



Effect of Structured Diabetic Foot Exercise on Ankle–Brachial Index and Foot Sensitivity in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Introduction: Type II Diabetes Mellitus is a chronic disease with an increasing incidence each year and can lead to complications such as neuropathy and peripheral circulatory disorders in the lower extremities. Structured diabetic foot exercise is a non-pharmacological intervention that has the potential to improve foot perfusion and sensitivity

Objective: This study aimed to determine the effect of structured diabetic foot exercise on the Ankle Brachial Index (ABI) values and foot sensitivity in patients with Type II Diabetes Mellitus at Kedaton Public Health Center.

Method: This research employed a quantitative method with a pre-experimental design using a one-group pretest–posttest approach. The study population consisted of patients with Type II Diabetes Mellitus without diabetic ulcers. A total of 30 respondents were selected using purposive sampling. Data analysis included descriptive analysis and the Wilcoxon Signed Rank Test with a significance level of 95% (p -value < 0.05).

Result The results showed that before the intervention, 14 respondents (46.7%) had normal ABI values (>1.0) and 14 respondents (46.7%) were in the borderline category (0.6–0.8). Most respondents (66.7%) had neuropathy (>3 points) in the pretest foot sensitivity assessment. After the intervention, 27 respondents (90.0%) had normal ABI values (>1.0), and 21 respondents (70.0%) were categorized as non-neuropathy (>7 points) in the posttest assessment. The Wilcoxon Signed Rank Test revealed p -values of <0.002 and <0.000 . It can be concluded that structured diabetic foot exercise significantly affects ABI values and foot sensitivity in patients with Type II Diabetes Mellitus at Kedaton Public Health Center in 2025.

Conclusion: Structured diabetic foot exercise can be recommended as an alternative intervention to improve ABI values and foot sensitivity in diabetic patients.

Keywords: ankle brachial index, diabetic foot exercise, foot sensitivity

Introduction

Diabetes mellitus is a common chronic condition that occurs when the pancreas does not produce enough insulin or when the body cannot use insulin efficiently (International Diabetes Federation, 2021). According to World Health Organization (WHO) data, in 2022, 14% of adults aged 18 and over had diabetes, a 7% increase from 1990. More than half (59%) of adults aged 30 and over with diabetes were not taking medication for their diabetes in 2022. Diabetes was the cause of 1.6 million deaths in 2021, and 47% of all diabetes deaths occurred before the age of 70 (WHO, 2024).

According to data from the International Diabetes Federation (IDF), in 2021, the number of people with diabetes reached approximately 537 million. This figure is projected to increase to 643 million by 2030 and reach 783 million by 2045. In 2021, Indonesia ranked fourth among the top 10 countries with 19.5 million diabetes sufferers, a figure projected to reach 28.6 million by 2045 (International Diabetes Federation, 2021).

According to the Indonesian Health Survey (SKI), the prevalence of diabetes mellitus in Indonesia, based on doctor diagnosis, increased from 1.5% with 1,017,290 people in 2018 to 1.7% with 877,531 people in 2023 (SKI, 2023). Meanwhile, the prevalence of diabetes mellitus cases based on doctor diagnosis in Lampung Province was approximately 0.99% with 31,462 people (Riskasdas, 2018). In 2024, data from the Lampung Provincial Health Office showed that the number of people with diabetes mellitus was approximately 93,747. Bandar Lampung ranked first in diabetes mellitus care services with an incidence of 20,437 (Lampung, 2024).

Diabetes mellitus can cause macrovascular and microvascular complications. The incidence of type 2 diabetes mellitus is currently increasing, as patients with type 2 diabetes mellitus experience decreased insulin sensitivity to glucose, resulting in continued glucose production, leading to high blood glucose levels. Hyperglycemia causes metabolic disorders, reduced peripheral sensation, and damage to nerves leading to the muscles in the legs and blood vessels in the peripheral circulatory system. One long-term complication that results in significant morbidity is neuropathy (Khomsah et al., 2020). Symptoms include numbness, tingling, pain (burning, stinging, stabbing, and deep aches), and can lead to wounds, infections, and even amputation (Elafros et al., 2022). Diabetic ulcers, or foot ulcers, are wounds on the lower legs of people with diabetes that can cause pathological problems, such as infection, open wounds, or deep tissue damage due to nerve disorders, peripheral vascular disease of varying severity, and metabolic complications of diabetes (Muduli et al., 2015).

