3	10 × 1-minute intervals at ~90% HR _{max} , RPE ~15. 1-minute active recovery (15% of max workload) between intervals	Cycle ergometer	3	Continuous 30 minutes at 65–75% HR _{max} , RPE 11–13	Both HIIT and MICT led to similar improvements in VO ₂ max. However, neither HIIT or MICT caused any significant change in body composition,

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Robinson et al.,2015	2	Stationary cycling	5	4set of 10 × 1-minute intervals at 85–90% HRmax, 1-minute active recovery at 20% Wpeak. From 4 - 10 over 2 weeks	Cycle ergometer	5	20 -50 minutes at 60–65% HRmax. From 20 to 50 minutes over 2 weeks	Both HIIT and MICT led to improvements in cardiorespiratory fitness. Both groups experienced a small drop in weight and BMI.
Rodrigues et al.,2015	16	Treadmill/ Cycle ergometer	3	1:4 min high-intensity interval. 85–95% HRmax 4:4 min 85–95% HRmax. Active recovery: 3-minute intervals at 50–70% HRmax,16 minutes	Treadmill/ Cycle ergometer	5	30 minutes Intensity: 60–70% HRmax	MICT lead to modest reductions in body composition (BMI, WC), 4-HIIT group showed more improvements in cardiorespiratory fitness and body composition compared to 1-HIIT.

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Sabag et al., 2020	12	Cycle Ergometer	3	4-min at 90% VO ₂ peak	Cycle Ergometer	3	MICT: 40–55-min at 60% VO ₂ peak	Both HIIT and MICT have similar Vo ² max peak improvement. No significant change in BMI and WC in both group
Sawyer et al., 2016	8	Cycling	3	Warm-up: 5 min at 50–60%. HIIT: 10 ×1 min at 90–95% HRmax with 1 min recovery.	Cycling	3	MICT: 30 min at 70–75% HRmax. Cool-down: 5 min.	HIIT decreased waist circumference and body fat percentage more than MICT.
Scherjeve et al., 2008	12	Treadmill	3	4×4-min intervals at 85-95% of HRmax. 3-min active breaks between intervals at 50-60% of HRmax.	Treadmill	3	47 minutes of continuous walking at 60-70% of HRmax.	Both HIIT and MICT shows similar improvements in VO ₂ peak

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Scott et al., 2019 a	12	Body weight exercises.	3	≥80% of predicted HRmax. Weeks 1–4: 4 intervals increases by 1 interval every 2 weeks Maximum: 8 intervals	Walking, cycling, swimming	3	65% of predicted HRmax. Weeks 1–4: 30 minutes per session. Increased by 5 minutes every two weeks up to 50 minutes.	Both HIIT (Lab-HIT) and (Home-MICT) shows improvement of cardiovascular fitness,
Scott et al., 2019 b	12	Stationary cycling	3	Cycling at 80%-90%HRR Home-HIIT and 1 min rest	Walking	3	65% of predicted HRmax. Weeks 1–4: 30 minutes per session. Increased by 5 minutes every two weeks up to 50 minutes.	Both significantly improved VO ² max, Body fat and BMI decreased in both groups. Home-HIIT led to a greater reduction in visceral fat.
Zapata-Lamana et al., 2018	12	Cycling	3	HIIT: 4 ×4 at 90% VO ₂ peak, with 2 min recovery.	Cycling	3	MICT: 45–50 min at 95% of first ventilatory threshold.	No significant differences in body mass and fat mass changes between HIIT and MICT.

Study	Duration (weeks)	HIIT Modality	HIIT Frequency days/week	HIIT Protocol	MICT Modality	MICT Frequency days/week	MICT Protocol	Main Outcomes
Zhang et al., 2015	12	Treadmill	4	Warm-up: 10 min. HIIT: 4 sets of 4 min at 85–95% HRmax, with 3 min walks and 7 min rest.	Treadmill	4	MICT: 33 min at 60–70% HRmax. Cool-down: 5 min.	No significant differences in body mass and fat mass changes between HIIT and MICT.

5.3 Result of Studies

5.3.1 Changes in Cardiorespiratory Fitness HIIT vs MICT

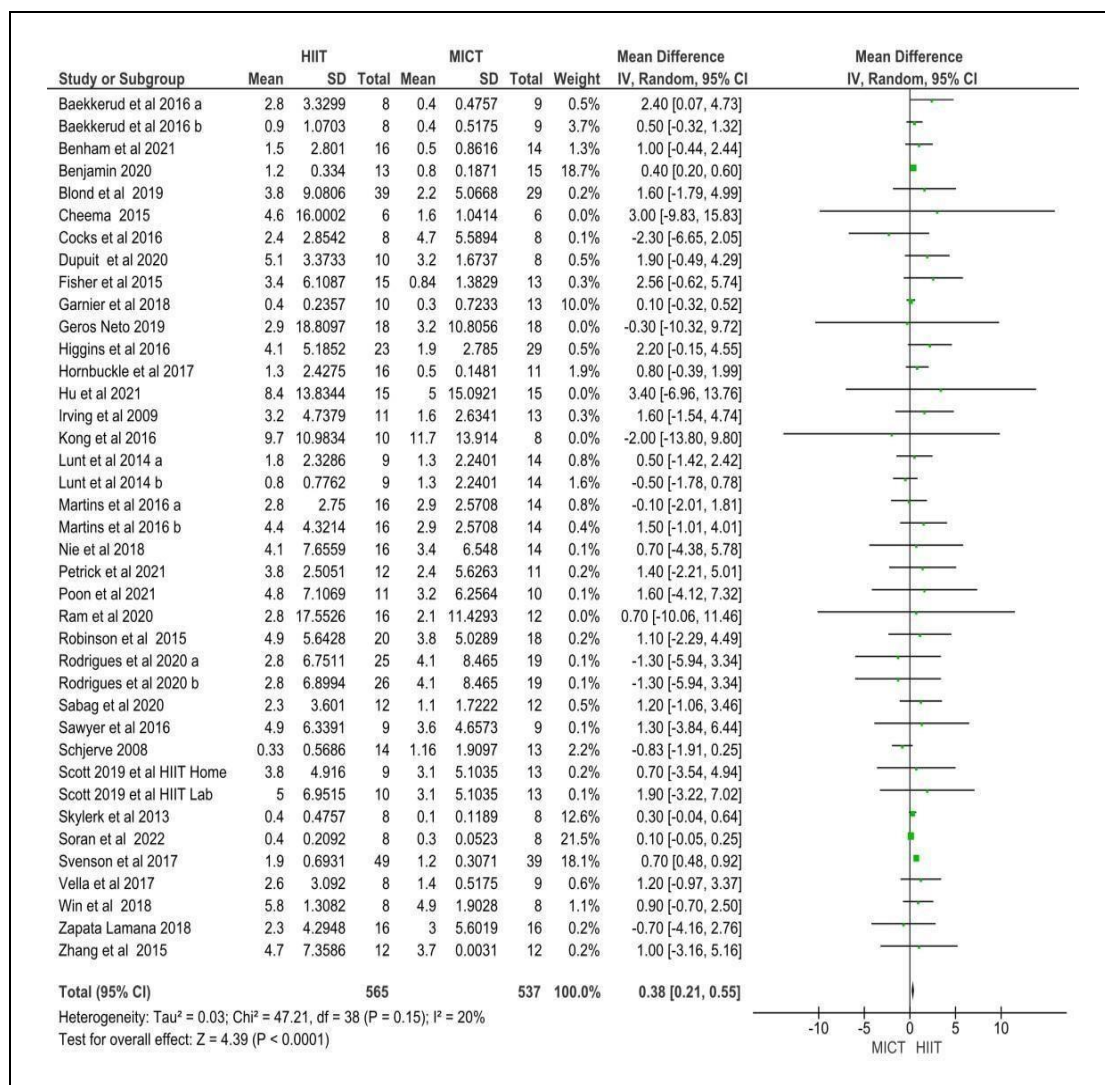


Figure 5.1 Forest Plot of Changes in Peak Oxygen Consumption in HIIT vs MICT

The forest plot demonstrates that HIIT was significantly more effective than MICT in improving peak oxygen consumption among obese adults. The pooled mean difference was 0.38 mL·kg⁻¹·min⁻¹ (95% CI: 0.21 to 0.55 mL·kg⁻¹·min⁻¹), indicating that the overall effect significantly preferred to HIIT. The result was statistically significant, as shown by the overall effect test (Z = 4.39, p < 0.0001). In addition, the heterogeneity was low (I² = 20%), suggesting that the results were relatively consistent across the included studies. Therefore, HIIT appears to be a more effective exercise

intervention than MICT for improving peak oxygen consumption and cardiorespiratory fitness among obese adults.

