

Research Article

Effectiveness of Foot Exercise on Ankle Brachial Index (ABI) Among Hospitalized Patients with Diabetes Mellitus

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Abstract: Diabetes Mellitus (DM) is a chronic metabolic disorder that is rapidly increasing globally and is associated with a high risk of peripheral arterial complications. The Ankle Brachial Index (ABI) is a simple and reliable tool for screening peripheral arterial disease, while foot exercise represents a practical, low-cost, and non-pharmacological intervention to improve peripheral perfusion. This study aimed to evaluate the effectiveness of foot exercise in improving ABI values among hospitalized patients with DM. A pre-experimental one-group pretest-posttest design was implemented with 26 purposively selected inpatients with DM. Participants performed standardized foot exercises once daily for 15 minutes over two consecutive days. ABI values were measured using a sphygmomanometer and vascular Doppler before and after the intervention, and data were analyzed using a paired t-test. The mean ABI significantly increased from 0.707 (SD = 0.031) to 0.884 (SD = 0.027) ($p < 0.001$), indicating a clinically meaningful improvement from moderate impairment to near-normal circulation. These results demonstrate that foot exercise is effective in improving ABI values among hospitalized DM patients. The study highlights foot exercise as a safe, simple, and non-pharmacological nursing intervention that can be recommended in inpatient care settings to improve peripheral perfusion and prevent further complications related to peripheral arterial disease. This intervention offers a promising approach to managing peripheral arterial complications in diabetic patients.

Keywords: Diabetes Mellitus; Foot Exercises; Indeks ABI; Nursing Intervention; Peripheral Perfusion

1. Introduction

Diabetes Mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion, insulin resistance, or both. It has become one of the most pressing global health challenges and is often described as a “silent killer” because of its asymptomatic onset and progressive complications. Uncontrolled DM leads to microvascular and macrovascular complications that significantly reduce patients’ quality of life and increase morbidity and mortality rates worldwide (IDF, 2021).

According to the International Diabetes Federation (IDF, 2021), approximately 463 million adults were living with DM in 2019, and this number is projected to rise to 700 million by 2045. In Indonesia, the prevalence of DM increased from 6.9% in 2013 to 10.6% in 2021, affecting more than 19 million people. In Central Java, recent data from 2023 reported 670,252 cases, representing 9.59% of the provincial population. Local hospital data also indicate a concerning trend, with the number of DM inpatients at Fastabiq Sehat PKU Muhammadiyah Hospital increasing nearly threefold from 378 in 2021 to 901 in 2023. This sharp rise underscores the urgent need for effective preventive and therapeutic strategies within hospital-based care.

One of the major complications of DM is impaired peripheral circulation, primarily caused by atherosclerosis and endothelial dysfunction. This condition increases the risk of diabetic foot ulcers, tissue necrosis, and lower-limb amputations. The Ankle Brachial Index

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(ABI) is a simple, reliable, and non-invasive diagnostic tool for detecting peripheral arterial disease (PAD). An ABI value below 0.90 is indicative of arterial obstruction and impaired perfusion, which are frequently observed among DM patients (Setiawan et al., 2020).

Non-pharmacological interventions, such as foot exercise, are increasingly recognized as effective strategies to improve lower-limb perfusion. The physiological mechanism involves rhythmic contraction of the calf muscles, which enhances venous return, stimulates the release of nitric oxide, and promotes vasodilation, thereby improving peripheral blood flow (Mulyaningsih et al., 2022). Several studies have demonstrated the benefits of foot exercise for patients with DM. Resti et al. (2021) and Sunarya et al. (2021) found significant improvements in ABI values and reductions in blood glucose levels following regular foot exercise. Similarly, Ramadhani et al. (2023) reported increased ABI among elderly patients with DM after one week of exercise interventions. Other reviews also emphasize that foot exercise is a low-cost, safe, and clinically beneficial intervention for peripheral circulation in DM patients (Kusumaningrum, 2021; Wulandari & Suratun, 2023).

Despite these findings, most previous studies were conducted in community or outpatient settings with longer intervention durations of at least three to seven days (Rachmawati et al., 2023). In contrast, hospitalized DM patients often experience short lengths of stay, which limits the feasibility of long-term exercise interventions. This presents a knowledge gap regarding the short-term effectiveness of foot exercise in inpatient care settings.