According to the Indonesian Endocrinology Association (2021), diabetes management encompasses five main pillars: education, diet, regular exercise, appropriate medication, and self-monitoring of blood sugar levels. One of the most effective pillars in managing diabetes mellitus is exercise and physical activity (Colberg et al., 2016). Physical activity encompasses all movements that increase energy, while exercise is planned and structured physical activity (Colberg et al., 2016). However, most people with diabetes, especially the elderly or those with physical limitations, are unable to participate in conventional exercise. Therefore, forms of physical activity are needed that are safe, easy to follow, and still provide therapeutic benefits (Panjaitan et al., 2025).

Examples of physical exercise for diabetes patients include brisk walking, cycling, swimming, diabetes gymnastics, yoga, weight training, and Zumba. Foot exercises are exercises performed by people with diabetes mellitus to prevent wounds and help improve blood circulation in the feet. These foot exercises can increase blood flow to the feet, improve circulation, strengthen leg muscles, and facilitate joint movement (Siregar, 2022). One simple supporting examination that can be performed to detect peripheral circulatory disorders in

the feet is by measuring the Ankle Brachial Index (ABI) and the sensitivity of the feet of people with diabetes mellitus.

This is supported by research (Khomsah et al., 2020) on the implementation of the effectiveness of home exercise on the ankle-brachial index (ABI) and foot sensitivity score in patients with type 2 diabetes mellitus with results showing that the value of the ankle-brachial index (ABI) and foot sensitivity score after the intervention experienced an increase in the Ankle Brachial Index (ABI) with an initial average value of 0.817 after the intervention to 0.917 and the foot sensitivity score with an initial average value of 8.00 after the intervention to 10.33. It can be concluded that there is an effect of home exercise on the value of the ankle-brachial index (ABI) and foot sensitivity score after the intervention. This intervention can be recommended as an alternative therapy to prevent complications of peripheral artery disease. In this study, respondents implemented foot exercises 3 times for 2 weeks. This structured diabetic foot exercise can be given to people with diabetes mellitus to prevent peripheral vascular disorders. It is given to those with diabetes mellitus to improve circulation and thus enhance sensation in the peripheral areas.

Based on data from a pre-survey of staff at the Kedaton Community Health Center on October 10, 2025, the number of diabetes mellitus sufferers reached 934 cases in 2022, increased to 1,095 cases in 2023, and reached 1,678 cases in 2024. Diabetes mellitus cases at the Kedaton Community Health Center fluctuated throughout 2025. In April, there were 152 cases, May 168 cases, June 118 cases, July 150 cases, and August 156 cases.

Interviews with community health center staff revealed that the community health center's efforts to manage type 2 diabetes mellitus cases include implementing the Prolanis program regularly, which includes scheduled Prolanis exercises, blood sugar checks during community health posts (Posbindu), and diabetic foot care visits (if needed).

Based on a pre-survey of 10 people with type 2 diabetes mellitus who participated in Prolanis exercises at the Kedaton Community Health Center, seven respondents complained of tingling and pain in their legs and feet, while three respondents complained of unsteadiness when walking. Of these 10 patients, seven reported only taking medication from the community health center and a doctor to reduce their tingling and pain in their feet. Three patients reduced their symptoms by taking medication and incorporating foot exercises such as regular morning walks. Therefore, researchers provided structured diabetic foot exercise therapy with regular movements, lasting 15 minutes, four times a week for eight sessions.