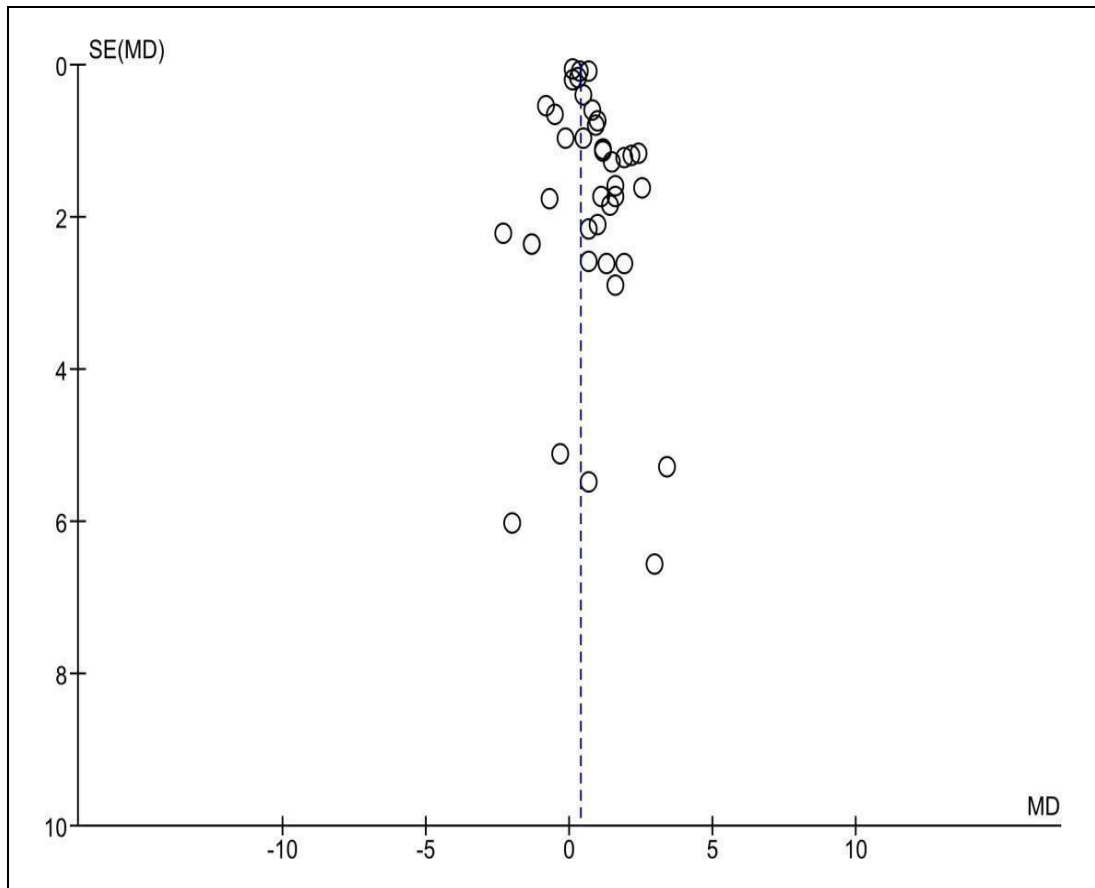


Figure 5.2 Funnel Plot of Changes in Cardiorespiratory Fitness between HIIT and MICT

The funnel plot demonstrates a slightly asymmetrical distribution of studies examining cardiorespiratory improvement among obese adults. Most studies are concentrated near the top of the plot and close to the pooled effect estimate, indicating that the more precise studies were generally consistent with the overall finding. However, several less precise studies are dispersed at the lower section of the plot, showing greater variation in effect estimates. This pattern suggests the possible presence of small-study effects.

5.3.2 Changes in Body Mass Index HIIT vs MICT

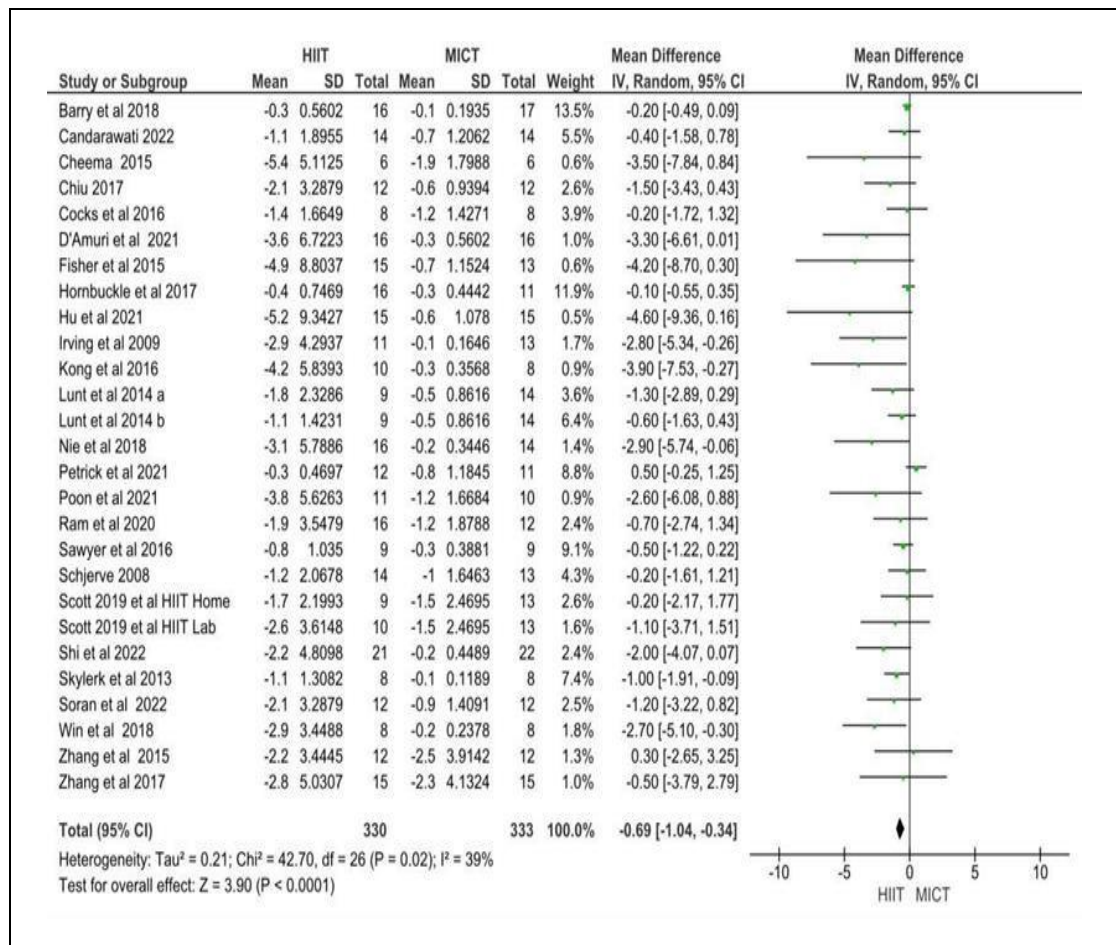


Figure 5.3 Forest Plot of Changes in Body Mass Index in HIIT vs MICT

The forest plot shows that HIIT produced a significantly greater reduction in body mass index (BMI) compared with MICT among obese adults. The pooled mean difference was -0.10 kg/m^2 with a 95% confidence interval of -0.15 to -0.05 , and the overall effect was statistically significant ($Z = 4.07$, $p < 0.0001$). Since the confidence interval does not cross zero, the result favours HIIT, although the effect size is small. The heterogeneity was 0%, indicating that the findings were highly consistent across the included studies. This suggests that HIIT may be slightly more effective than MICT in reducing BMI among obese adults.

