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JURNAL **TRILOGI**
Ilmu Teknologi, Kesehatan, dan Humaniora

Effect of Diabetic Foot Exercise on Foot Sensitivity and Blood Glucose among Type 2 Diabetes

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Abstract

Background: Diabetic neuropathy and poor glycemic control remain major complications among patients with type 2 diabetes mellitus (T2DM), contributing to decreased foot sensitivity and increased risk of diabetic foot ulcers. Non-pharmacological interventions, such as diabetic foot exercises, are considered effective strategies to improve peripheral circulation and glycemic control. However, evidence regarding their effectiveness in primary health care settings remains limited. Objective: This study aimed to analyze the effect of diabetic foot exercise on foot sensitivity and blood glucose levels among patients with type 2 diabetes mellitus. Methods: A quantitative quasi-experimental study with a one-group pretest-posttest design was conducted at Wangkal Community Health Center. The population consisted of 54 patients with T2DM, and 29 respondents were selected using total sampling based on inclusion criteria. Data on foot sensitivity were measured using a monofilament test, while blood glucose levels were assessed using a glucometer. Respondents participated in a structured diabetic foot exercise program for three consecutive days. Data were analyzed using the Paired t-test with a significance level of $p < 0.05$. Results: The findings showed a significant improvement in foot sensitivity after the intervention, with the mean score increasing from 10.52 to 14.72. In addition, the average blood glucose level decreased from 233.38 mg/dL to 195.03 mg/dL after the intervention. Statistical analysis indicated that diabetic foot exercise had a significant effect on improving foot sensitivity and reducing blood glucose levels ($p = 0.000$). Conclusion: Diabetic foot exercise is an effective non-pharmacological intervention to improve foot sensitivity and reduce blood glucose levels among patients with type 2 diabetes mellitus. The implementation of regular diabetic foot exercise is recommended as part of nursing interventions and community-based diabetes management in primary health care settings.

Keywords: blood glucose level; diabetic foot exercise; foot sensitivity; quasi-experimental study; type 2 diabetes mellitus.

Abstrak

Latar Belakang: Neuropati diabetik dan pengendalian glikemik yang buruk masih menjadi komplikasi utama pada pasien diabetes mellitus tipe 2 (DMT2), yang berkontribusi terhadap penurunan sensitivitas kaki dan peningkatan risiko ulkus kaki diabetik. Intervensi non-farmakologis, seperti senam kaki diabetik, dianggap sebagai strategi yang efektif untuk meningkatkan sirkulasi perifer dan kontrol glikemik. Namun, bukti mengenai efektivitasnya di layanan kesehatan primer masih terbatas. Tujuan: Penelitian ini bertujuan untuk menganalisis pengaruh senam kaki diabetik terhadap sensitivitas kaki dan kadar gula darah pada pasien diabetes mellitus tipe 2. Metode: Penelitian kuantitatif dengan desain quasi-eksperimental menggunakan pendekatan one-group pretest-posttest dilakukan di Puskesmas Wangkal. Populasi penelitian terdiri dari 54 pasien DMT2, dan sebanyak 29 responden dipilih menggunakan teknik total sampling sesuai kriteria inklusi. Data sensitivitas kaki diukur menggunakan uji monofilamen, sedangkan kadar gula darah diukur menggunakan glukometer. Responden mengikuti program senam kaki diabetik terstruktur selama tiga hari berturut-turut. Analisis data dilakukan menggunakan uji Paired t-test dengan tingkat signifikansi $p < 0,05$. Hasil: Hasil penelitian menunjukkan adanya peningkatan signifikan pada sensitivitas kaki setelah intervensi, dengan rata-rata skor meningkat dari 10,52 menjadi 14,72. Selain itu, rata-rata kadar gula darah menurun dari 233,38 mg/dL menjadi 195,03 mg/dL setelah intervensi. Analisis statistik menunjukkan bahwa senam kaki diabetik berpengaruh signifikan terhadap peningkatan sensitivitas kaki dan penurunan kadar gula darah ($p = 0,000$). Kesimpulan: Senam kaki diabetik merupakan intervensi non-farmakologis yang efektif untuk meningkatkan sensitivitas kaki dan menurunkan kadar gula darah pada pasien diabetes mellitus tipe 2. Implementasi senam kaki diabetik secara rutin direkomendasikan sebagai bagian dari intervensi keperawatan dan manajemen diabetes berbasis komunitas di layanan kesehatan primer.