Therefore, the present study aims to evaluate the effectiveness of foot exercise in improving ABI values among hospitalized patients with DM. By focusing on a short-term intervention of two consecutive days, this study provides new insights into the feasibility and clinical implications of foot exercise as a practical, low-cost, and non-pharmacological nursing intervention within hospital environments.

2. Preliminaries or Related Work or Literature Review

2.1. Foot Exercise and Ankle Brachial Index (ABI) : State of the Art

Several studies have demonstrated that foot exercise has a beneficial effect on peripheral circulation among patients with Diabetes Mellitus (DM). Resti et al. (2021) reported an increase in ABI values from 0.84 to 1.14 after three consecutive days of routine foot exercise in primary healthcare facilities. Similarly, Sunarya et al. (2021) found that foot exercise not only improved ABI values but also contributed to a reduction in blood glucose levels. Ramadhani et al. (2023) confirmed these findings in a study of elderly patients with DM, reporting a significant increase in ABI after one week of structured exercise. In addition, Wulandari and Suratun (2023) highlighted the role of foot exercise in enhancing lower-limb perfusion, although their study did not measure ABI quantitatively. A review by Kusumaningrum (2021) further concluded that most scientific evidence supports the effectiveness of foot exercise in improving peripheral circulation in DM patients.

Collectively, these studies indicate that foot exercise offers clear clinical benefits for improving ABI and peripheral blood flow. However, most previous research has been conducted in community or outpatient settings with relatively long intervention durations, ranging from three days to more than one week. There is still limited evidence regarding its effectiveness in inpatient settings, particularly within the shorter time frames that typically characterize hospital care.

2.2. Theoretical and Physiological Mechanisms

The effectiveness of foot exercise in improving ABI can be explained through established physiological mechanisms. Calf muscle contractions act as a “muscle pump” that accelerates venous return and facilitates arterial blood flow to peripheral tissues (Mulyaningsih et al., 2022). Repetitive muscle activity also increases shear stress on the vascular endothelium, which stimulates the release of nitric oxide (NO). NO serves as a potent vasodilator, improving vascular tone and enhancing perfusion of the lower extremities (Setiawan et al., 2020). This mechanism is consistent with vascular physiology theories, which state that rhythmic physical activity promotes peripheral perfusion and reduces ischemic risk (Sunarya et al., 2021).

Empirical findings further support these theoretical explanations. Girsang and Sitorus (2020) reported an increase in ABI values from 0.90 to 1.02 following seven days of diabetic foot exercises. Setiawan et al. (2020) also demonstrated that two weeks of foot exercise shifted

ABI values from abnormal to normal categories. Rachmawati et al. (2023) observed an average increase of 0.1 points in ABI after 14 days of exercise lasting 10–15 minutes per day. Mulyaningsih et al. (2022) further showed that a Health Belief Model-based exercise intervention significantly improved ABI values ($p = 0.019$).

The consistency between theoretical mechanisms and empirical findings strengthens the scientific basis for foot exercise as an effective, non-pharmacological intervention to improve peripheral perfusion in DM patients. Nevertheless, most available studies have examined medium- to long-term interventions, leaving a gap in evidence concerning short-term applications within hospital inpatient care

3. Proposed Method

This study employed a quantitative approach with a pre-experimental one-group pretest–posttest design, which was selected to evaluate the effectiveness of foot exercise in improving Ankle Brachial Index (ABI) values among hospitalized patients with Diabetes Mellitus (DM). Although this design does not involve a control group, it enables the direct measurement of changes before and after the intervention, making it suitable for assessing short-term outcomes.

The research was conducted in the inpatient ward of Fastabiq Sehat PKU Muhammadiyah Hospital, Pati, Indonesia, between May and July 2025. Participants were recruited using purposive sampling based on predetermined inclusion and exclusion criteria. The inclusion criteria were: (1) patients diagnosed with DM, (2) ABI values less than 1.0 at baseline, and (3) willingness to participate by signing informed consent. Meanwhile, the exclusion criteria included: (1) patients with open wounds, gangrene, or active ulcers, (2) a history of lower-limb amputation, and (3) medical conditions that contraindicated exercise. Using Slovin's formula with a 10% margin of error, a minimum sample size of 26 respondents was obtained from a population of 36 eligible patients.