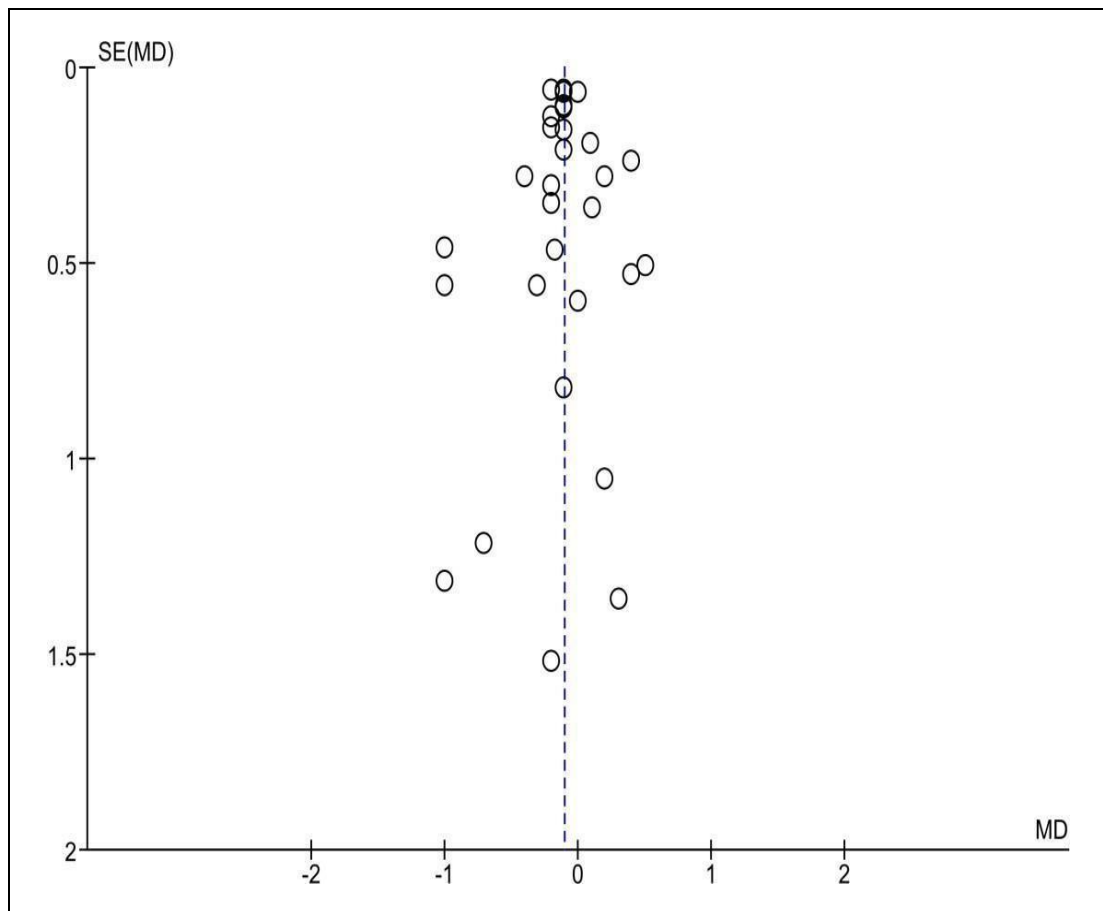


Figure 5.4 Funnel Plot of Changes Body Mass Index between HIIT and MICT

The funnel plot shown provides a visual representation of the variability and precision of study results in the meta-analysis comparing High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) for Body Mass Index (BMI) reduction in an obese population. The plot reveals that the data points are scattered around the vertical line at MD = 0, representing no effect, indicating symmetry around this central line. This symmetry suggests that both studies reporting large and small effect sizes are represented equally. In this study the distribution appears balanced, which enhances the reliability of the findings from the meta-analysis.

5.3.3 Changes in Percentage Body Fat in HIIT vs MICT

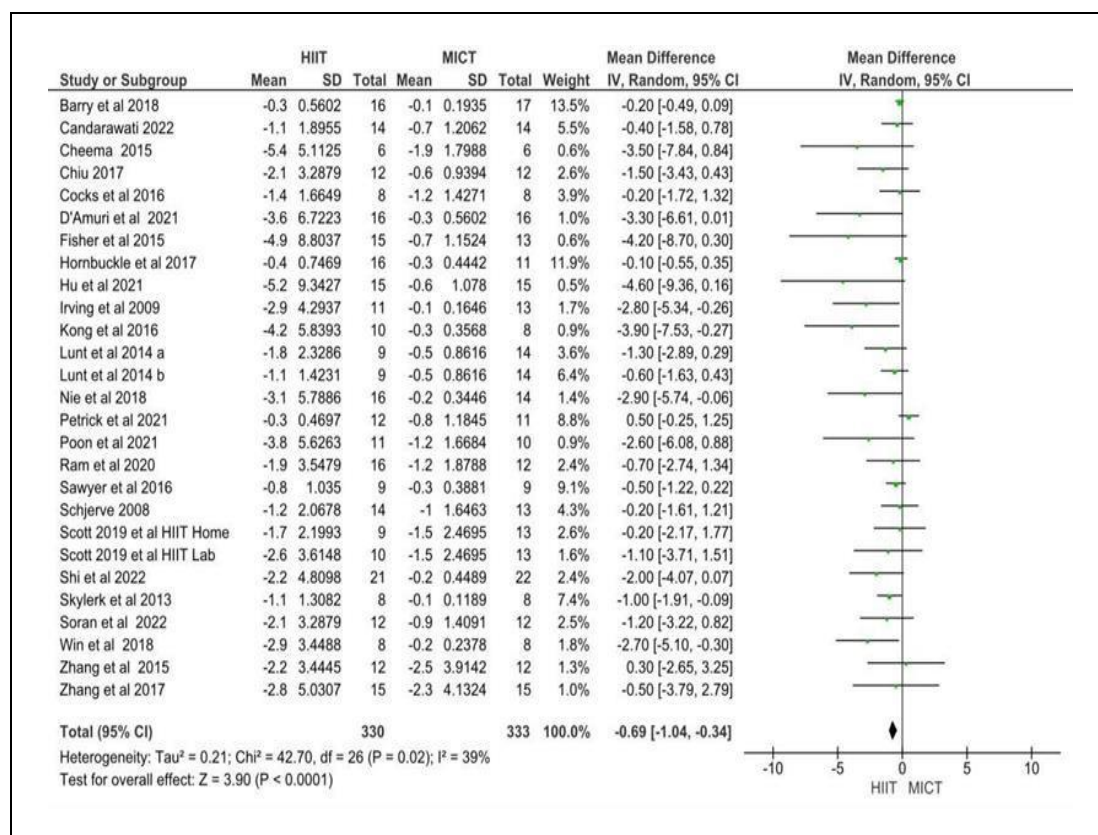


Figure 5.5 Forest Plot Changes in Percentage Body Fat between HIIT versus MICT

This forest plot compares the effects of High-Intensity Interval Training and Moderate-Intensity Continuous Training on percentage body fat among adults living with obesity. The pooled result showed a mean difference of -0.69 with a 95% confidence interval of -1.04 to -0.34, indicating a statistically significant difference between the two interventions. Because the pooled estimate is negative and the confidence interval does not cross zero, the overall result favours HIIT, suggesting that HIIT produced a greater reduction in percentage body fat than MICT. The overall effect was also statistically significant ($Z = 3.90$, $p < 0.0001$), which strengthens the evidence that HIIT may be more effective than MICT for improving this outcome. The heterogeneity for this analysis was moderate ($I^2 = 39\%$), which indicates that there was some variation in the magnitude of effect across the included studies. Somehow, the pooled estimate remained clearly in favour of HIIT, indicating that the higher-intensity approach may provide a more effective stimulus for reducing body fat percentage.