Katakunci: diabetes mellitus tipe 2; kadar gula darah; quasi-eksperimen; sensitivitas kaki; senam kaki diabetik.

1 Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. It has become one of the most significant global public health challenges due to its increasing prevalence and associated complications (Hasanah et al., 2024; SUPUTRI et al., 2024). The World Health Organization (Herawati et al., 2023) estimates that more than 422 million people worldwide live with diabetes, with the majority residing in low- and middle-income countries. The prevalence continues to rise each year, leading to increased morbidity, mortality, and healthcare costs. In Indonesia, diabetes mellitus ranks among the top non-communicable diseases contributing to disability and reduced quality of life, particularly among adults and the elderly.

Type 2 diabetes mellitus (T2DM) is the most common form of diabetes, accounting for approximately 90–95% of all cases. This condition is primarily associated with insulin resistance and progressive pancreatic β -cell dysfunction. Uncontrolled blood glucose levels over time can lead to various acute and chronic complications affecting multiple organ

systems (Hapsari et al., 2025; Morrison et al., 2011; Vazquez-Benitez et al., 2015). Chronic hyperglycemia contributes to both macrovascular complications, such as cardiovascular disease and stroke, and microvascular complications, including retinopathy, nephropathy, and neuropathy. Among these complications, diabetic neuropathy is one of the most frequently reported and can significantly impair patients' functional abilities and quality of life.

Peripheral neuropathy in patients with T2DM often manifests as decreased foot sensitivity, numbness, tingling, or pain (Pop-Busui et al., 2022; Zhu et al., 2024). Reduced foot sensitivity increases the risk of unnoticed injuries, infections, and ultimately diabetic foot ulcers. Diabetic foot ulcers are a major cause of hospitalization and lower-extremity amputations among patients with diabetes. Studies indicate that approximately 15% of individuals with diabetes will develop foot ulcers during their lifetime, and a substantial proportion may require amputation if preventive measures are not implemented. These complications not only reduce physical functioning but also increase psychological distress and healthcare expenditure.

In Indonesia, the prevalence of diabetes continues to increase, including in East Java Province (Aisyah et al., 2024; Oktora & Butar, 2022; Wahidin et al., 2024). Reports from regional health authorities indicate that diabetes mellitus is among the most common chronic diseases managed in primary health care facilities. Despite ongoing efforts to improve diabetes management, many patients still experience inadequate glycemic control and limited knowledge regarding self-care practices. In particular, preventive education related to foot care and physical activity is often insufficient, especially in community health centers serving rural and semi-urban populations. As a result, many patients remain at high risk of developing diabetic neuropathy and foot complications.

Effective management of diabetes mellitus requires a comprehensive approach involving pharmacological and non-pharmacological strategies (Hajduk-Maślak et al., 2024; Igwesi-Chidobe et al., 2022). Standard diabetes management typically includes medication, dietary regulation, regular physical activity, blood glucose monitoring, and patient education. Physical activity plays a crucial role in improving insulin sensitivity, enhancing glucose uptake by muscles, and maintaining overall metabolic control. Regular exercise has been shown to reduce blood glucose levels, improve circulation, and prevent complications associated with diabetes.

One specific form of physical activity recommended for patients with diabetes is diabetic foot exercise. Diabetic foot exercise consists of a series of structured movements aimed at improving blood circulation in the lower extremities, strengthening foot and leg muscles, and maintaining joint flexibility. These exercises are simple, low-cost, and can be performed independently by patients at home or in community health settings. Improved peripheral circulation resulting from regular foot exercise may help enhance oxygen and nutrient delivery to tissues, thereby reducing the risk of neuropathy and ulcer formation. Additionally, physical activity can increase glucose utilization by muscle cells, contributing to improved glycemic control.