Several previous researchers have not conducted much research on the Ankle Brachial Index (ABI) value along with the level of foot sensitivity, especially in diabetic foot exercise interventions. Previous research on diabetic exercise has been done a lot, but in this study there are additional movements in the exercise, namely toe curls and toe spread movements. Based on this background, the author is interested in taking the title "Implementation of Structured Diabetic Foot Exercise on ABI Values and Foot Sensitivity in Type II Diabetes Mellitus Patients at the Kedaton Community Health Center, 2025".

Objective

This study aimed to determine the effect of structured diabetic foot exercise on the Ankle Brachial Index (ABI) values and foot sensitivity in patients with Type II Diabetes Mellitus at Kedaton Public Health Center.

Method

The type of research is quantitative research, namely research conducted to answer research questions by following scientific principles, namely concrete/empirical, objectively measurable, rational and systematic, with research data obtained in the form of numbers and analysis using statistical methods (Ggreni, 2022). The design that will be used in this study is Pre Experiment Designs, with a One Group Pretest Posttest approach where in this design does not use a comparison group (control), but has been conducted the first observation (pretest) which allows for changes after the experiment (Notoatmodjo, 2022). This study aims to determine the Effect of Structured Diabetic Foot Exercises on ABI values and foot sensitivity in a group of adults with type 2 Diabetes Mellitus at the Kedaton Health Center, Bandar Lampung in 2025.

This research employed a quantitative method with a pre-experimental design using a one-group pretest & posttest approach. The study population consisted of patients with Type II Diabetes Mellitus without diabetic ulcers. A total of 30 respondents were selected using purposive sampling. The bivariate test used in this study was the Wilcoxon Signed Rank Test because this study only had one treatment group whose values were tested before and after treatment. The results of the study were considered effective if the p-value was <0.05. The statistical test calculations were carried out using a computerized system. Data analysis included descriptive analysis and the Wilcoxon Signed Rank Test with a significance level of 95% (p-value < 0.05).

Result

Table 1. Frequency Distribution of Respondent Characteristics of Type 2 Diabetes Mellitus Patients Before Structured Diabetic Foot Exercises

Respondent Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	5	16.7
Female	25	83.3
Usia		
26 – 45 years	4	13.3
46 – 60 years	26	86.6
Duration of Diabetes		
< 2 years	11	36.7
> 2 years	19	63.3
Total	30	100.0

Based on Table above the largest number of respondents were female, with 25 respondents (83.3%). The largest number of respondents were in the 46-65 age group, with 26 respondents. (86.6%), and in the category of long-term DM sufferers, the majority suffered from DM for > 2 years, amounting to 19 respondents (63.3%).

Table 2. ABI Scores and Foot Sensitivity in Type 2 Diabetes Mellitus Patients Before Structured Diabetic Foot Exercises

Group	Frequency (n)	Percentage (%)
Ankle Brachial Index (ABI)		
>1,0 Normal	14	46.7
<0,6 – 0,8 Borderline	14	46.7
>1,3 Incompressible Vessles	2	6.7
Sensitivitas Kaki		
>7 Points, No Neuropathy	10	33.3
>3 Points, Neuropathy	20	66.7
Total	30	100.0

Based on Table above the ABI scores and foot sensitivity of 30 respondents with Type 2 Diabetes Mellitus (DM) were obtained. The pretest Ankle Brachial Index (ABI) scores showed that The highest number was in the >1.0 Normal category with 14 respondents (46.7%) and the <0.6-0.8 Borderline category with 14 respondents (46.7%). Meanwhile, the highest number of pretest foot sensitivity scores was in the >3 Points and Neuropathy categories with 20 respondents (66.7%).

