

EFFECTIVENESS OF DIABETIC FOOT EXERCISE ON BLOOD GLUCOSE LEVELS AMONG PATIENTS WITH DIABETES MELLITUS: A QUASI-EXPERIMENTAL STUDY

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Abstract

Background: Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia caused by impaired insulin production, decreased insulin sensitivity, or both. Poor glycemic control may lead to various serious complications. Physical activity is an essential component of diabetes management, and diabetic foot exercise has emerged as a simple, inexpensive, and easily implemented intervention. Nevertheless, evidence supporting its effectiveness remains limited. **Objective:** This study aimed to evaluate the effect of diabetic foot exercise on blood glucose levels in patients with diabetes mellitus. **Methods:** A quasi-experimental study using a pretest–posttest control group design was conducted among 40 patients with DM at Wawonasa Community Health Center, Manado, Indonesia. Participants were divided into an intervention group and a control group, each consisting of 20 individuals. The intervention group performed diabetic foot exercises for four weeks, while the control group received routine care. **Results:** Blood glucose levels decreased significantly in the intervention group ($p < 0.001$), whereas no significant change was found in the control group ($p = 0.059$). The reduction in blood glucose levels was significantly greater among participants who performed diabetic foot exercises ($p = 0.044$). **Conclusion:** Diabetic foot exercise is an effective, safe, and low-cost strategy for improving glycemic control in patients with diabetes mellitus.

Keywords: Diabetic Foot Exercise, Blood Glucose, Glycemic Control, Quasi-Experimental Study

Introduction

Diabetes mellitus (DM) remains a major public health concern worldwide and is recognized as one of the most prevalent chronic non-communicable diseases. This metabolic disorder is marked by persistently elevated blood glucose concentrations resulting from inadequate insulin secretion, reduced insulin sensitivity, or the coexistence of both conditions ^[1]. The global burden of diabetes continues to rise at an alarming rate. In 2021, more than 537 million adults were living with the disease, and this number is projected to increase to approximately 783 million by 2045 ^[2]. Poorly controlled blood glucose levels can lead to a wide range of serious complications affecting multiple organ systems. These include diabetic nephropathy, retinopathy, neuropathy, cardiovascular disorders, and peripheral vascular disease, all of which may substantially impair health status and functional capacity ^[3]. Consequently, achieving and maintaining optimal glycemic control has become a fundamental objective in diabetes management, as it plays a critical role in preventing complications, slowing disease progression, and improving the overall quality of life of individuals living with diabetes ^[4].

Diabetes management requires a comprehensive approach involving pharmacological therapy and lifestyle modification. Regular physical activity is an important non-pharmacological strategy

because muscle activity enhances glucose uptake, improves insulin sensitivity, and supports metabolic control ^[5]. However, older adults and patients with limited mobility may experience difficulties participating in conventional exercise programs, emphasizing the need for simple and accessible physical activities ^[6]. Diabetic foot exercise is a low-cost and practical intervention involving structured foot and ankle movements aimed at improving peripheral circulation, maintaining muscle function, and supporting glucose regulation. By promoting muscle activation and enhancing peripheral blood circulation, this exercise may facilitate glucose uptake and support better glycemic regulation in individuals with diabetes mellitus ^{[5],[7]}.

Previous research has demonstrated that diabetic foot exercise may contribute to lowering blood glucose levels and enhancing peripheral blood circulation, foot sensitivity, and lower-extremity function among patients with diabetes mellitus ^{[8],[9],[10]}. However, several studies have used one-group pretest–posttest designs, resulting in limited evidence regarding comparative effectiveness. Differences in intervention duration, frequency, and participant characteristics also indicate the need for further research using stronger study designs. Therefore, this study was conducted to assess the effectiveness of diabetic foot exercise in reducing blood glucose levels among patients with diabetes mellitus through a quasi-experimental pretest–posttest control group study design. The findings are expected to provide evidence supporting the use of diabetic foot exercise as a complementary nursing intervention and an accessible strategy for improving glycemic control in diabetes management.

Method

Research Design

This study employed a quasi-experimental pretest–posttest control group design to examine the impact of diabetic foot exercise on blood glucose levels in patients with type 2 diabetes mellitus. The study was conducted at Wawonasa Community Health Center, Manado City, North Sulawesi, Indonesia. The study included an intervention group receiving diabetic foot exercise and a control group receiving routine diabetes care. Blood glucose levels were measured at the beginning of the study and reassessed after the completion of the four-week intervention period.