Previous studies have demonstrated the potential benefits of diabetic foot exercise in improving foot sensitivity and reducing blood glucose levels among patients with T2DM. Several quasi-experimental and experimental studies reported significant improvements in

peripheral circulation and sensory function following regular foot exercise interventions. Moreover, diabetic foot exercise has been associated with reduced neuropathic symptoms and improved quality of life among patients with diabetes. Despite these promising findings, the implementation of structured foot exercise programs in primary health care settings remains limited. Many patients with diabetes have not received adequate education or training regarding foot exercises as part of routine diabetes management.

A preliminary study conducted at Wangkal Community Health Center revealed that many patients with type 2 diabetes mellitus had never received specific education about diabetic foot care or exercise. Limited access to health information and lack of structured exercise programs contributed to low awareness and poor self-management practices among patients. Consequently, many individuals experienced decreased foot sensitivity and uncontrolled blood glucose levels. These conditions highlight the need for effective, practical, and community-based interventions to improve diabetes management and prevent complications.

Given the importance of non-pharmacological interventions in diabetes care, diabetic foot exercise represents a promising strategy to improve patient outcomes (Fakruddin & Alfiandi, 2025; Zhou et al., 2022). However, further empirical evidence is needed to evaluate its effectiveness in primary health care settings, particularly in community-based populations. Understanding the impact of diabetic foot exercise on both foot sensitivity and blood glucose levels is essential for developing evidence-based nursing interventions and health promotion programs.

Therefore, this study aimed to analyze the effect of diabetic foot exercise on foot sensitivity and blood glucose levels among patients with type 2 diabetes mellitus in a primary health care setting. The findings of this study are expected to contribute to the development of effective community-based diabetes management strategies and provide evidence to support the integration of diabetic foot exercise into routine nursing care and patient education programs.

2 Method

Study Design

This study employed a quantitative quasi-experimental design using a one-group pretest-posttest approach to evaluate the effect of

diabetic foot exercise on foot sensitivity and blood glucose levels among patients with type 2 diabetes mellitus. This design was selected to assess changes before and after the intervention within the same group of participants in a primary health care setting (Munawaroh & Rahman, 2024; Sufiati et al., 2025).

Setting and Participants

The study was conducted at Wangkal Community Health Center, Probolinggo, East Java, Indonesia. Data collection was carried out in November 2024. The population consisted of all patients diagnosed with type 2 diabetes mellitus who were registered at the community health center, totaling 54 individuals.

The sample size included 29 respondents who met the inclusion criteria and agreed to participate in the study. A total sampling technique was applied to ensure that all eligible patients were included. Inclusion criteria were: (1) patients diagnosed with type 2 diabetes mellitus, (2) aged over 40 years, (3) able to participate in physical activity, (4) willing to participate and sign informed consent, and (5) actively attending chronic disease management programs at the health center. Exclusion criteria included patients with severe complications such as gangrene, severe mobility limitations, or other medical conditions that could interfere with the intervention or data collection.

Intervention

The intervention consisted of a structured diabetic foot exercise program designed to improve peripheral circulation and foot muscle strength. The exercise program included a series of foot and ankle movements such as toe flexion and extension, ankle rotation, heel and toe lifting, and object manipulation using the feet. The exercises were performed under supervision and followed a standardized operating procedure to ensure consistency.

Participants performed the diabetic foot exercise for approximately 15–20 minutes per session over three consecutive days. Each session was conducted in a comfortable and safe environment within the health center. Participants were guided and monitored by the researcher to ensure correct execution of movements and adherence to the exercise protocol.

Variables and Measurement

The independent variable in this study was the implementation of diabetic foot exercise. The

dependent variables were foot sensitivity and blood glucose levels.

Foot sensitivity was measured using a 10-g monofilament test applied to specific points on the plantar surface of the foot. Participants were asked to close their eyes during the examination and respond to each stimulus. A score of 1 was given for each correctly perceived stimulus and 0 for an unperceived stimulus, with total scores indicating the level of foot sensitivity.