Table 3. ABI Scores and Foot Sensitivity in Type 2 Diabetes Mellitus Patients After Structured Diabetic Foot Exercises

Kelompok	Frekuensi (n)	Presentase (%)
Ankle Brachial Index (ABI)		
>1,0 Normal	27	90.0
<0,6 – 0,8 Borderline	3	10.0
Sensitivitas Kaki		
>7 Points, No Neuropathy	21	70.0
>3 Points, Neuropathy	9	30.0
Total	30	100.0

Based on Table above the ABI scores and foot sensitivity of 30 respondents with Type 2 Diabetes Mellitus (DM) were obtained. The Ankle Brachial Index (ABI) posttest scores showed that the highest number of respondents were in the >1.0 Normal category (27 respondents (90.0%)), and the highest number of respondents in the posttest foot sensitivity score (30.0%) were in the Category >7 Points, No Neuropathy as many as 21 respondents (70.0%).

Table 4. The Effect of Structured Diabetic Foot Exercises on ABI Values and Foot Sensitivity in Type 2 Diabetes Mellitus Patients

Group	N	Mean + s.b	p-value
Foot Sensitivity Pretest	30	1.67 ± 0.497	0.000
Foot Sensitivity Posttest		1.30 ± 0.466	
Ankle Brachial Index (ABI) Pretset	30	1.67 ± 0.802	0.002
Ankle Brachial Index (ABI) Postset		1.10 ± 0.305	

Table above shows a change in Ankle Brachial Index (ABI) values before and after Structured Diabetic Foot Exercise therapy, with a p-value of 0.002. It is known that the results

of the foot sensitivity values before and after also experienced changes after being given Structured Diabetic Foot Exercise therapy with a p-value of 0.000.

Discussion

Based on the results before the intervention, several respondents reported experiencing pain, difficulty walking, and leg tenderness during the first intervention with diabetic foot exercises. They found that they were unable to perform the exercises properly and experienced obstacles in the movements. After four sessions of the intervention, respondents felt more comfortable and their joints were less stiff. This is because structured diabetic foot exercises can improve blood circulation in the feet, strengthen small foot muscles, prevent foot deformities, and reduce foot problems.

The researchers hypothesized that those previously experiencing PAD and impaired blood circulation could improve after structured diabetic foot exercises because they were not yet elderly, allowing blood flow to return to normal after the foot exercises. Based on the data obtained in this study, there were changes in the Ankle Brachial Index (ABI) score and foot sensitivity before (pretest) and after (posttest) the intervention in the form of structured diabetic foot exercises in patients with type 2 diabetes mellitus at the Kedaton Community Health Center in Bandar Lampung. However, based on field data, one respondent showed no change after the intervention. However, considering the respondent's age, this is a factor in the increase in PAD, this could be due to the respondent's regular physical activity, such as walking, gymnastics, and other sports. Therefore, structured diabetic foot exercises can be recommended as an important part of a diabetes management program to improve the quality of life of sufferers and reduce complications associated with diabetes.

In the study, entitled "The Effect of Structured Diabetic Foot Exercises on ABI Values and Foot Sensitivity in Type II Diabetes Mellitus Patients at the Kedaton Community Health Center in 2025," a Wilcoxon Signed Rank Test was used to evaluate changes in Ankle Brachial Index (ABI) and foot sensitivity before and after the structured diabetic foot exercise intervention. The Wilcoxon Signed Rank Test revealed a significant Ankle Brachial Index (ABI) p-value of <0.002 and a p-value of <0.000 for foot sensitivity. This p-value (<0.05) indicates that H_a is accepted and H_o is rejected, indicating that structured diabetic foot exercises have an effect on Ankle Brachial Index (ABI) and foot sensitivity in type 2 diabetes mellitus patients at the Kedaton Community Health Center in 2025.

This significant increase in ABI values can be interpreted as increased blood vessel elasticity and improved blood flow in the lower extremities. The ABI is an important indicator for assessing the risk of peripheral artery disease (PAD), which is common in people with type 2 diabetes mellitus. Increased blood flow and improved vascular function after structured diabetic foot exercises indicate that this intervention is effective in reducing the risk of PAD and improving vascular health (American Diabetes Association, 2021).