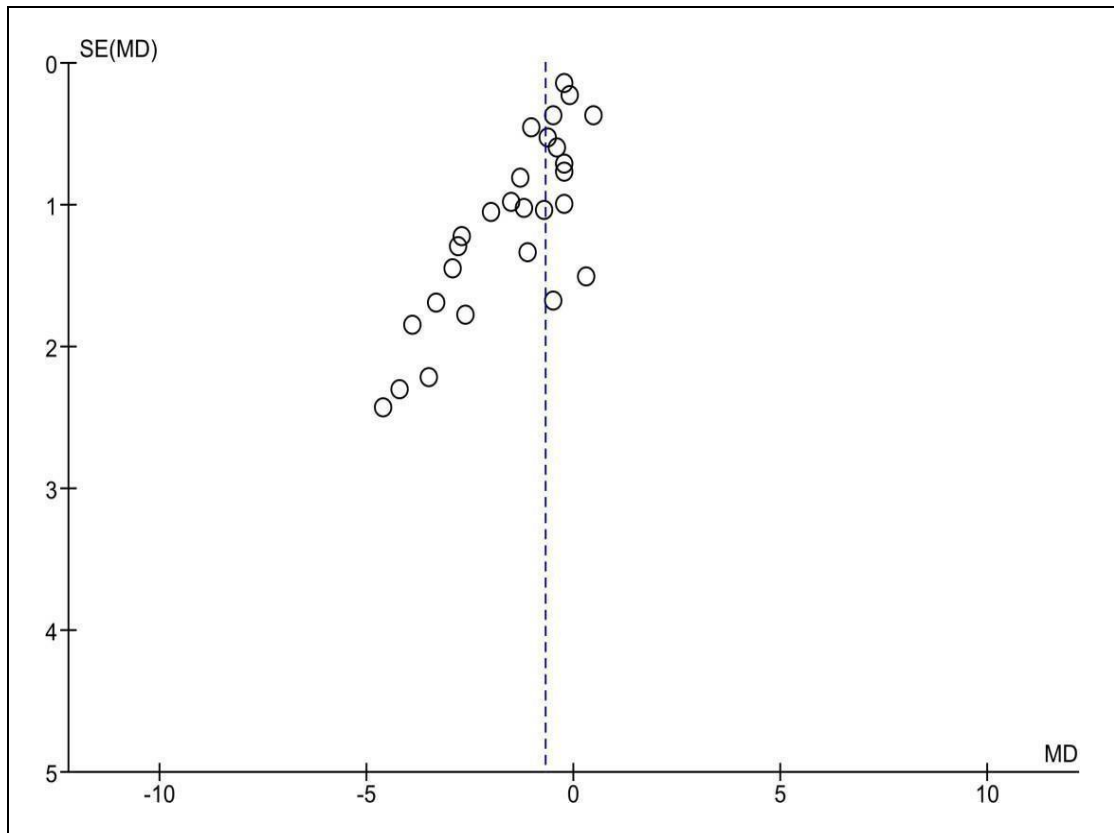


Figure 5.6 Funnel plot of changes in percentage body fat between HIIT vs MICT

The funnel plot suggests that the studies included in this meta-analysis exhibit a wide range of effects of HIIT and MICT on body fat reduction, with most studies finding that HIIT is slightly more effective than MICT. However, there is considerable variability in the magnitude of this effect across studies, with some studies showing significant reductions in body fat, while others report minimal or no difference between the two exercise modalities. The larger studies tend to show more moderate and consistent effects, while the smaller studies demonstrate more variation in their results due to the inherent uncertainty in estimating effects with smaller sample sizes. Despite the spread of data points, the overall trend points towards HIIT being a slightly more significant.

5.3.4 Changes in Waist Circumferences in HIIT vs MICT

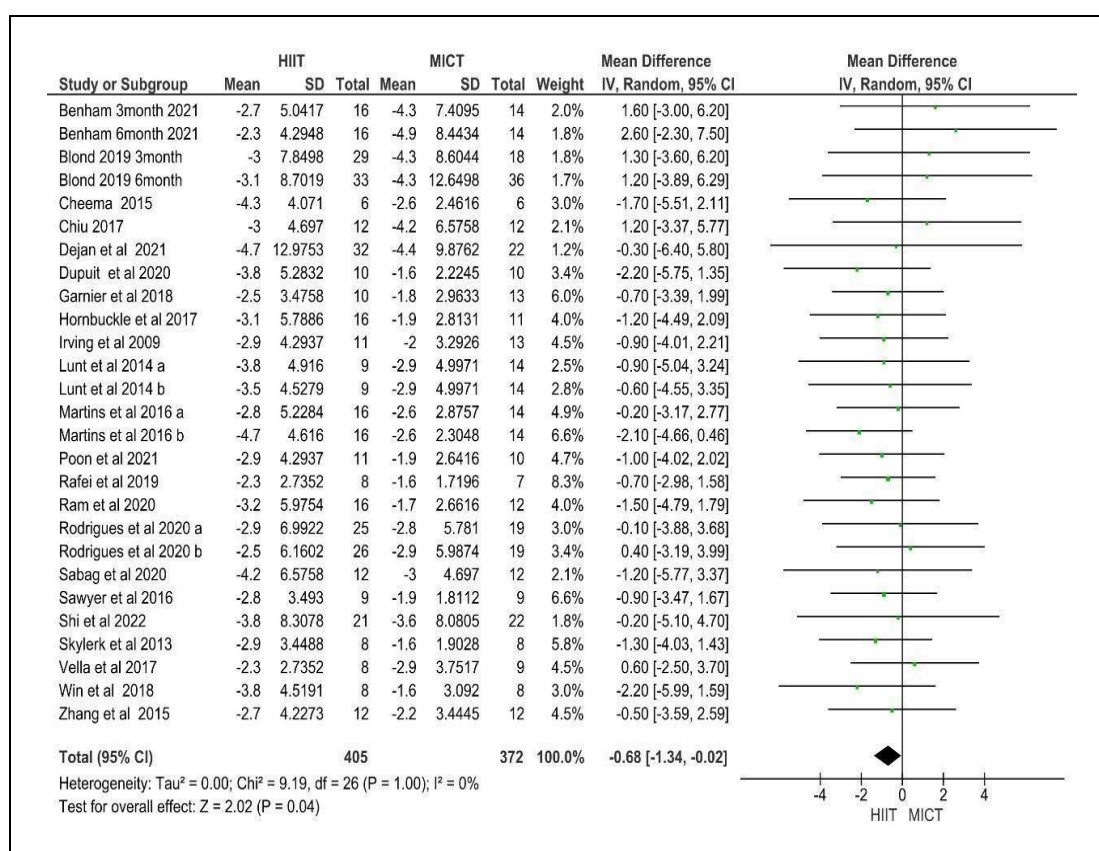


Figure 5.7 Forest Plot of Changes in Waist Circumference in HIIT vs MICT

This forest plot compares the effects of High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) on waist circumference reduction among adults living with obesity. The pooled result showed a mean difference of -0.68 with a 95% confidence interval of -1.34 to -0.02, indicating a statistically significant difference between the two interventions ($Z = 2.02$, $p = 0.04$). The pooled effects significant suggesting that HIIT produced a slightly greater reduction in waist circumference than MICT. In addition, the heterogeneity was 0%, which indicates that the findings were highly consistent across the included studies. From a clinical perspective, this finding is important because waist circumference reflects central adiposity, which is closely associated with cardiometabolic risk. Therefore, the reduction of percentage of body fat observed in slightly more effective in targeting abdominal fat accumulation than moderate-intensity continuous exercise.