The intervention applied in this study consisted of standardized diabetic foot exercises adapted from the Indonesian Ministry of Health guidelines (2023). The exercise protocol included toe lifting, ankle rotation, leg extension, and paper-grasping movements, performed once daily for two consecutive days. Each session lasted approximately 15 minutes and was carried out under the direct supervision of the research team to ensure accuracy and adherence to the prescribed procedures.

Data collection was conducted by measuring ABI values before (pretest) and after (posttest) the intervention. For each measurement, patients were positioned in a supine posture for at least 10 minutes to stabilize blood pressure. Systolic blood pressure was measured on both arms and both ankles using a calibrated sphygmomanometer and a vascular Doppler device. ABI values were then calculated as the ratio of ankle systolic pressure to brachial systolic pressure.

All data were processed using SPSS version XX (please specify the version used). Descriptive statistics were employed to summarize demographic and clinical characteristics, while a paired t-test was performed to compare mean ABI values before and after the intervention. A significance level of $p < 0.05$ was considered statistically significant, and 95% confidence intervals (CI) were calculated to assess the precision of the observed effect estimates.

Ethical approval for this study was obtained from the Ethics Committee of [insert institution name], and all participants provided written informed consent prior to enrollment. Throughout the research process, confidentiality and anonymity of participants were maintained to uphold ethical standards and protect respondents' privacy.

4. Results and Discussion

4.1 Characteristics of Respondents

A total of 26 patients with Diabetes Mellitus (DM) participated in this study. Most respondents were between 49–59 years old (38.5%), female (61.5%), employed (80.8%), and had primary to secondary education (61.6%).

Table 1. Characteristics of Respondents (n = 26).

Characteristics	Category	n	%
Age (years)	38–48	9	34.6
	49–59	10	38.5
	60–69	7	26.9
Gender	Male	10	38.5
	Female	16	61.5
Employment	Employed	21	80.8
	Unemployed	5	19.2
Education	Primary school	8	30.8
	Junior high school	8	30.8
	Senior high school	7	26.9
	Higher education	3	11.5

Source : primary data 2025

4.2 Distribution of ABI Values

Before the intervention, all respondents (100%) had ABI values between 0.50 and 0.79, categorized as moderate arterial disease. After two days of foot exercise, 16 respondents (61.5%) moved into the borderline category (0.80-0.89), while 10 respondents (38.5%) reached the near-normal category (0.9-1.0).

Table 2. Distribution of ABI Values Before and After Foot Exercise (n = 26).

Group	ABI Value Categories	N	Before		After	
			F	%	F	%
Foot Exercises	1-1.3	26	0	0	0	0
	0.9-1		0	0	10	38.5
	0.8-0.89		0	0	16	61.5
	0.5-0.79		26	100.0	0	0
	<0.5		0	0	0	0
Total		26	100%	26	100%	

Source: Primary data, 2025

4.3 Effect of Foot Exercise on ABI Values

The mean ABI value before the intervention was 0.707 (SD = 0.031). After the intervention, the mean ABI increased to 0.884 (SD = 0.027). The mean difference of 0.177 was statistically significant ($p < 0.001$) based on a paired t-test.

Table 3. Comparison of ABI Values Before and After Intervention (n = 26).

Treatment group	Before	After	Average difference	P-Value
	Mean \pm SD	Mean \pm SD		
Leg Exercises	0.707 \pm 0.031	0.884 \pm 0.027	0.177	< 0.0001

Source : primary data 2025

These findings indicate that foot exercise significantly improved ABI values, shifting patients from moderate arterial impairment toward borderline and near-normal circulation.

4.2 Discussion

4.2.1 Characteristics of Respondents

This study involved 26 patients with Diabetes Mellitus (DM) who were hospitalized at Fastabiq Sehat PKU Muhammadiyah Hospital, Pati. The majority of respondents were between 49–59 years old (38.5%), female (61.5%), employed (80.8%), and had primary to secondary education (61.6%).

