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The Relationship between Aerobic Exercise and Blood Sugar Levels and Blood Pressure in Patients with Type 2 Diabetes Mellitus

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Abstract
Introduction: *Diabetes mellitus and hypertension are degenerative diseases with a high prevalence in the elderly population and commonly occur together as comorbidities, contributing to worsening metabolic and cardiovascular conditions. The coexistence of these diseases increases the risk of serious metabolic complications. Aerobic is a recommended non-pharmacological intervention because it helps control blood glucose levels, improves insulin sensitivity, and reduces blood pressure through mechanisms that enhance endothelial function and cardiorespiratory capacity.* ***Objective:*** *This study aims to analyze the relationship between aerobic activity levels and the status of diabetes mellitus and hypertension in elderly individuals diagnosed with type 2 diabetes mellitus in the community.* ***Method:*** *An analytical observational study with a cross-sectional design.* ***Result and Discussion****: The Mann-Whitney test showed a significant association between aerobic activity and diabetes mellitus status ($p = 0.001$), indicating that lower aerobic levels were associated with higher glucose levels. Aerobic activity was also significantly associated with hypertension status ($p < 0.001$), showing that lower aerobic increased the likelihood of elevated blood pressure.* ***Conclusions:*** *Increasing aerobic activity is an important non-pharmacological strategy to manage metabolic and cardiovascular risks in older adults with diabetes, and should be integrated into structured community health programs.*

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Introduction

The global population is aging rapidly, creating new challenges for communities, families, and individuals. As the number of older adults continues to increase, the proportion of those experiencing disability is also rising significantly (Zhao et al., 2024). Diabetes mellitus is a major global health issue that has grown rapidly in the 21st century. Various studies indicate that diabetes causes approximately 3.96 million deaths worldwide, with this number increasing to 4.20 million in 2019. Furthermore, diabetes is the fourth leading cause of disability globally, contributing to a disability-adjusted life years (DALYs) burden of 66.3 million. Among all types of diabetes, type 2 diabetes mellitus is the most prevalent, accounting for around 90% of cases (Liu et al., 2022). Type 2 diabetes mellitus is characterized by chronic hyperglycemia resulting from insulin resistance and impaired insulin secretion. Clinically, insulin resistance refers to the requirement for higher-than-normal insulin levels to maintain normoglycemia. At the cellular level, it reflects an inadequate insulin signaling response, from receptor activation to downstream metabolic processes (Decroli et al., 2022).

One of the greatest challenges for individuals with type 2 diabetes mellitus is maintaining blood glucose levels within the normal range. Optimal glycemic control is crucial to delay or prevent various diabetes-related complications that can reduce quality of life and increase mortality risk. Although pharmacological therapy plays an important role, many patients with type 2 diabetes still struggle to achieve optimal glycemic control due to several contributing factors, including lifestyle behaviors such as insufficient physical activity (Ramadhan & Syarif, 2025). Therefore, non-pharmacological interventions remain an essential component of glycemic management in type 2 diabetes mellitus (Luo et al., 2023).

Clinically, many individuals with type 2 diabetes mellitus also experience hypertension. The American Diabetes Association (ADA) reports that two out of three people with diabetes have hypertension. Other studies show that approximately 60% of hypertensive patients also have diabetes mellitus. This strong relationship highlights the importance of managing type 2 diabetes mellitus with careful attention to comorbidities. Optimal glycemic control is essential to prevent microvascular and macrovascular complications. Therefore, managing both blood glucose and blood pressure is a primary priority in the care of patients with type 2 diabetes mellitus (Zhai et al., 2023).

Physical activity is recommended as an effective strategy for managing type 2 diabetes mellitus because it enhances insulin sensitivity, improves metabolism, and lowers blood pressure by increasing vascular elasticity and cardiovascular function (Kanaley et al., 2023). Aerobic exercise, which involves rhythmic activities using large muscle groups, has been proven effective in type 2 diabetes management. It increases insulin sensitivity and glucose uptake by muscles, thereby reducing blood glucose levels (Pan et al., 2018). Additionally, aerobic exercise provides cardiovascular benefits by improving vascular elasticity and reducing vascular resistance, leading to decreases in both systolic and diastolic blood pressure (Liang et al., 2021).

Despite its proven benefits, adherence to aerobic exercise among individuals with type 2 diabetes remains low due to barriers such as lack of motivation, limited knowledge, and certain health conditions (Katanolli et al., 2022). Moreover, many studies only focus on one clinical parameter either blood glucose or blood pressure resulting in limited evidence that examines both indicators simultaneously. A better understanding of the relationship between aerobic activity and these two outcomes is crucial, as it has significant implications for improving metabolic control and cardiovascular health.