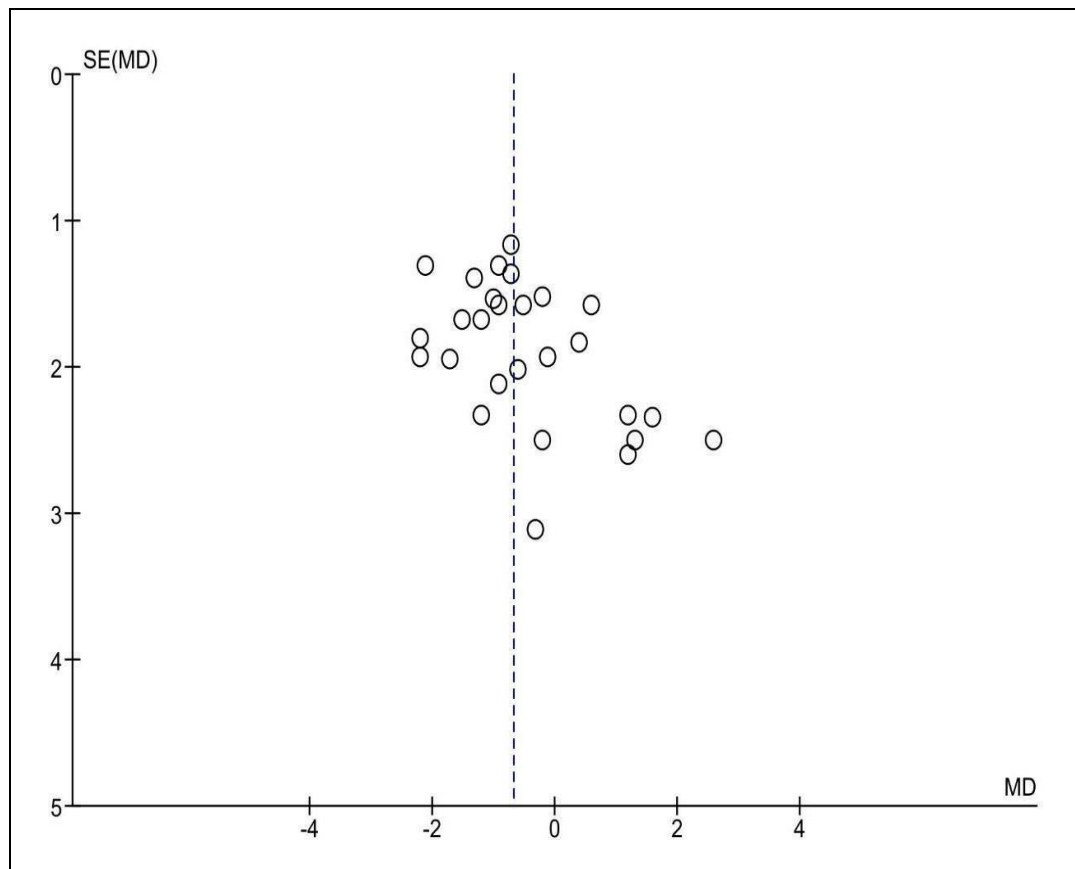


Figure 5.8 Funnel Plot of Changes in Waist Circumferences between HIIT and MICT

The funnel plot for waist circumference demonstrates a slightly asymmetrical distribution of studies around the pooled effect estimate. Although several studies are clustered near the centre of the plot, indicating reasonable consistency among the included studies, some studies are more widely scattered on one side. This pattern suggests the possible presence of small-study effects or publication bias. However, as most studies remain relatively close to the overall effect line, the evidence still provides reasonable support for the effect of exercise intervention on reducing waist circumference among obese adults.

5.3.5 Changes in Visceral Fat in HIIT vs MICT

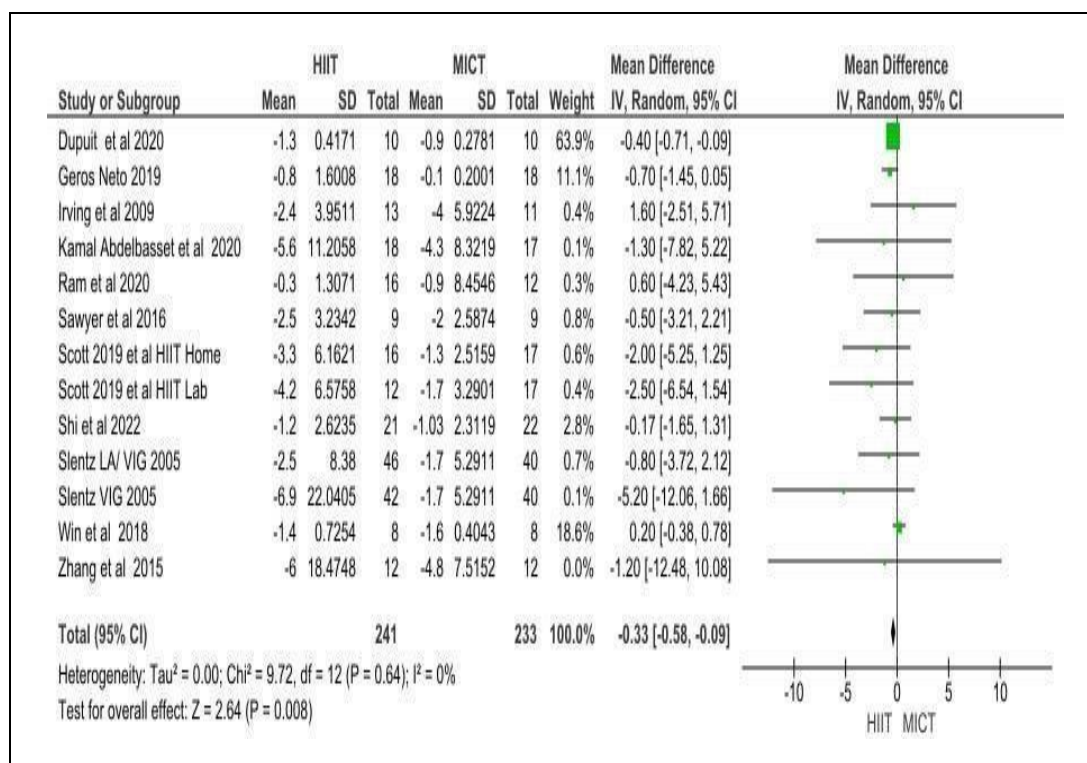


Figure 5.9 Forest Plot shows Changes in Visceral Fat in HIIT vs. MICT.

The forest plot shows pooled mean difference was -0.33 (95% CI: -0.58 to -0.09), and the overall effect was statistically significant ($Z = 2.64$, $p = 0.008$). This suggests that HIIT may be a more effective exercise intervention than MICT for reducing visceral fat. HIIT produced a significantly greater reduction in visceral fat compared with MICT among adults with obesity. Furthermore, the heterogeneity was negligible ($I^2 = 0\%$), suggesting that the findings were consistent across the included studies. Therefore, the evidence supports the effectiveness of HIIT as a superior strategy for visceral fat reduction among obese adults. Given the strong association between visceral fat and metabolic health risks, the reduction observed through HIIT may provide important health benefits for obesity management and prevention of related cardiometabolic complications.

