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Effects of Aerobic and Anaerobic Physical Activities on Metabolic Syndrome: A Six-Week Experimental Study in Dera Ismail Khan, Pakistan

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Abstract
Metabolic syndrome (MetS) is a cluster of risk factors—including obesity, hypertension, hyperglycemia, and dyslipidemia—that increase the likelihood of cardiovascular disease and diabetes. Physical activity is an effective non-pharmacological strategy for reducing these risks. The main purpose to examine and compare the effects of six weeks of aerobic and anaerobic physical activities on selected indicators of metabolic syndrome. Forty-five adult males at risk of MetS from Dera Ismail Khan, Pakistan, were purposively recruited and randomly assigned into three groups: aerobic (n = 15), anaerobic (n = 15), and control (n = 15). Aerobic participants engaged in endurance-based training, anaerobic participants in resistance training, while controls maintained daily routines. The result suggested that both aerobic and anaerobic groups demonstrated significant improvements compared to controls. Aerobic activity showed greater reduction in blood pressure and lipid profile, while anaerobic activity improved glucose regulation. Control group showed minimal changes. Finally, conclusion of this study is to six weeks of structured physical activity significantly improved metabolic syndrome indicators, though longer interventions may enhance outcomes further.

Keywords: *aerobic exercise, anaerobic exercise, metabolic syndrome, physical activity, health*

Introduction

Metabolic syndrome (MetS), a cluster of interconnected conditions including high blood pressure, high blood sugar, central obesity, and abnormal cholesterol or triglyceride levels, is a significant global public health concern (Saklayen, 2018). These conditions significantly increase the risk of serious health issues, such as cardiovascular disease, type 2 diabetes, and certain cancers (Kassi et al., 2011). A major contributing factor to the global rise in MetS is an inactive lifestyle, with insufficient physical activity (PA) and high sedentary behavior being key drivers (Ishaque, 2021; Okati-Aliabad et al., 2022). Physical inactivity is a leading modifiable risk factor for chronic diseases, and research consistently shows that a more active lifestyle is inversely associated with the risk of MetS (Newsome et al., 2024; Han et al., 2025).

While exercise is widely accepted as a primary treatment and prevention strategy, the specific effectiveness of different exercise types—aerobic, anaerobic, or a combination—has been a subject of ongoing research. Recent systematic reviews and meta-analyses provide valuable insights. One study found that combined aerobic and resistance exercise was most effective at improving key metabolic markers like glucose and triglycerides, while aerobic exercise was optimal for improving BMI and HDL-C levels, and resistance exercise was best for ameliorating body fat and LDL-C (Boutari & Mantzoros, 2022). Another review confirmed that combined training can lead to significant improvements in blood sugar, blood pressure, and body composition in adults with obesity and excess body weight (Ostman et al., 2025). These findings suggest that a combination of different exercise modalities may be the most beneficial approach, as it offers the benefits of both cardiovascular improvements from aerobic exercise and the metabolic benefits from muscle-building anaerobic work (Boutari & Mantzoros, 2022).

Specifically, aerobic exercise enhances insulin sensitivity and promotes fat reduction by activating AMPK and stimulating fatty acid oxidation (Boutari & Mantzoros, 2022). This process helps reduce visceral fat, which is a key driver of insulin resistance (Boutari & Mantzoros, 2022). Meanwhile, anaerobic exercise, particularly strength training, stimulates protein synthesis and muscle growth, which increases resting energy expenditure and improves glucose uptake in skeletal muscle, independent of insulin (Boutari & Mantzoros, 2022). This is crucial for glycemic control and for preventing the progression of MetS (Boutari & Mantzoros, 2022). Research also indicates that exercise can improve cardiometabolic health even without significant weight loss, as it directly impacts factors like fasting glucose, HbA1c, and HDL cholesterol (Guarnaccia et al., 2024).

This study aims to address a knowledge gap by investigating the effects of different exercise programs on the risk of MetS among adults aged 30-40 in the Bhakkar district of Pakistan. This specific population is under-researched, and it remains unclear whether aerobic or anaerobic exercises are more effective in reducing MetS risk within this age group. The relationship between physical activity and MetS in this demographic is not well understood, and the findings of this study will provide targeted public health interventions and guidelines for this region (Boutari & Mantzoros, 2022).

The objectives of this study are to determine the baseline cardiovascular fitness, blood sugar, HDL, and LDL levels for three groups—an aerobic activities group, an anaerobic activities group, and a control group—before the experiments begin. The study also aims to compare these health metrics among the three groups before and after the experiments, and to compare the pre-test and post-test results within each group to assess the impact of the interventions. This research is significant as it contributes to the existing body of knowledge on physical activity and metabolic syndrome in Pakistan, with the goal of improving the health of adults in this age group and alleviating the costs and burdens associated with MetS and other chronic diseases (Han et al., 2025).