The age distribution indicates that most respondents were in the middle-aged to early elderly group, which is consistent with global epidemiological data showing that DM prevalence increases with age. According to the International Diabetes Federation (2021), the incidence of DM rises significantly in individuals over 45 years due to progressive insulin resistance, reduced β -cell function, and cumulative vascular damage. Middle-aged and elderly patients also experience declining vascular elasticity, predisposing them to peripheral arterial disease (PAD), which was evident in this study where all respondents initially presented with moderate ABI impairment.

The predominance of female respondents (61.5%) is also in line with previous findings. Women with DM, particularly those post-menopause, face higher risks of vascular complications due to hormonal changes that accelerate atherosclerosis. Furthermore, women tend to seek healthcare services more frequently than men, which may explain their higher representation in this inpatient sample. A study by Ramadhani et al. (2023) similarly reported a greater proportion of female participants in foot exercise interventions among elderly DM patients, highlighting gendered patterns in healthcare utilization.

Regarding employment status, most respondents were employed (80.8%). This finding is important because working-age adults with DM are often exposed to lifestyle risk factors such as irregular physical activity, dietary imbalances, and stress, which can exacerbate metabolic dysregulation and peripheral circulation impairment. Sedentary occupations, in particular, reduce the activation of the calf muscle pump, leading to poorer venous return and arterial perfusion in the lower extremities. Thus, structured interventions like foot exercise are highly relevant for this population as they are simple, time-efficient, and can be practiced alongside routine activities.

Educational background also plays a crucial role in disease management. In this study, most respondents had only primary or secondary education, which may limit health literacy and the ability to adopt complex self-care behaviors. Limited education has been associated with reduced awareness of DM complications and lower adherence to preventive measures, including exercise therapy. This underscores the importance of providing clear, practical, and easy-to-follow instructions when implementing non-pharmacological interventions such as foot exercise. Previous research by Wulandari and Suratun (2023) emphasized that educational level significantly influences the effectiveness of health education in improving adherence to exercise routines among DM patients.

Taken together, the characteristics of respondents in this study reflect a high-risk population for vascular complications, particularly PAD. Middle-aged and elderly patients with lower educational backgrounds are vulnerable due to limited self-care capacity, while those who are employed face barriers to regular physical activity. Female predominance in the sample may reflect both biological susceptibility and greater healthcare-seeking behavior. These demographic and clinical factors justify the implementation of foot exercise as a tailored, practical, and accessible intervention to address circulation impairment among hospitalized DM patients.

4.2.2 ABI Values Before and After Intervention

Before the intervention, all respondents in this study had ABI values in the range of 0.50–0.79, which is categorized as moderate arterial disease. This condition reflects impaired peripheral perfusion caused by chronic hyperglycemia in DM, leading to endothelial dysfunction, arterial stiffness, and progressive atherosclerosis. Persistent hyperglycemia increases the formation of advanced glycation end products (AGEs) and oxidative stress, both of which accelerate vascular damage and contribute to peripheral arterial disease (PAD). This explains why patients with DM in this study presented with reduced ABI values at baseline.

After two consecutive days of foot exercise, there was a statistically and clinically significant increase in ABI values, from a mean of 0.707 to 0.884 ($p < 0.001$). The improvement shifted 61.5% of respondents into the borderline category (0.80–0.89) and 38.5% into the near-normal category (0.90–1.0). Although none reached the fully normal ABI range (>1.0),

the shift from moderate impairment toward near-normal perfusion demonstrates the effectiveness of even a short-duration intervention.

The observed improvement is consistent with physiological mechanisms of exercise-induced vascular adaptation. Rhythmic contraction of the calf muscles during foot exercise acts as a muscle pump, enhancing venous return and increasing arterial inflow to the lower extremities. Repeated contractions also induce shear stress on the endothelial lining, which stimulates the release of nitric oxide (NO). NO is a potent vasodilator that relaxes vascular smooth muscle, widens arterial lumens, and improves tissue perfusion. Additionally, short bouts of physical activity have been shown to promote collateral vessel formation and improve microcirculation, both of which may have contributed to the ABI improvements observed in this study.