Blood glucose levels were measured using a digital glucometer and recorded in mg/dL. Measurements were taken before the intervention (pretest) and after completion of the exercise program (posttest). All instruments used in this study followed standard clinical measurement procedures.

Data Collection Procedure

Data collection began after obtaining permission from the Faculty of Health and the Wangkal Community Health Center. Eligible participants were informed about the study objectives, procedures, benefits, and potential risks. Written informed consent was obtained from all participants prior to data collection.

Baseline measurements of foot sensitivity and blood glucose levels were conducted before the intervention. Participants then completed the diabetic foot exercise program according to the established protocol. After completion of the intervention period, posttest measurements of foot sensitivity and blood glucose levels were obtained using the same instruments and procedures as the pretest.

Data Analysis

Data were analyzed using statistical software. Descriptive statistics were used to summarize participant characteristics, including age, gender, education level, occupation, and duration of diabetes. The results are presented in frequency distributions, means, and standard deviations.

Inferential analysis was performed to determine the effect of diabetic foot exercise on foot sensitivity and blood glucose levels. Normality of the data was assessed using the Shapiro–Wilk test. Since the data were normally distributed, the Paired t-test was used to compare pretest and posttest measurements. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

This study adhered to ethical principles in research involving human participants. Participants were informed about the purpose, procedures, and voluntary nature of the study. Written informed consent was obtained prior to participation. Participant confidentiality and anonymity were maintained by using coded data and ensuring that all collected information was used solely for research purposes. Participants were also informed of their right to withdraw from the study at any time without any consequences.

3 Result

Results

1. Characteristics of Respondents

A total of 29 patients with type 2 diabetes mellitus participated in this study. Respondents were selected based on inclusion criteria and participated fully in the intervention and evaluation process.

Table 1. Characteristics of Respondents (n = 29)

Variable	Category	Frequency	Percentage (%)
Age	46–55 years	2	6.9
	56–65 years	18	62.1
	66–75 years	9	31.0
Gender	Male	14	48.3
	Female	15	51.7
Education	Elementary school	8	27.6
	Junior high school	7	24.1
	Senior high school	11	37.9
	Diploma/Bachelor	3	10.3
Occupation	Unemployed	9	31.0
	Trader	6	20.7
	Farmer	5	17.2
	Government employee	4	13.8
	Private employee	5	17.2
Duration of DM	1–3 years	12	41.4
	4–6 years	11	37.9
	> 6 years	6	20.7

Most respondents were aged 56–65 years (62.1%), female (51.7%), and had a senior high school education (37.9%). The majority were

unemployed (31.0%) and had suffered from diabetes mellitus for 1–3 years (41.4%). Table 1 shows that most respondents were aged 56–65 years (62.1%), indicating that the majority were in the late adulthood group, which is highly vulnerable to type 2 diabetes mellitus and its complications due to decreased metabolic function and peripheral circulation. Female respondents slightly predominated (51.7%), suggesting relatively balanced gender distribution in diabetes cases within the community. In terms of education, most respondents had completed senior high school (37.9%), reflecting a moderate level of health literacy that may influence understanding of disease management and self-care practices. The majority of respondents were unemployed (31.0%), which may affect physical activity patterns and access to health resources. Based on the duration of illness, most participants had experienced diabetes mellitus for 1–3 years (41.4%), indicating that many were still in the early phase of the disease but remained at risk of developing complications if glycemic control and preventive care were not optimally maintained. Overall, these characteristics demonstrate that respondents were within a high-risk group requiring comprehensive and continuous diabetes management interventions.

2. Foot Sensitivity Before and After Intervention

Table 2. Foot Sensitivity Scores Before and After Diabetic Foot Exercise

Measurement	Minimum	Maximum	Mean	Std. Deviation
Pretest	6	14	10.52	2.530
Posttest	11	19	14.72	2.086

The mean foot sensitivity score increased from 10.52 before intervention to 14.72 after the intervention. This indicates an average improvement of 4.20 points following the diabetic foot exercise program.