Based on these issues, it is important to conduct research analyzing the relationship between aerobic activity, blood glucose levels, and blood pressure in patients with type 2 diabetes mellitus. This study is expected to provide the effectiveness of aerobic exercise and serve as a foundation for healthcare practitioners to develop more comprehensive educational and intervention programs for individuals with type 2 diabetes mellitus.

Method

This study received ethical approval from the Health Research Ethics Committee (HREC) of Dr. Moewardi General Hospital under approval number 2.312/XI/HREC/2025. The study employed a cross-sectional design and was conducted in November 2025. A total of 37 respondents were recruited from the elderly community health post (Posyandu Lansia) in Senden, Colomadu, using a convenience sampling technique, in which participants were selected based on their availability during data collection and fulfillment of the inclusion criteria.

The inclusion criteria consisted of elderly individuals who were willing to participate as respondents, able to communicate effectively, and in adequate physical and cognitive condition. The exclusion criteria included those with physical or neurological impairments limiting mobility, such as stroke or Parkinson's disease, severe cognitive disorders, a history of injuries affecting walking ability, or any other medical condition that could influence the assessment outcomes.

The classification of diabetes mellitus and hypertension followed the World Health Organization (WHO) criteria. Diabetes mellitus was determined if fasting blood glucose levels were equal to or above 126 mg/dL. Hypertension was diagnosed if systolic blood pressure reached or exceeded 140 mmHg or diastolic blood pressure reached or exceeded 90 mmHg.

Result and Discussion

1. Result

A total of 37 older adults participated in this study. The age group was predominantly 60–65 years old (59.5%), followed by those aged 66–70 years (16.2%), 71–75 years (16.2%), and 76–80 years (8.1%). The mean age was 1.73 with a standard deviation of 1.018. Most respondents were female, accounting for 89.2%, while males represented 10.8% of the sample. The mean value for sex was 1.11 with a standard deviation of 0.315.

Table 1
Characteristics of the Respondent

Variable	N (%)	Min	Max	Mean ± SD
Age (Years)		1	4	1.73 ± 1.1018
60-65	22 (59.5%)			
66-70	6 (16.2%)			
71-75	6 (16.2%)			
76-80	3 (8.1%)			
Gender		1	2	1.11 ± 0.315
Man	4 (10.8%)			
Woman	33 (89.2%)			

Table 2
Normality Test

Data	*p-value*	Description
Aerobic-Diabetes Melitus	0.000	Non-normally distributed data
Aerobic-Hypertension	0.000	Non-normally distributed data

Table 2 presents the results of the normality test performed using the Shapiro–Wilk test, which shows that all variables in this study were not normally distributed, with p-values < 0.05.

Tabel 3
Correlation Test

Data	Z	r	*Asymp. sig. (2-tailed)*
Aerobic-Diabetes Melitus	-3.404	-0.56	0.001
Aerobic-Hypertension	-3.788	-0.62	0.000

The Mann–Whitney test results indicate a significant association between aerobic activity levels and diabetes mellitus status ($p = 0.001$). The Z-score of –3.404 with an effect size of $r = –0.56$ suggests a strong and statistically meaningful effect, indicating that individuals with lower aerobic activity levels tend to have higher blood glucose levels.

Additionally, aerobic activity was also significantly associated with hypertension status ($p < 0.001$). The Z-score of –3.788 and effect size $r = –0.62$ further demonstrate a strong relationship, showing that lower aerobic activity is associated with a greater likelihood of elevated blood pressure among respondents.

2. Discussion

In this study, the demographic characteristics of the respondents represent a typical profile of older adults with a high risk of metabolic and cardiovascular diseases. A total of 59.5% of respondents were within the age range of 60–65 years, followed by those aged 66–70 years (16.2%), 71–75 years (16.2%), and 76–80 years (8.1%). Entering older adulthood, particularly beginning around age 60, structural changes in blood vessels and increased arterial stiffness or vascular aging occur, potentially triggering increased insulin resistance and elevated blood pressure, both of which contribute to the development of type 2 diabetes mellitus and hypertension (Poon et al., 2020). The underlying molecular mechanisms involve oxidative stress, chronic inflammation, and extracellular matrix degradation (Hao et al., 2025).

The predominance of female respondents (89.2%) compared to males (10.8%) has important physiological implications. Among postmenopausal women, decreased estrogen levels lead to the loss of vascular and metabolic protection, including reduced endothelial function, increased oxidative stress, and decreased insulin sensitivity, thereby elevating the risk of hypertension and impaired glucose regulation. Estrogen normally enhances vasodilation through the nitric oxide pathway and supports glucose homeostasis by improving pancreatic β-cell responsiveness to insulin. Thus, its decline contributes to the progression of type 2 diabetes and cardiovascular diseases in older (Sabbatini & Kararigas, 2020).