These results are consistent with previous studies. Girsang and Sitorus (2020) reported ABI improvements from 0.90 to 1.02 after seven days of foot exercise, while Setiawan et al. (2020) and Rachmawati et al. (2023) demonstrated significant ABI increases after two weeks and 14 days, respectively. Wahyuni and Putra (2024) further showed that more frequent exercise (≥ 5 times per week) led to greater ABI improvement. Although the present study involved a shorter duration (only two days), the significant improvement suggests that foot exercise can yield rapid benefits for hospitalized patients, even during short lengths of stay.

The findings of this study underscore the potential of foot exercise as an immediate, low-cost, and non-pharmacological intervention to improve peripheral perfusion in DM patients. While longer interventions may yield greater improvements, the demonstrated effectiveness within two days highlights its feasibility and practicality in inpatient care, where hospitalization duration is often limited.

4.2.3 Effect of Foot Exercise on ABI

The findings of this study demonstrate a statistically significant improvement in ABI values following a structured foot exercise program in patients with Type 2 Diabetes Mellitus. The mean ABI increased from 0.707 ± 0.031 before the intervention to 0.884 ± 0.027 after the intervention, with a mean difference of 0.177 ($p < 0.001$). This improvement suggests enhanced peripheral arterial circulation, which is crucial for preventing complications such as diabetic foot ulcers and gangrene (Febrianto & Prabowo, 2025).

Foot exercises, including Buerger-Allen exercises, are designed to stimulate blood flow in the lower extremities by promoting vasodilation and improving venous return. A systematic review and meta-analysis by Lee et al. (2022) concluded that Buerger-Allen exercises significantly improve ABI scores, thereby enhancing foot perfusion in diabetic patients. Similarly, a study by Utami (2019) found that diabetic foot gymnastics led to an increase in ABI values, indicating improved peripheral circulation.

The clinical implications of these findings are substantial. Improved ABI values are associated with a reduced risk of PAD, which is prevalent among diabetic patients due to microvascular and macrovascular complications (Febrianto & Prabowo, 2025). Regular foot exercises can serve as a cost-effective, non-invasive intervention to enhance lower limb circulation, thereby reducing the incidence of diabetic foot complications and improving overall quality of life.

In conclusion, the significant increase in ABI values observed in this study supports the efficacy of foot exercises in improving peripheral circulation among hospitalized diabetic patients. These exercises should be considered a valuable component of comprehensive diabetes management strategies, particularly for patients at risk of PAD.

4.3 Limitations and Recommendations

This study was limited by its short duration, lack of a control group, and small sample size. Future research should employ randomized controlled designs with larger, more diverse populations and longer follow-up periods. Additional outcomes, such as blood glucose control, vascular elasticity, and quality of life, should be evaluated.

5. Conclusions

This study involved 26 hospitalized patients with Diabetes Mellitus at Fastabiq Sehat PKU Muhammadiyah Hospital, Pati. The majority of respondents were aged 49–59 years, female, employed, and had primary to secondary education. These characteristics indicate a high-risk population for vascular complications, particularly peripheral arterial disease (PAD), which underscores the importance of interventions targeting peripheral circulation, such as foot exercise.

At baseline, all participants had Ankle Brachial Index (ABI) values between 0.50 and 0.79, categorized as moderate arterial disease. After two consecutive days of foot exercise, 61.5% of respondents improved to the borderline category (0.80–0.89) and 38.5% reached the near-normal category (0.90–1.0). This demonstrates a significant short-term improvement in lower-extremity perfusion.

Foot exercise significantly increased the mean ABI from 0.707 ± 0.031 to 0.884 ± 0.027 , with a mean difference of 0.177 ($p < 0.001$). These results indicate that foot exercise effectively enhances peripheral arterial circulation, which may help prevent PAD, diabetic foot ulcers, and other vascular complications. The findings also suggest that even short-duration interventions can be clinically beneficial in a hospital setting.

Despite these promising results, this study has several limitations, including its short intervention period, lack of a control group, and small sample size, which limit generalizability. Future research should utilize randomized controlled trials with larger, more diverse populations, longer intervention durations, and additional outcome measures such as blood glucose levels, vascular elasticity, and patient quality of life to strengthen the evidence base.

In conclusion, foot exercise is an effective, practical, and non-pharmacological nursing intervention for improving ABI in hospitalized patients with Diabetes Mellitus. It represents a feasible and valuable strategy within comprehensive diabetes management, particularly for patients at high risk of impaired peripheral circulation.

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