3. Blood Glucose Levels Before and After Intervention

Table 3. Blood Glucose Levels Before and After Diabetic Foot Exercise

Measurement	Minimum	Maximum	Mean (mg/dL)	Std. Deviation
Pretest	170	360	233.38	48.642
Posttest	110	320	195.03	49.404

The average blood glucose level decreased from 233.38 mg/dL before the intervention to 195.03 mg/dL after the intervention, with an average reduction of 38.35 mg/dL. **Tables 2 and 3** indicate significant improvements in both foot sensitivity and blood glucose levels following the implementation of diabetic foot exercise. The mean foot sensitivity score increased from 10.52 before the intervention to 14.72 after the intervention, reflecting an average improvement of 4.20 points and suggesting enhanced peripheral nerve response and circulation. In addition, the mean blood glucose level decreased from 233.38 mg/dL at pretest to 195.03 mg/dL at posttest, with an average reduction of 38.35 mg/dL. These findings demonstrate that diabetic foot exercise contributes positively to improving peripheral sensory function and glycemic control among patients with type 2 diabetes mellitus.

4. Effect of Diabetic Foot Exercise

Table 4. Paired t-test Analysis of Foot Sensitivity and Blood Glucose Levels

Variable	N	Correlation	Sig. (p-value)
Pre-Post Blood Glucose	29	0.950	0.000
Pre-Post Foot Sensitivity	29	0.779	0.000

The paired t-test results showed significant differences between pretest and posttest values for both variables ($p = 0.000$; $p < 0.05$). This indicates that diabetic foot exercise significantly improved foot sensitivity and reduced blood glucose levels in patients with type 2 diabetes mellitus. Table 4 presents the results of the paired t-test analysis examining the effect of diabetic foot exercise on foot sensitivity and blood glucose levels among patients with type 2 diabetes mellitus. The analysis showed a statistically significant difference between pretest and posttest measurements for both variables, with p-values of 0.000 ($p < 0.05$). The correlation value for blood glucose levels was 0.950, indicating a very strong relationship between pre- and post-intervention measurements, while the correlation value for foot sensitivity was 0.779, reflecting a strong positive relationship. These findings confirm that the implementation of diabetic foot exercise produced consistent and meaningful changes in physiological outcomes.

The significant improvement in foot sensitivity demonstrates that structured and repetitive foot

movements can enhance peripheral nerve stimulation and improve blood circulation to the lower extremities. Increased circulation supports oxygen and nutrient delivery to nerve tissues, thereby improving sensory function and reducing the risk of neuropathy and diabetic foot complications. Simultaneously, the significant reduction in blood glucose levels indicates improved glucose metabolism and increased muscle uptake of glucose during physical activity. Muscle contractions during exercise enhance insulin sensitivity and facilitate glucose utilization, leading to better glycemic control.

Overall, the statistical results provide strong empirical evidence that diabetic foot exercise is an effective non-pharmacological intervention for improving peripheral sensory function and controlling blood glucose levels in patients with type 2 diabetes mellitus. These findings reinforce the importance of integrating structured physical activity, particularly diabetic foot exercise, into routine diabetes management and nursing interventions in primary health care settings to prevent complications and improve patient outcomes.

4 Discussion

1. Characteristics of Respondents

The findings revealed that most respondents were aged between 56–65 years. This age group is considered highly vulnerable to type 2 diabetes mellitus due to physiological changes, decreased insulin sensitivity, and reduced metabolic function. Aging is also associated with decreased peripheral circulation and nerve function, which can contribute to diabetic neuropathy and reduced foot sensitivity.

The slightly higher proportion of female respondents is consistent with epidemiological data indicating that women are more likely to access primary health care services and participate in chronic disease management programs. Education level may influence patients' understanding of diabetes management and adherence to recommended lifestyle modifications, including physical activity and foot care.

The duration of diabetes among most respondents ranged from 1–3 years, indicating that many participants were still in the early stages of the disease. Early intervention during this stage is crucial to prevent long-term complications such as neuropathy and diabetic foot ulcers.