Previous research conducted by (Rahman et al., 2021) showed that regular physical exercise, including foot exercises, can improve peripheral nerve function, which is often impaired in people with type 2 diabetes mellitus. This is because physical exercise can increase blood flow to the lower extremities, thereby improving oxygen and nutrient supply to nerve tissue. This is in line with the statement (Siregar, 2022), which states that foot exercises can help improve blood circulation in the feet, ultimately improving nerve sensitivity. Meanwhile, according to (Wahyuni & Nina Arisfa, 2022), the foot movements performed during foot exercises for diabetes sufferers are similar to foot massage. Applying pressure and movement to the feet influences hormones, increasing endorphin production,

which plays a role in reducing pain and dilating blood vessels, resulting in a decrease in blood pressure, especially brachial systolic blood pressure, which is directly related to ABI values.

The changes in Ankle Brachial Index (ABI) and foot sensitivity found in this study indicate that structured diabetic foot exercises are an effective non-pharmacological intervention in improving vascular and peripheral nerve function in patients with type 2 diabetes mellitus. Therefore, structured diabetic foot exercises can be recommended as part of a comprehensive diabetes management program. Regularly performing structured diabetic foot exercises can help prevent diabetes complications such as diabetic neuropathy and peripheral artery disease, which often reduce the quality of life for people with diabetes. Therefore, integrating structured diabetic foot exercises into a diabetes management program can provide significant long-term benefits for the health and well-being of patients.

According to researchers, age and duration of DM are factors that influence the improvement or transition from abnormal to normal conditions in PAD and foot sensitivity symptoms. In older individuals, there is a physiological aging process characterized by decreased blood vessel elasticity and increased arterial stiffness, which causes reduced peripheral blood flow and slows the process of perfusion repair. Furthermore, the longer a person has DM, the greater the risk of chronic hyperglycemia, which can cause microvascular and macrovascular damage. Therefore, younger patients with short-term DM tend to have a better chance of peripheral circulation flow and improved foot sensitivity compared to older patients with longer DM, especially if supported by optimal glycemic management and structured interventions. Based on the results of ABI measurements and foot sensitivity, there were changes, as well as respondents who stated that symptoms such as tingling and pain in the legs were reduced after structured diabetic foot exercises. The results of the study concluded that structured diabetic foot exercises had a significant effect on improving ABI values and foot sensitivity in patients with type 2 diabetes mellitus at the Kedaton Community Health Center in 2025. Therefore, structured diabetic foot exercises can be recommended as an integral part of a comprehensive diabetes management program.

Conclusion

Respondents were categorized by gender as female (83.3%), with the majority being between 46 and 60 years old (86.6%), and the majority having had diabetes for more than 2 years (63.3%). Ankle-Brachial Index (ABI) scores before the Structured Diabetic Foot Exercises were in the >1.0 Normal category for 14 respondents (46.7%) and $<0.6-0.8$ Borderline for 14 respondents (46.7%). Meanwhile, the pretest foot sensitivity scores were highest in the >3 Points category, and Neuropathy for 20 respondents (66.7%). Ankle-Brachial Index (ABI) scores after the Structured Diabetic Foot Exercises were in the >1.0 Normal category for 27 respondents (90.0%), and the posttest foot sensitivity scores were highest in the >7 Points and No Neuropathy category for 21 respondents (70.0%).

Structured Diabetic Foot Exercises significantly improved Ankle Brachial Index (ABI) values with a p-value of <0.002 . Structured Diabetic Foot Exercises significantly improved foot sensitivity values with a p-value of <0.000 . The results showed that Structured Diabetic Foot Exercises significantly improved ABI values with a significance value of <0.002 . The ABI value improved by $1.67 + 0.802$ to $1.10 + 0.305$.

The results showed that Structured Diabetic Foot Exercises significantly improved foot sensitivity values with a significance value of <0.001 . The foot sensitivity value improved by $1.67 + 0.497$ to $1.30 + 0.466$.

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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

No declare.

Ethical consideration

Not applicable.

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