Population and Sample

The study population consisted of adult patients with a confirmed diagnosis of type 2 diabetes mellitus who received healthcare services at Wawonasa Community Health Center, Manado City, North Sulawesi, Indonesia, throughout the study period. Participants were recruited through a purposive sampling technique, with selection based on predefined inclusion and exclusion criteria. A total of 40 respondents met the eligibility requirements and were enrolled in the study, including 20 individuals assigned to the diabetic foot exercise group and 20 individuals allocated to the control group. Eligible participants were patients diagnosed with type 2 diabetes mellitus, aged 45 years or older, with a disease duration of at least one year, experiencing elevated blood glucose levels, capable of communicating effectively and performing diabetic foot exercises, and willing to participate as indicated by signed informed consent. Participants were excluded if they had severe diabetic foot complications, physical impairments that limited exercise participation, medical conditions that contraindicated physical activity, involvement in other structured exercise programs, hospitalization during the study period, or failure to complete the intervention protocol.

Data Sources and Measurement Instruments

Primary data were collected directly from participants through demographic questionnaires and blood glucose measurements. Participant characteristics included age, sex, educational level, occupation, and duration of diabetes mellitus. Blood glucose levels were measured using a calibrated digital glucometer following standardized procedures and expressed in mg/dL. Measurements were conducted twice: before the intervention (pretest) and after four weeks of intervention (posttest). Blood glucose reduction was calculated by subtracting post-intervention values from pre-intervention values.

Data Collection Technique

Data were collected by trained researchers using structured interviews with participants and direct assessment of blood glucose levels at Wawonasa Community Health Center, Manado City, North Sulawesi, Indonesia. The intervention group underwent a structured diabetic foot exercise program for four weeks, involving a series of foot and ankle movements aimed at enhancing peripheral blood circulation, increasing muscle activity, and supporting glucose metabolism. The control group continued to receive routine diabetes management without diabetic foot exercise.

Data Analysis

This study involved adult patients diagnosed with type 2 diabetes mellitus who were receiving treatment at Wawonasa Community Health Center, Manado City, North Sulawesi, Indonesia, during the research period. Participants were selected using a purposive sampling approach, whereby respondents were chosen according to established inclusion and exclusion criteria. In total, 40 participants fulfilled the eligibility requirements and were included in the study. Of these, 20 participants were assigned to the diabetic foot exercise group, while the remaining 20 were placed in the control group. The inclusion criteria encompassed patients with a confirmed diagnosis of type 2 diabetes mellitus, aged 45 years and above, having lived with the disease for at least one year, presenting with elevated blood glucose levels, possessing the ability to communicate and perform diabetic foot exercises independently, and expressing willingness to participate through written informed consent. Individuals were excluded from the study if they experienced severe diabetic foot complications, had physical limitations that hindered exercise performance, suffered from medical conditions restricting physical activity, were involved in other exercise-based interventions, required hospitalization during the study, or were unable to complete the intervention until the end of the research period.

Results

A total of 40 patients with diabetes mellitus participated. In this study, 40 participants were included, with 20 participants assigned to the diabetic foot exercise group and 20 participants allocated to the control group. The demographic and clinical characteristics of the participants are summarized in Table 1. The mean age of respondents was 62.60 ± 6.78 years in the diabetic foot exercise group and 61.85 ± 9.50 years in the control group, indicating that most participants were older adults. The average duration of diabetes mellitus was 8.48 ± 4.49 years in the intervention group and 9.90 ± 4.98 years in the control group, showing comparable disease duration between groups before the intervention. Female respondents predominated in both groups, accounting for 62.5% of the total sample. Most participants were housewives (52.5%), and the majority had an elementary school education (57.5%). Overall, the initial characteristics of participants in both groups showed comparable distributions across variables, including age, diabetes duration, sex, occupation, and educational attainment. These comparable characteristics indicate that the groups had similar demographic and clinical profiles before the implementation of the diabetic foot exercise intervention.

Table 1. Baseline Sociodemographic and Clinical Characteristics of Participants Assigned to the Intervention and Control Groups (N = 40)

Characteristics	Diabetic Foot Exercise (n=20)	Control (n=20)	Total (n=40)
Age (years), Mean $\pm$ SD	62,60 $\pm$ 6,78	61,85 $\pm$ 9,50	-
Duration of Diabetes (years), Mean $\pm$ SD	8,48 $\pm$ 4,49	9,90 $\pm$ 4,98	-
Sex, n (%)			
Male	9 (45,0)	6 (30,0)	15 (37,5)
Female	11 (55,0)	14 (70,0)	25 (62,5)
Occupation, n (%)			
Employed	5 (25,0)	4 (20,0)	9 (22,5)
Homemaker	8 (40,0)	13 (65,0)	21 (52,5)
Unemployed	7 (35,0)	3 (15,0)	10 (25,0)
Educational Level, n (%)			
Elementary School	10 (50,0)	13 (65,0)	23 (57,5)
Junior High School	1 (5,0)	2 (10,0)	3 (7,5)
Senior High School	8 (40,0)	3 (15,0)	11 (27,5)
Bachelor's Degree	0 (0,0)	2 (10,0)	2 (5,0)
Diploma IV	1 (5,0)	0 (0,0)	1 (2,5)

Note: Data are expressed as mean $\pm$ standard deviation (SD) for numerical variables and as frequency with percentage values for categorical variables.