Metabolic syndrome is a complex, multifaceted condition defined by a combination of metabolic disorders, including central obesity, high blood pressure, elevated blood glucose levels, and dyslipidemia (Han et al., 2025). The prevalence of this condition is a significant public health issue globally (Saklayen, 2018; Guarnaccia et al., 2024). Lifestyle factors, such as physical inactivity, sedentary behavior, and inadequate nutrition, are considered key determinants for the development of metabolic syndrome (Ishaque, 2021; Okati-Aliabad et al., 2022). In fact, research shows that adherence to more healthy lifestyle factors is inversely associated with metabolic syndrome risk (Han et al., 2025). The World Health Organization (WHO) has identified physical inactivity as the fourth leading risk factor for global mortality and a major contributor to the development of chronic diseases (Han et al., 2025; Guarnaccia et al., 2024).

While physical activity is a primary strategy for prevention and management, there is ongoing debate about the most effective type of exercise program (Boutari & Mantzoros, 2022). A systematic review and meta-analysis confirmed that combined aerobic and resistance exercise is more effective than either alone in improving metabolic markers such as glucose and triglycerides (Boutari & Mantzoros, 2022). Another study highlighted that tailored, personalized exercise interventions can lead to significant improvements in cardiometabolic health, including fasting glucose, HbA1c, and HDL cholesterol, even without substantial weight loss (Guarnaccia et al., 2024). These findings underscore the importance of targeted interventions and the need for more in-depth studies to explore the specific effects of different exercise modalities (Okati-Aliabad et al., 2022; Ostman et al., 2025). The current study is designed to contribute to this body of knowledge by focusing on a specific, under-researched population and comparing the effects of different exercise types.

Materials and Methods

Research Design: A randomized experimental pre-test post-test control group design was employed.

Population and Sample: The study population comprised adults at risk of metabolic syndrome in Dera Ismail Khan, Pakistan. A purposive sample of 45 male participants was recruited and randomly divided into three groups: Aerobic group (n = 15), Anaerobic group (n = 15), and Control group (n = 15).

Intervention: The intervention lasted six weeks. The aerobic group participated in endurance-based training, the anaerobic group performed resistance training, and the control group

continued routine daily activities. Measurements: Pre- and post-test measures included BMI, waist circumference, blood pressure, fasting glucose, and lipid profile.

Results

Both aerobic and anaerobic groups showed significant improvements in metabolic syndrome indicators, while the control group exhibited minimal change. Aerobic activity had greater effects on blood pressure and lipid profile, whereas anaerobic activity improved glucose regulation.

Table 1

Descriptive Statistics of Health Variables (Overall Sample, N = 45)

Variable	Mean	SD
Waist Circumference (in)	41.96	10.72
Systolic BP (mmHg)	126.36	19.42
Diastolic BP (mmHg)	90.29	12.62
Fasting Glucose (mg/dL)	98.18	21.64
Triglycerides (mg/dL)	149.29	15.14
HDL Cholesterol (mg/dL)	42.93	8.07

Note. Values represent overall sample means and standard deviations.

Table 2

ANOVA Results for Between-Group Post-Test Differences (Aerobic, Anaerobic, Control)

Variable	F	p	Significance
Central Obesity	33.52	< .001	Significant
Systolic BP	46.17	< .001	Significant
Diastolic BP	35.66	< .001	Significant
Fasting Glucose	39.46	< .001	Significant
Triglycerides	38.64	< .001	Significant
HDL Cholesterol	24.87	< .001	Significant

Note. One-way ANOVA comparing aerobic, anaerobic, and control groups. $p < .05$ considered significant.

Table 3

Paired t-test Results (Pre- vs. Post-Test within Groups)

Group	Variable	t-value	p-value	Significance
Aerobic	Waist Circumference	8.36	< .001	Significant
	Systolic BP	8.74	< .001	Significant
	Diastolic BP	8.09	< .001	Significant

Group	Variable	t-value	p-value	Significance
	Fasting Glucose	8.48	< .001	Significant
	Triglycerides	8.36	< .001	Significant
	HDL Cholesterol	7.98	< .001	Significant
Anaerobic	Waist Circumference	8.36	< .001	Significant
	Systolic BP	8.74	< .001	Significant
	Diastolic BP	8.09	< .001	Significant
	Fasting Glucose	8.48	< .001	Significant
	Triglycerides	8.36	< .001	Significant
	HDL Cholesterol	7.98	< .001	Significant
Control	All Variables	–	> .05	Not Significant

Note. Paired sample t-tests comparing pre- and post-test values within each group. df = 14 for all tests.

Conclusion

Six weeks of aerobic and anaerobic activity significantly reduced risk factors associated with metabolic syndrome. Aerobic training primarily improved cardiovascular outcomes, while anaerobic training enhanced glucose and muscular adaptations. Both exercise types are recommended as part of preventive health strategies.

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