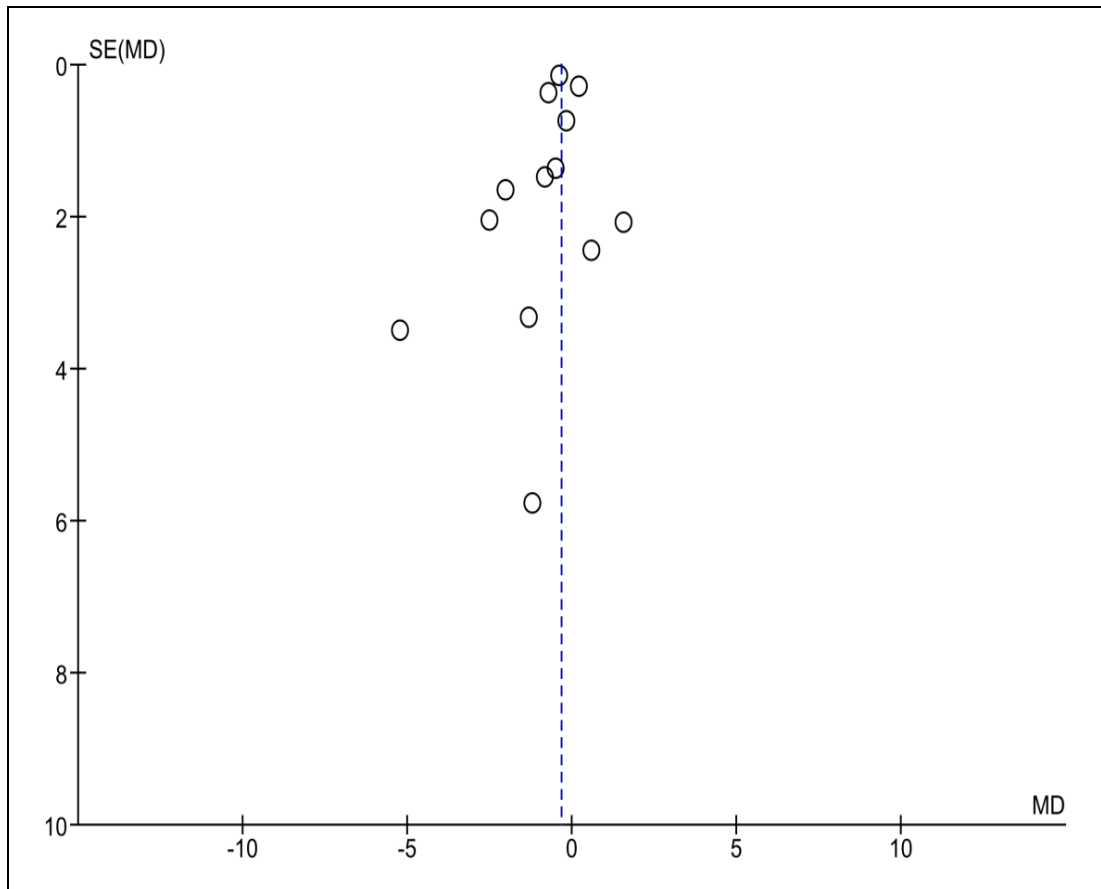


Figure 5.10 Funnel Plot Changes of Visceral Fat between HIIT and MICT

The funnel plot for visceral fat shows a slightly asymmetrical distribution of studies around the overall effect line. Most studies are grouped near the top of the plot, indicating better precision and consistency among the included studies. However, several studies are spread unevenly, particularly towards one side of the plot. This suggests a possible small-study effect.

5.4 Discussion of Study

The findings of this meta-analysis indicate that High-Intensity Interval Training (HIIT) provides greater improvements than Moderate-Intensity Continuous Training (MICT). The statistically significant findings observed in the forest plots may be further understood through the training protocols applied in the included studies. Overall, the studies that demonstrated significant outcomes commonly involved structured HIIT program with repeated high-intensity exercise bouts and consistent weekly training frequency. These characteristics suggest that the physiological benefits of HIIT among

obese adults may be influenced not only by exercise intensity, but also by the design of the intervention, including modality, duration, frequency, and recovery structure.

For cardiorespiratory fitness, Petrick et al. 2020 applied a 6-week cycle ergometer HIIT program performed five times per week. The protocol consisted of very high-intensity cycling at approximately 170% of peak power output, involving 4 to 6 sets of 30-second all-out sprints with 2 minutes of recovery between intervals. This sprint-based protocol may have provided a strong cardiovascular stimulus, which could explain the significant improvement in peak oxygen consumption observed in the forest plot. The repeated exposure to near-maximal exercise intensity may enhance aerobic capacity by increasing cardiovascular demand, oxygen utilization, and exercise tolerance among obese adults.

For body mass index, Benham et al. 2021 was identified as one of the studies showing a statistically significant mean difference in favour of HIIT. The reduction in BMI may be associated with the ability of HIIT to increase exercise intensity and energy expenditure within a shorter training duration. Among obese adults, this is important because BMI reduction often requires consistent energy expenditure and long-term adherence to exercise. Therefore, the significant finding from this study supports the role of HIIT as a useful exercise strategy for improving weight-related outcomes in obese populations.

For percentage body fat, the significant findings can be linked to the protocols used by Cheema et al. 2015 and Zhang et al. 2015. Cheema et al. 2015 implemented a 12-week boxing-based HIIT program performed four times per week. The protocol consisted of three intervals using a 2:1 intense activity-to-rest ratio, with a total session duration of 30 minutes at more than 75% of maximum heart rate. Meanwhile, Zhang et al. 2015 used a 12-week treadmill-based HIIT program, also performed four times per week. The session included a 10-minute warm-up, followed by four sets of 4-minute intervals at 85–95% HRmax, with 3-minute walking recovery periods and a 7-minute rest period. These protocols suggest that repeated exposure to vigorous-intensity exercise may contribute to greater reductions in body fat percentage among obese adults. The combination of high energy demand, intermittent recovery, and repeated high-intensity effort may increase metabolic stress and post-exercise oxygen consumption, thereby supporting fat reduction.

For waist circumference, the protocols used by Dupuit et al. 2020 and Martins et al. 2016 provide useful insight into the reduction of central adiposity. Dupuit et al.

2020 applied a 12-week cycling HIIT program performed three times per week. The session began with a 5-minute warm-up, followed by repeated 8-second high-intensity cycling bouts at 80–90% HRmax. In comparison, Martins et al. 2016 used a 12-week sprint-based HIIT programme performed three times per week, involving 8 seconds of sprinting followed by 12 seconds of recovery at 85–90% of maximal heart rate. The full HIIT protocol lasted 20–25 minutes per session, while the lower-volume version lasted 10–12 minutes per session. These findings suggest that short, repeated high-intensity intervals may be beneficial for reducing waist circumference among obese adults. Since waist circumference reflects abdominal fat accumulation, these protocols may be particularly relevant for improving central adiposity and reducing cardiometabolic risk. For visceral fat, the protocol of Dupuit et al. 2020 explain the significant reduction observed in the forest plot. The study used a 12-week cycling HIIT intervention performed three times weekly, involving repeated 8-second cycling bouts at 80–90% HRmax after a 5-minute warm-up. This type of protocol may be effective for visceral fat reduction because high-intensity intervals require substantial energy expenditure and may promote greater metabolic adaptation than moderate-intensity continuous exercise. Visceral fat is strongly associated with metabolic dysfunction and cardiovascular risk; therefore, a reduction in this outcome is particularly meaningful for obese populations.

Most protocols lasted between 6 and 12 weeks and were performed three to five times per week. These characteristics may explain the favourable effects of HIIT on cardiorespiratory fitness, body fat percentage, waist circumference, and visceral fat. Therefore, HIIT may be considered a practical and effective exercise strategy for obese adults when the program is appropriately designed according to exercise intensity, recovery period, intervention duration, and individual exercise tolerance.