The differences in blood glucose levels before and after the intervention were analyzed using the Wilcoxon Signed Rank Test, as the data did not meet the assumption of a normal distribution. The analysis was conducted to assess the effect of diabetic foot exercise on glycemic control among individuals with diabetes mellitus. In the diabetic foot exercise group (n = 20), the median blood glucose level decreased from 185.0 mg/dL (IQR = 68.0) before the intervention to 131.5 mg/dL (IQR = 84.0) after four weeks of diabetic foot exercise. The statistical test revealed a significant difference in blood glucose levels before and after the intervention ($Z = -3.920$, $p < 0.001$), indicating a meaningful change following the diabetic foot exercise program.

This finding indicates that diabetic foot exercise was associated with a significant improvement in blood glucose control among patients with diabetes mellitus. Meanwhile, the control group (n = 20) showed a decrease in median blood glucose levels from 250.0 mg/dL (IQR = 96.0) at baseline to 222.5 mg/dL (IQR = 83.0) after the observation period. However, this reduction was not statistically significant ($Z = -1.885$, $p = 0.059$), suggesting that routine care without additional diabetic foot exercise did not produce a meaningful change in blood glucose levels during the study period.

The comparison of changes between groups showed that respondents who received diabetic foot exercise experienced a larger reduction in blood glucose levels, with a median decrease of 53.5 mg/dL, compared with 27.5 mg/dL in the control group. These results suggest that diabetic foot exercise may contribute to improved glucose regulation through increased physical activity, which can support glucose utilization and enhance metabolic control. Overall, these results indicate that a four-week diabetic foot exercise intervention contributed to a reduction in blood glucose levels among patients with diabetes mellitus. The significant changes observed in the intervention group suggest that diabetic foot exercise may serve as an effective complementary non-pharmacological strategy to support diabetes management in addition to conventional treatment.

Table 2. Changes in Blood Glucose Levels Before and After the Intervention in the Diabetic Foot Exercise and Control Groups

Group	Pre-Intervention Median (IQR), mg/dL	Post-Intervention Median (IQR), mg/dL	Z	p-value
Diabetic Foot Exercise (n = 20)	185,0 (68,0)	131,5 (84,0)	-3,920	<0,001*
Control (n = 20)	250,0 (96,0)	222,5 (83,0)	-1,885	0,059

Note: Data are presented as median and interquartile range (IQR). Statistical analysis was performed using the Wilcoxon Signed Rank Test. * $p < 0.05$ indicates statistical significance.

The comparison of changes in blood glucose levels between the two groups showed that participants who received diabetic foot exercise experienced a more substantial reduction in blood glucose levels compared with those in the control group. The mean reduction in blood glucose was 56.0 ± 30.4 mg/dL in the diabetic foot exercise group compared with 25.2 ± 58.6 mg/dL in the control group. The average difference in blood glucose reduction between the two groups was 30.8 mg/dL. The Independent Samples t-Test demonstrated that this difference was statistically significant ($t = 2.087$, $p = 0.044$). These results indicate that diabetic foot exercise may provide greater benefits in improving glycemic control compared with routine diabetes care alone among patients with diabetes mellitus.

Table 3. Comparison of Mean Reduction in Blood Glucose Levels Between the Diabetic Foot Exercise and Control Groups

Group	n	Mean Reduction $\pm$ SD (mg/dL)	p-value
Diabetic Foot Exercise	20	56.0 ± 30.4	
Control	20	25.2 ± 58.6	
Mean Difference		30.8 mg/dL	0.044*

Note: The statistical evaluation was conducted using the Independent Samples t-Test, with a p-value of <0.05 considered indicative of statistical significance.

Discussion

This study found that diabetic foot exercise was effective in significantly lowering blood glucose levels among patients with diabetes mellitus. Participants in the intervention group experienced a greater reduction in blood glucose compared with the control group, suggesting that diabetic foot exercise can be used as a beneficial non-pharmacological intervention to support glycemic control. These findings are consistent with current clinical recommendations that emphasize regular physical activity as a core component of diabetes management ^{[4],[11]}. Most participants were older adults with a mean age of around 62 years, reflecting the higher prevalence of type 2 diabetes in this age group. Age-related physiological changes such as reduced insulin sensitivity, decreased β -cell function, and lower physical activity levels contribute to poorer glycemic control in older populations ^{[12],[13]}.