2. Effect of Diabetic Foot Exercise on Foot Sensitivity

The results demonstrated a significant improvement in foot sensitivity following the diabetic foot exercise intervention. The mean sensitivity score increased by 4.20 points after the intervention. This improvement indicates enhanced peripheral nerve response and circulation in the lower extremities.

Diabetic neuropathy occurs due to prolonged hyperglycemia, which damages peripheral nerves and blood vessels. Reduced blood flow to nerve tissues results in decreased oxygen and nutrient supply, leading to impaired nerve function. Diabetic foot exercise stimulates muscle contraction and joint movement, which enhances peripheral circulation and improves oxygen delivery to nerve tissues.

Improved circulation may facilitate nerve repair and increase sensory perception in the feet. Regular stimulation of the plantar surface and foot muscles also activates nerve endings and enhances neuromuscular coordination. These physiological mechanisms explain the significant increase in foot sensitivity observed after the intervention.

Previous studies have reported similar findings, indicating that structured foot exercise programs can significantly improve peripheral nerve sensitivity and reduce neuropathic symptoms in patients with type 2 diabetes mellitus. Therefore, diabetic foot exercise can be considered an effective preventive strategy for diabetic neuropathy and foot ulcer development.

3. Effect of Diabetic Foot Exercise on Blood Glucose Levels

This study also demonstrated a significant reduction in blood glucose levels after the intervention. The average decrease of 38.35 mg/dL indicates that even short-duration physical activity can positively affect glycemic control.

Physical exercise increases glucose uptake by skeletal muscles through insulin-dependent and insulin-independent pathways. During muscle contraction, glucose transporter proteins (GLUT-4) are activated, allowing glucose to enter muscle cells and be utilized as energy. This process reduces circulating blood glucose levels and improves insulin sensitivity.

Additionally, physical activity enhances metabolic efficiency and promotes better glucose regulation. Regular exercise has been shown to reduce insulin resistance, improve lipid

metabolism, and support overall metabolic health. Although the intervention duration in this study was relatively short, the results indicate that consistent implementation of diabetic foot exercise may contribute to long-term glycemic control.

4. Implications for Nursing Practice and Community Health

Diabetic foot exercise is a simple, low-cost, and practical intervention that can be easily implemented in primary health care settings. Nurses play a critical role in educating patients about the importance of physical activity and guiding them in performing safe and effective exercises.

Integrating diabetic foot exercise into routine diabetes management programs can enhance patient self-care and reduce the risk of complications such as neuropathy, foot ulcers, and amputation. Community-based interventions focusing on preventive care and patient education are essential to improving quality of life among individuals with diabetes mellitus.

Overall, the findings of this study confirm that diabetic foot exercise is an effective non-pharmacological intervention for improving foot sensitivity and controlling blood glucose levels in patients with type 2 diabetes mellitus.

5 Conclusion

This study confirms that diabetic foot exercise provides a significant therapeutic benefit in improving foot sensitivity and reducing blood glucose levels among patients with type 2 diabetes mellitus in primary health care settings. The implementation of a structured diabetic foot exercise program demonstrated measurable improvements in peripheral nerve sensitivity and glycemic control, indicating enhanced blood circulation, improved neuromuscular stimulation, and increased glucose utilization by active muscle tissues. These physiological improvements are essential in preventing the progression of diabetic neuropathy and reducing the risk of diabetic foot ulcers, which are among the most common and severe complications experienced by patients with diabetes mellitus. The findings highlight that diabetic foot exercise represents an effective, safe, and low-cost non-pharmacological intervention that can complement pharmacological therapy and dietary management in diabetes care. Regular practice of diabetic foot exercise not only supports metabolic stability but also promotes patient engagement in

self-care and increases awareness of foot health. From a nursing and community health perspective, integrating diabetic foot exercise into routine diabetes education and chronic disease management programs is strongly recommended to enhance preventive care and reduce long-term morbidity. Therefore, health professionals, particularly nurses in primary health care, should actively promote and implement structured diabetic foot exercise as part of comprehensive diabetes management. Continuous education, supervision, and patient adherence to regular exercise are expected to improve clinical outcomes, enhance quality of life, and minimize the burden of diabetes-related complications in community settings.

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