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The Effects of Resistance Exercise on Blood Glucose Levels and Ankle-Brachial Index in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Introduction: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder marked by elevated blood glucose levels due to insulin resistance or impaired insulin secretion. The rising prevalence of T2DM in Indonesia, particularly in Bandar Lampung, highlights the need for effective interventions. While programs like Prolanis offer basic support, specific interventions to improve vascular health and prevent complications are still limited.
Objective: This study aimed to assess the effect of resistance exercise on blood sugar levels, foot sensitivity, and ankle-brachial index (ABI) values in patients with T2DM at Kedaton Health Center, Bandar Lampung.
Method: A quantitative quasi-experimental design with a one-group pretest-posttest model was used. Thirty-two individuals with T2DM were selected through purposive sampling. Participants underwent resistance exercise interventions involving repetitive limb movements. Blood sugar levels and ABI values were measured before and after the intervention.
Results: The results demonstrated a significant decrease in blood sugar levels and a notable improvement in ABI values after the intervention, with both outcomes showing a p-value of 0.000. These findings indicate that resistance exercise can enhance glycemic control and peripheral vascular function.
Conclusion: Resistance exercise significantly reduces blood sugar levels and improves ABI values in individuals with T2DM. This form of physical activity offers a promising non-pharmacological approach to managing diabetes and preventing complications. It is recommended that resistance exercise be integrated into routine diabetes care programs. Further research with varied methods and larger samples is encouraged to validate and expand these findings.

Keywords: ankle-brachial index, blood glucose, diabetes mellitus, resistance exercise

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Introduction

Diabetes mellitus is a metabolic disorder characterized by elevated blood glucose levels (hyperglycemia) resulting from impairments in insulin secretion, insulin action, or both. This condition arises due to the inability of the pancreas to produce sufficient insulin to meet the body's needs (Asyikin & Ratnasari Dewi, 2024). Over the past few decades, the global burden of diabetes mellitus has been increasing steadily. According to the World Health Organization (WHO), diabetes is directly responsible for approximately 1.5 million deaths annually (WHO; Aarsand, Hemmingsen et al., 2023). The International Diabetes Federation (IDF) reported that in 2021, 537 million individuals worldwide were living with diabetes, a figure projected to rise to 643 million by 2030 and 783 million by 2045. Indonesia is among the countries experiencing a rapid increase in diabetes cases, with 19.5 million cases recorded in 2021 and an estimated rise to 28.6 million by 2045 (Ditjen, 2024).

Based on IDF data from 2021, Indonesia ranked seventh globally for the highest number of diabetes cases, recording 10.7 million cases. The top three countries were China (140.9 million), India (74.2 million), and Pakistan (33 million) (International Diabetes Federation, 2021). Moreover, the 2023 Indonesian Health Survey (SKI) reported an increase in the national diabetes prevalence, from 10.9% in 2018 (Riskesdas) to 11.7% in 2023. The provinces with the highest diabetes prevalence include DKI Jakarta (3.1%), DI Yogyakarta (2.9%), and East Kalimantan (2.3%), while the lowest prevalence was reported in Papua Pegunungan (0.2%). Lampung Province ranked 25th nationally, with a prevalence rate of 1.2% (Indonesian Health Survey, 2023).

Data from the 2018 Basic Health Research (Riskesdas) further revealed that the highest prevalence of diabetes mellitus in Lampung Province occurred in individuals aged 65–74 years (4.84%). Among cities and regencies in Lampung, Metro City recorded the highest prevalence (3.03%), followed by Bandar Lampung (2.25%) and East Lampung Regency (1.55%) (Riskesdas, 2018).

Kedaton Health Center, an inpatient primary care facility in Bandar Lampung City, has reported a consistent rise in diabetes mellitus cases over the years. In 2021, 1243 cases were recorded, increasing to 2383 in 2022, and slightly rising to 2432 cases in 2023. From January to October 2024, 1595 cases had already been reported, indicating a continuing upward trend. Monthly case data from 2024 show fluctuations: 610 cases from January to March, 628 from April to July, followed by 131 cases in August, 109 in September, and 140 in October.

An interview conducted with 10 diabetes mellitus patients at Kedaton Health Center revealed that half of them had a hereditary history of diabetes. Although four respondents reported regular exercise, nine stated they only engaged in physical activity during the Prolanis (Chronic Disease Management Program) sessions. These sessions typically involve aerobic exercise, without specific interventions for foot ulcer prevention. Most patients reported relying on medication to control their blood sugar, with eight of them using insulin. However, preventive or therapeutic measures for diabetic foot complications were largely absent, as most patients perceived foot care as unnecessary unless visible symptoms appeared.

The health center has implemented several strategies to manage type 2 diabetes mellitus, including the Prolanis program, which encompasses scheduled diabetic aerobics, routine blood glucose monitoring during Posbindu (integrated health post) visits, and diabetic foot care when needed. However, the need for more targeted and comprehensive interventions, such as resistance exercise programs, remains evident to better address blood glucose control and prevent complications such as peripheral artery disease.

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Objective

It is known the effect of resistance exercise on blood sugar levels, foot sensitivity, and ankle brachial index values in patients with type 2 diabetes mellitus at the Kedaton Health Center, Bandar Lampung in 2024..