Female participants were more dominant in both groups. This may be related to higher health service utilization among women and metabolic changes after menopause that increase the risk of diabetes ^[14]. In addition, most respondents had low educational attainment and a long duration of diabetes (>8 years), which may negatively affect diabetes self-management ability and increase the risk of complications due to prolonged exposure to hyperglycemia ^[11]. These characteristics highlight the need for simple, practical, and accessible interventions in this population.

The results indicated a significant decrease in blood glucose levels among participants in the intervention group following four weeks of diabetic foot exercise. These findings are in agreement with

previous research demonstrating that structured foot exercise programs can contribute to improved glycemic control in individuals with type 2 diabetes mellitus ^[10]. The physiological mechanism may be explained by increased skeletal muscle activity during exercise, which enhances glucose uptake through GLUT-4 translocation independent of insulin. This process improves insulin sensitivity and facilitates glucose utilization by peripheral tissues. Additionally, improved peripheral circulation resulting from repeated foot and ankle movements may enhance oxygen delivery and metabolic efficiency, further supporting glucose regulation ^[15]. The intervention group showed a significantly greater decline in blood glucose levels compared with the control group. Although participants in the control group also experienced a reduction in blood glucose, the improvement was relatively smaller than that observed in the intervention group. These findings indicate that diabetic foot exercise may offer additional advantages beyond standard diabetes care and routine treatment in supporting glycemic control ^[4].

From a clinical perspective, diabetic foot exercise is a simple, low-cost, and safe intervention that can be performed by older adults without specialized equipment. Its practicality makes it suitable for integration into community-based diabetes management programs. Nurses play a key role in educating patients, demonstrating exercise techniques, and supporting adherence to improve long-term outcomes. This aligns with evidence emphasizing the importance of self-management education in diabetes care ^[16]. The findings of this study provide several meaningful implications. From a clinical perspective, diabetic foot exercise may be recommended as a complementary intervention to support improved glycemic control among individuals with type 2 diabetes mellitus. In nursing practice, it can be incorporated into routine health education programs to enhance patient self-management skills. At the community level, this intervention may be implemented as part of chronic disease management programs due to its simplicity, safety, and low cost. Furthermore, promoting regular diabetic foot exercise may help reduce the risk of long-term diabetes complications by improving blood glucose control.

This study has several limitations. First, the relatively small sample size and the single-center setting at Wawonasa Community Health Center, Manado City, North Sulawesi, Indonesia may limit the generalizability of the findings to other healthcare settings. Second, the relatively short intervention period of four weeks may have limited the ability to assess the long-term effects of diabetic foot exercise on sustained glycemic control. Third, participant adherence to the exercise program was not continuously monitored in detail, which may influence the consistency of the intervention effect. Finally, potential confounding variables, including dietary patterns, medication adherence, and physical activity performed outside the intervention program, were not completely controlled in this study. Future research involving larger sample sizes, extended follow-up durations, and more rigorous management of potential confounding factors is recommended to provide stronger evidence regarding the effectiveness of diabetic foot exercise.

Conclusion

The present study revealed that diabetic foot exercise can serve as an effective non-pharmacological approach to decrease blood glucose levels in individuals with diabetes mellitus. Participants in the intervention group experienced a significant reduction in blood glucose levels after completing the diabetic foot exercise program, while the control group showed no statistically significant changes. Furthermore, the magnitude of blood glucose reduction was significantly greater among participants who performed diabetic foot exercises compared with those who received routine care alone. The findings suggest that regular diabetic foot exercise contributes to improved glycemic control through enhanced peripheral circulation, increased glucose uptake by skeletal muscles, and improved insulin sensitivity. As a simple, low-cost, and easily implemented physical activity, diabetic foot exercise can be incorporated into routine diabetes self-management practices and community-based diabetes care programs.

From a clinical perspective, diabetic foot exercise offers additional benefits beyond blood glucose reduction, including the promotion of lower-extremity circulation, maintenance of foot function, and potential prevention of diabetes-related foot complications. Therefore, healthcare professionals, particularly nurses, should actively educate and encourage patients with diabetes mellitus to perform diabetic foot exercises regularly as part of comprehensive diabetes management. Overall, diabetic foot exercise represents an accessible and effective complementary intervention that may support better metabolic outcomes and improve the quality of diabetes care. Future research involving larger sample sizes, extended follow-up periods, and the inclusion of additional clinical parameters, such as glycated hemoglobin (HbA1c), is recommended to further validate the long-term effectiveness of diabetic foot exercise in diabetes management.

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