5.5 Summary of Studies

This meta-analysis demonstrates that High-Intensity Interval Training (HIIT) produced greater improvements than Moderate-Intensity Continuous Training (MICT) across several important physiological outcomes in obese populations. This suggests that the high-intensity nature of HIIT may provide a stronger physiological stimulus for enhancing aerobic capacity and cardiovascular function compared with continuous moderate-intensity exercise. In obese populations, improvements in cardiorespiratory

fitness are particularly important because obesity is often associated with reduced exercise capacity, increased cardiovascular strain, and higher risk of metabolic complications. Therefore, the improvement in peak oxygen consumption observed in this meta-analysis indicates that HIIT may help enhance the body's ability to use oxygen more efficiently during physical activity. This supports the role of HIIT as a beneficial intervention for improving functional fitness and reducing obesity-related cardiovascular risk.

Apart from cardiorespiratory fitness, HIIT also demonstrated significant effects on body composition outcomes, including body mass index, percentage body fat, waist circumference, and visceral fat. Although some effect sizes were relatively small, the consistent direction of the findings prone to HIIT intervention. This suggests that HIIT provide meaningful benefits for obese populations by supporting reductions in overall body weight, total adiposity, abdominal fat, and harmful fat accumulation around internal organs. Overall, the evidence from this meta-analysis supports HIIT as an effective and practical exercise intervention for obese populations. Its ability to improve both fitness-related and fat-related health outcomes highlights its potential value in structured obesity management program.

However, HIIT should be prescribed carefully according to individual fitness levels, health status, and exercise tolerance. This is important because obese individuals may have different physical capacities, comorbidities, and safety considerations that need to be addressed before engaging in higher-intensity exercise. Future research should further examine how HIIT program can be adapted to the needs of obese populations by considering individual preferences, health conditions, age, baseline fitness, and adherence barriers.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 General Discussion

The findings of this thesis show that aerobic exercise is an effective intervention for obese adults. Compared with control conditions, aerobic exercise produced significant improvements in cardiorespiratory fitness, body mass index, percentage body fat, waist circumference, and visceral fat. These findings suggest that aerobic exercise does not only support weight management, but also improves body composition and reduces obesity-related health risks. This is important because obesity is not only related to excess body weight, but also to poor cardiorespiratory fitness, higher body fat, abdominal obesity, and visceral fat accumulation. Therefore, aerobic exercise can be considered a practical and evidence-based strategy for obesity management.

In terms of body mass index, aerobic exercise showed a significant reduction compared with control conditions. Although the reduction was modest, it still indicates that aerobic exercise contributes positively to weight-related outcomes among obese adults. However, BMI should not be interpreted alone because it does not differentiate between fat mass and lean mass. Therefore, the reduction in BMI becomes more meaningful when supported by improvements in percentage body fat, waist circumference, and visceral fat. The reduction in percentage body fat further supports the effectiveness of aerobic exercise in improving body composition. This finding is important because percentage body fat provides a clearer indication of adiposity compared with BMI. The overall results suggest that aerobic exercise can help reduce fat mass among obese adults.

This research finding clearly notify that aerobic exercise showed a significant reduction in waist circumference. This finding is clinically meaningful because waist circumference reflects central adiposity, which refers to fat accumulation around the abdominal area. Excess abdominal fat is strongly associated with a higher risk of cardiometabolic problems, including insulin resistance, hypertension, type 2 diabetes, and cardiovascular disease. Therefore, the reduction in waist circumference suggests that aerobic exercise may help reduce abdominal fat accumulation and improve obesity-

related health risk. This indicates that the benefit of aerobic exercise is not limited to body weight reduction only, but also involves improvement in fat distribution, which is an important factor in obesity management.

Similarly, the reduction in visceral fat is particularly important because visceral fat is located around the internal organs and is more harmful than subcutaneous fat. High levels of visceral fat are closely linked with metabolic complications because this type of fat is more active in releasing inflammatory substances and disrupting normal metabolic function. Therefore, a reduction in visceral fat suggests that aerobic exercise may contribute to better metabolic health and lower the risk of obesity-related diseases. This finding strengthens the evidence that aerobic exercise is an effective intervention for obese adults, as it helps target not only overall body size but also harmful fat deposits that are strongly related to long-term health complications.

When comparing HIIT and MICT, HIIT showed greater improvements across several outcomes. HIIT was more effective in improving cardiorespiratory fitness, as shown by the improvement in peak oxygen consumption. This suggests that higher-intensity aerobic training provides a stronger cardiovascular stimulus than moderate-intensity continuous exercise. For obese adults, improvement in cardiorespiratory fitness is important because it can enhance exercise tolerance, functional capacity, and long-term cardiovascular health. HIIT also produced greater reductions in BMI, percentage body fat, waist circumference, and visceral fat compared with MICT. Although some of the effect sizes were small, the findings consistently favoured HIIT. This suggests that repeated high-intensity exercise intervals may create a stronger metabolic demand and may be more effective for improving body composition. However, HIIT should be prescribed carefully because obese adults may have different fitness levels, health conditions, and exercise tolerance.

Overall, the findings suggest that both aerobic exercise and HIIT are useful for obesity management. Aerobic exercise is effective when compared with control conditions, while HIIT appears to provide additional benefits compared with MICT. However, the findings should be interpreted with caution because some funnel plots showed possible asymmetry and small-study effects. Differences in exercise protocol, intervention duration, sample size, and participant characteristics may also influence the results. Therefore, future studies should continue to identify the most effective, safe, and sustainable exercise protocols for obese adults.

6.2 Future Recommendations

Future research should aim to address several gaps in the current literature regarding the effects of different exercise protocols on cardiorespiratory fitness and health parameters. These comparisons should focus on physical fitness parameters, and inflammatory markers. While initial evidence suggests that HIIT may be effective in managing obesity, there is currently insufficient data to recommend it as a replacement for MICT in obese patients. Therefore, further studies are necessary to evaluate the efficacy of HIIT in obese population.

These studies should include larger sample sizes and control groups to ensure robust and generalizable results. Additionally, research should investigate the differences in exercise adherence between HIIT and MICT. Understanding which exercise protocol is more sustainable and enjoyable for obese patients will help determine the most effective approach for long term obesity management. The inconsistency in study outcomes thus far highlights the need for comprehensive and well-designed trials to clarify the potential benefits of varying exercise intensities. By addressing these research gaps, better understanding for the most effective exercise protocols in improving health outcomes and managing obesity can be figure out.

There are some gaps in the research that need to be filled in the near future. These include comparing the effects of this time-efficient protocol on repeated high-intensity training at the same point in time and continuous moderate intensity exercise on cardiometabolic risk factors, physical fitness parameters, and inflammatory markers. Furthermore, while the initial evidence supporting the effectiveness of HIIT in controlling and managing obese patients is compelling, there is currently insufficient evidence to replace a MICT approach with HIIT.

Therefore, additional research is necessary, particularly in the context of obese patients. Furthermore, to support the limitations of the present study, further research is need to conduct more studies on obese patients with larger sample sizes and control groups to explain the potential benefits of varying exercise intensities between HIIT and MICT in managing and controlling obesity.

6.3 Conclusions

Exercise training has been widely recognized as an effective approach for managing obesity. In a nut shell, this research found that aerobic exercise is an effective intervention for improving health-related outcomes among obese adults. Compared with control conditions, aerobic exercise significantly improved body composition outcomes, including body mass index, percentage body fat, waist circumference, and visceral fat. These findings show that aerobic exercise is not limited to general weight reduction, but also contributes to improvements in adiposity, abdominal fat, and harmful visceral fat accumulation. Therefore, aerobic exercise should be considered an important component of obesity management programs.

The comparison between HIIT and MICT further demonstrated that HIIT produced greater improvements across several outcomes. HIIT was more effective than MICT in improving cardiorespiratory fitness and reducing BMI, percentage body fat, waist circumference, and visceral fat. Although some effect sizes were small, the consistent direction of findings suggests that HIIT may provide a stronger physiological and metabolic stimulus than moderate-intensity continuous exercise. This may be due to the repeated exposure to high-intensity exercise bouts, which can increase cardiovascular demand, energy expenditure, and metabolic adaptation.