Method

This study employed a quantitative approach with a quasi-experimental design, specifically utilizing a one-group pretest-posttest model. The population consisted of individuals diagnosed with type 2 diabetes mellitus who were registered at the Kedaton Health Center in Bandar Lampung. A total of 32 respondents were selected as the sample using a purposive sampling technique based on predefined inclusion and exclusion criteria.

Result

Table 1. Pretest and Posttest Comparison of Blood Sugar Levels and Ankle Brachial Index

Group	N	Mean ± SD	*p-value*
Pretest Blood Sugar Levels	32	377.84 ± 96.615	0.000
Posttest Blood Sugar Levels		307.13 ± 81.010	
Pretest *Ankle Brachial Index*	32	0.810 ± 0.093	0.000
Posttest *Ankle Brachial Index*		0.869 ± 0.087	

Based on table above shows that there is a difference in the average blood sugar levels before and after being given resistance exercise intervention with a p-value of 0.000. The results of the ankle brachial index study also show a difference in the average value before and after being given resistance exercise intervention with a p-value of 0.000.

Discussion

Physical exercise plays an important role in improving insulin sensitivity, which refers to the body's ability to respond to insulin and utilize glucose for energy. Insulin acts as a key that allows glucose to enter cells from the bloodstream. Enhanced insulin sensitivity helps in better blood sugar regulation and reduces the risk of insulin resistance, a key factor in the development of type 2 diabetes mellitus. According to Sundayana et al. (2021), physical exercise significantly affects blood sugar levels in individuals with diabetes mellitus, as it increases glucose uptake by active muscles during physical activity, leading to a direct reduction in blood glucose levels. Regular physical activity contributes to better glycemic control over time.

In the present study, the intervention involved resistance exercise, which included repetitive hand and foot movements designed to activate large muscle groups. Rayi Anggita et al. (2021) reported that during physical activity, muscles utilize stored glucose for energy, thereby decreasing glucose reserves and leading to better blood sugar control in patients with type 2 diabetes mellitus.

Furthermore, Fitriani (2024) noted that resistance training, when performed at least four times per week for 30 minutes per session, significantly improves insulin sensitivity. This effect is attributed to enhanced muscle permeability and an increase in insulin receptor density and sensitivity in contracting muscles, thus promoting more efficient glucose uptake.

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The findings of this study support these previous reports. The paired *t*-test results for blood sugar levels and Ankle Brachial Index (ABI), as well as the Wilcoxon test for foot sensitivity, all showed statistically significant improvements with $p < 0.05$, indicating that resistance exercise had a beneficial effect on these clinical outcomes in patients with type 2 diabetes mellitus at Kedaton Health Center, Bandar Lampung. This is consistent with the study by Fitriani et al. (2024), which found that supervised and consistent resistance exercise not only improves glycemic control but also enhances muscle strength and overall physical function. The increased muscle activity during resistance training promotes glucose uptake, and larger muscle mass allows greater glucose storage as glycogen, thereby contributing to stable blood sugar levels and reducing the risk of complications.

In addition to glycemic control, resistance exercise also influences vascular and neurological health. Prameswari et al. (2024) demonstrated that strength training enhances systemic blood flow, including to the lower extremities. Improved circulation is critical for nerve health and helps reduce the risk of diabetic neuropathy. Resistance training stimulates nerve function in the feet, enhancing sensitivity and alleviating symptoms such as numbness or tingling. Stronger lower limb muscles also protect peripheral nerves from pressure or injury.

The improvement in ABI observed in this study suggests enhanced vascular elasticity and peripheral circulation. Hidayati (2022) emphasized that regular resistance exercise in diabetic patients can prevent diabetic foot ulcers, improve blood flow, strengthen leg muscles, prevent foot deformities, and support joint mobility. Resistance training is also associated with improved endothelial function, which is vital for maintaining vascular health and preventing atherosclerotic plaque buildup. Furthermore, it reduces the risk of peripheral artery disease (PAD), a common vascular complication in diabetes.

Additionally, Ervanti et al. (2023) reported that active skeletal muscle movement stimulates the release of nitric oxide from blood vessels, which induces vasodilation and promotes healthy blood flow. This mechanism further supports the role of resistance training in maintaining stable blood glucose levels and improving ABI.

Conclusion

This study concludes that resistance exercise has a significant effect on improving health outcomes in individuals with type 2 diabetes mellitus. Specifically, resistance exercise effectively contributes to the reduction of blood sugar levels, indicating improved glycemic control. Additionally, resistance exercise plays an important role in enhancing ankle brachial index values, which reflects better peripheral circulation and vascular function.

The findings support the integration of resistance training into diabetes management programs as a non-pharmacological intervention to help regulate blood glucose and improve vascular health. Future research is recommended to expand the scope of this study by exploring other intervention methods, research designs, and analytical approaches to strengthen the evidence base and applicability of resistance exercise in various clinical and community settings.

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Authors' contribution

Each author contributed equally in all the parts of the research. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

Conflict of interest

The researchers stated that there is no conflict of interest related to the implementation and publication of the results of this research. The entire research process, from planning, data collection, analysis, to report preparation, was carried out independently without any influence or pressure from any third party. A commitment to research ethics is upheld throughout the research process, ensuring transparency, accuracy and honesty in reporting results. Respondents' participation was voluntary with informed consent, and their confidentiality and privacy were maintained in accordance with applicable research ethics standards. With this statement, researchers hope that the research results can be trusted and used as a valid reference for the development of science and health practices related to ethnomedicine and reproductive health.

Ethical consideration

Not applicable.

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