Additionally, the dominance of older age and female representation in this sample highlights the relevance of community-based health interventions, such as programs delivered through elderly community health posts (posyandu lansia). A previous study showed that moderate aerobic exercise reduces blood pressure in patients with type 2 diabetes and improves metabolic profiles in older adults with diabetes (Miranda-Tueros et al., 2024). Aerobic exercise also benefits psychological health, including reducing depressive symptoms in older adults with diabetes when combined with resistance training. Given that the respondents include older adults with common comorbidities such

as hypertension and diabetes, implementing sustainable community-based aerobic activity programs appears highly appropriate (Kamal *et al.,*, 2025).

Aerobic activity plays a central role in glucose metabolism regulation through increased insulin sensitivity, improved muscle glucose uptake via GLUT-4 activation, reduced systemic inflammation, and enhanced mitochondrial oxidative capacity. In this study, the Mann-Whitney test result ($p = 0.001$; $r = -0.56$) indicated a strong association between lower aerobic activity levels and higher blood glucose levels among older adults. This finding aligns with evidence that moderate-intensity aerobic exercise significantly reduces fasting blood glucose in type 2 diabetes patients through enhanced skeletal muscle metabolic function (Jiang et al., 2025).

Beyond metabolic mechanisms, aerobic activity provides protective effects by reducing visceral fat and modulating adipokines such as adiponectin, which improves insulin sensitivity. A 24-week combination of aerobic and structured exercise demonstrated significant glycemic improvements compared to control groups, indicating stable therapeutic effects rather than short-term responses (Terauchi et al., 2022).

In the elderly population, aerobic activity has added benefits because aging worsens insulin resistance due to muscle mass loss (sarcopenia) and endothelial dysfunction that impairs tissue perfusion. One study found that older adults with type 2 diabetes who regularly engaged in aerobic activity had better glycemic control and lower complication risks than those who were inactive, supporting physical activity as an effective community-level intervention. This finding is consistent with the pattern observed in this study, where respondents with low aerobic activity exhibited a higher tendency toward glycemic disturbances (Ramírez-Alvarado, 2023).

This study also demonstrated a significant association between aerobic activity and hypertension status ($p < 0.001$), with a Z-value of -3.788 and effect size $r = -0.62$, indicating a strong relationship. Physiologically, aerobic activity can lower blood pressure through improved endothelial function, reduced systemic vascular resistance, reduced sympathetic nervous system activity, and increased nitric oxide bioavailability. Supporting evidence shows that aerobic exercise significantly reduces both systolic and diastolic blood pressure in hypertensive individuals (Fu et al., 2022).

Specifically in the elderly population, age-related arterial stiffness does not diminish the cardiovascular benefits of aerobic activity. A study by (Alzahrani et al., 2023) found that aerobic exercise significantly reduced systolic blood pressure in older adults with hypertension without increasing cardiovascular risk, indicating that aerobic exercise is a safe and feasible strategy for this age group.

Aerobic exercise is also relevant for community-based implementation. It is effective in reducing blood pressure and is recommended as a first-line non-pharmacological therapy in older adults. Considering that respondents in this study demonstrated low physical activity levels, implementing aerobic exercise programs through posyandu lansia may serve as a highly relevant and contextually appropriate intervention (Zhang, 2025).

In addition to aerobic activity, health outcomes in patients with type 2 diabetes mellitus are influenced by several other factors that were not directly assessed in this study. Dietary patterns and nutritional status play a crucial role in glycemic control, as the quality of nutrient intake affects insulin sensitivity and glucose metabolism. Evidence from systematic reviews indicates that diets rich in fiber, fruits, and vegetables and low in ultra-processed foods are associated with better glycemic regulation, whereas high consumption of refined carbohydrates and added sugars is linked to poorer blood glucose

control and increased risk of type 2 diabetes mellitus (Díaz-benavides et al., 2025). In addition to nutritional factors, genetic predisposition contributes to interindividual variability in metabolic responses. Specific genetic variants have been shown to influence insulin resistance, glucose homeostasis, and susceptibility to diabetic complications, potentially resulting in different clinical outcomes despite similar non-pharmacological interventions (Sami et al., 2025). Therefore, the findings of this study should be interpreted within the context of other contributing factors, such as dietary patterns and genetic predisposition, which were not specifically examined. Future studies incorporating these variables may provide a more comprehensive understanding of diabetes management in older adults.

Conclusion

Aerobic activity shows a strong and significant association with diabetes mellitus and hypertension among older adults, where lower levels of aerobic activity are linked to higher blood glucose levels and elevated blood pressure. These findings underscore that aerobic interventions can serve as an effective and feasible non-pharmacological strategy to control metabolic and cardiovascular risks in the elderly, particularly within community-based settings such as elderly health posts.

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