Overall, the findings support the role of structured aerobic exercise, particularly HIIT, as a practical and effective strategy for obese adults. However, exercise prescription should be carefully designed according to individual fitness level, health condition, and exercise tolerance. HIIT may offer strong benefits, but it should be applied progressively and safely, especially among individuals with low baseline fitness or obesity-related health risks. Therefore, this thesis concludes that aerobic exercise and HIIT have important potential in obesity management, but future research is needed to identify the most effective, safe, and sustainable exercise protocols for different obese populations.

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APPENDICES

APPENDIX A

UiTM Ethic Exemption

www.uitm.edu.my



Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI(5/1/6)
Our reference : REC/07/2021 (EX/113)
Date : 15th July 2021

Assoc. Prof. Dr Hashbullah Ismail
(Nurul Najwa binti Aminul Mahzan - 2020380337)
Faculty of Sports Science and Recreation
Academic Building 3,
Universiti Teknologi MARA,
40450 Shah Alam,
SELANGOR

Dear Assoc. Prof. Dr Hashbullah,

ETHICS REVIEW EXEMPTION - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to Research Ethics Committee (REC). After considering your application, the Committee decides your proposal entitled "Effects of MICT and HIIT on Health-Related Fitness Components among Obese Type 1 Population" is exempted from ethics review.

Details of the ethics review exemption are as follows:

Ref. number:	REC/07/2021 (EX/113)
Authorised personnel:	1. Assoc. Prof. Dr Hashbullah Ismail 2. Nurul Najwa binti Aminul Mahzan 3. Noor Fatimah Ilias

UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The ethics review exemption of this project is conditional upon your continuing compliance with these guidelines and declaration.

If you require further information, please contact REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Yours sincerely,

PROFESSOR DATO' DR. ABU BAKAR ABDUL MAJEED
Chairman
UiTM Research Ethics Committee

c.c.: Dean, Faculty of Sports Science and Recreation, UiTM

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UNIVERSITI
TEKNOLOGI
MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI(5/1/6)
Our reference : REC/07/2021 (EX/113)
Date : 15th July 2021

Assoc. Prof. Dr Hashbullah Ismail
(Nurul Najwa binti Aminul Mahzan - 2020380337)
Faculty of Sports Science and Recreation
Academic Building 3,
Universiti Teknologi MARA,
40450 Shah Alam,
SELANGOR

Dear Assoc. Prof. Dr Hashbullah,

ETHICS REVIEW EXEMPTION - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to Research Ethics Committee (REC). After considering your application, the Committee decides your proposal entitled "Effects of MICT and HIIT on Health-Related Fitness Components among Obese Type 1 Population" is exempted from ethics review.

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If you require further information, please contact REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

Yours sincerely,

PROFESSOR DATO' DR. ABU BAKAR ABDUL MAJEED
Chairman
UiTM Research Ethics Committee

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APPENDIX B

Paper Publication

Malaysian Journal of Sport Science and Recreation
Vol. 20 . No. 1. 1-14, 2024.
DOI: <https://doi.org/10.24191/mjssr.v20i1.1133>



Effectiveness of exercises intensity in improving cardiorespiratory fitness and body fat percentage among obese adults: A systematic review and meta-analysis

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ABSTRACT

Exercise, as a non-pharmacological strategy, has demonstrated positive effects in managing cardiorespiratory fitness and adiposity among obese individuals. However, the comparative effectiveness of Moderate-Intensity Continuous Training (MICT) and High-Intensity Interval Training (HIIT) remains inconclusive. This study aimed to identify the most efficient exercise intensity for improving cardiorespiratory fitness and reducing body fat percentage in obese individuals. This review only included subjects who had a mean BMI of ≥ 30 kg/m², percentage body fat > 30 kg, aged between 18 and 60 years old and only consisted of intervention of exercises alone without caloric restriction. The study employed HIIT intervention at 85% Heart Rate Reserves (HRR) and MICT at 60% HRR. A systematic search of electronic databases was conducted from 1970 to October 2022, yielding twenty eligible studies. The PRISMA flowchart guided study selection, meanwhile the quality of included studies was assessed using TESTEX criteria. The results of the study indicated no significant difference between HIIT and MICT in improving cardiorespiratory fitness (WMD = 0.27; 95% CI: 0.01 to 0.53; P = 0.04; I²: 25%) or percentage body fat (WMD: 0.23; 95% CI: -0.53 to 0.07; P = 0.13; I²: 67%) among obese adults. Despite small changes, both exercise modalities demonstrated improvements. Therefore, health practitioners are encouraged to prescribe exercises tailored to individual preferences, as HIIT and MICT provide equivalent effects. This study contributes to the understanding of exercise interventions for managing obesity-related health outcomes.

Keywords: Obese Adults, Aerobic exercises, Body Composition, High Interval Intensity Training, Moderate Continuous Intensity Training





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2020380337
FACULTY OF SPORTS SCIENCE AND RECREATION
SR750
MASTER OF SCIENCE (SPORTS SCIENCE AND RECREATION)

This is to certify that the student has completed the following modules successfully:

MODULES		TOPICS
Module 1	:	Your Research Journey to GOT
Module 2	:	Working with your Supervisor
Module 3	:	Writing Literature Review
Module 4	:	Research Methodology
Module 5	:	Research Ethics and Safety
Module 6	:	Writing the Research Proposal
Module 7	:	Research Databases and Online Searches
Module 8	:	Publication in a Scientific Journal
Date	:	29/10/2020
File No	:	500-IPSiS (15/5/7)

THIS IS COMPUTER GENERATED CERTIFICATE. NO SIGNATURE REQUIRED.



MASO 2023 Scientific Conference on Obesity

Dear Ms. Nurul Najwa Binti Aminul Mahzan,

We are pleased to inform you that your abstract submission for the upcoming Malaysian Association for the Study of Obesity (MASO) Scientific Conference on Obesity 2023 has been accepted for an oral presentation.

Title: The Effect of the Exercises Intensity in Improving Cardiorespiratory Fitness and Body Composition in Obese Person: A Systematic Review and Meta-Analysis

Presentation Date: 5 September 2023 (Tuesday)

Poster Number: S8.4

Symposium: Symposium 8: Free Communication 2

Presentation Time: 4 p.m. - 5 p.m.

Your contribution will undoubtedly enrich the conference by adding valuable insights to the discussions on obesity research. We believe your work will spark meaningful conversations and contribute to the overall success of MASO 2023.

Kindly ensure that you are well-prepared for your presentation and adhere to the attached guidelines. You may now proceed to do the online registration at www.masoconference.org to attend the conference if you have not done so.

Should you have any questions or require further information, please feel free to reach out to us at maso.obesity@gmail.com. Further details and the scientific program of MASO 2023 could be found at www.masoconference.org.

We look forward to your participation in the conference and congratulations once again on your abstract acceptance.

Best regards,

Assoc Prof Dr Mohd Razif Shahril

Secretariat

MASO Scientific Conference on Obesity 2023

AUTHOR'S PROFILE



Nurul Najwa Binti Aminul Mahzan completed her Diploma in Sport Studies at the Faculty of Sport Science and Recreation, Universiti Teknologi MARA (UiTM). She later obtained her Bachelor's Degree from the same faculty at Universiti Teknologi MARA (UiTM) in 2021. Her academic background has equipped her with knowledge and practical experience in Sports Science, Community-Based Health Promotion, Physical Activity Programmes, and Exercise Physiology.

LIST OF PUBLICATIONS

Nurul Najwa Binti Aminul Mahzan. Effectiveness of Exercise Intensity in Improving Cardiorespiratory Fitness and Body Fat Percentage Among Obese Adults: A Systematic Review and Meta-Analysis. *Malaysian Journal of Sport Science and Recreation (MJSSR)*, Vol. 20, No. 1, 2024.

Nurul Najwa Binti Aminul Mahzan. Relationship Between Body Composition and Physical Activity Level Among Students. *Metabolism: Clinical and Experimental*, Vol. 116, 2021.