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# IMPACT OF DIABETIC FOOT EXERCISE ON ANKLE-BRACHIAL INDEX IN PATIENTS WITH DIABETES

**Dini Rudini**[1], **Lisa Anita Sari**[2], **Fadliyana ekawaty**[3], **Andika Sulistiawan**[4]

[1,2,3,4]Department of Nursing, Faculty of Medicine and Health Sciences, Universitas Jambi, Indonesia

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**ABSTRACT**

This study examined the effect of structured diabetic foot exercise on Ankle-Brachial Index (ABI) values among patients with type 2 diabetes mellitus (T2DM) at Simpang Kawat Public Health Center, Indonesia. A quasi-experimental one-group pretest–posttest design was applied involving 35 participants selected through purposive sampling. Participants completed two supervised diabetic foot exercise sessions over one week. ABI measurements were performed before and after the intervention using a calibrated vascular Doppler under standardized conditions. Data were analyzed using paired-sample t-tests, and effect sizes were calculated using Cohen's $d$. The results showed a significant increase in mean ABI values from $0.89 \pm 0.06$ to $0.94 \pm 0.05$ after the intervention ($p < 0.001$). Large effect sizes were identified in both the right and left lower extremities ($d = 1.39$ and $d = 1.28$), indicating meaningful clinical improvement in peripheral circulation. These findings suggest that structured diabetic foot exercise may support circulation-focused diabetes self-management and has potential to be implemented as a practical non-pharmacological intervention in primary-care settings. However, the absence of a control group and short intervention period remain important study limitations.



***Corresponding Author:***
Dini Rudini
Department of Nursing, Faculty of Medicine and Health Sciences,
Universitas Jambi, Indonesia
Email: : dinirudini@unja.ac.id

## 1. INTRODUCTION

Diabetes mellitus remains a major public health challenge because its prevalence continues to increase and its long-term complications contribute substantially to disability, reduced quality of life, and healthcare burden[1], [2]. Among these complications, peripheral artery disease (PAD) is particularly important because impaired lower-extremity perfusion increases the risk of pain, delayed wound healing, diabetic foot ulceration, and amputation [3].

Early identification and management of circulatory impairment are therefore essential, especially in primary care settings where many patients with type 2 diabetes mellitus (T2DM) receive routine follow-up and preventive care [4], [5].

The Ankle-Brachial Index (ABI) is a practical and non-invasive indicator of peripheral perfusion that can be used in community and primary-care settings to screen for PAD risk [6]. In patients with T2DM, reduced ABI values may indicate early vascular compromise, making ABI a relevant outcome for preventive and rehabilitative interventions [7].

Because advanced vascular examinations are often unavailable in routine primary care, low-cost interventions that can be paired with simple vascular monitoring are particularly valuable [8], [9]. Diabetic foot exercise has been promoted as a supportive non-pharmacological strategy to improve lower-limb circulation through repeated muscle contraction, activation of the skeletal muscle pump, and improved peripheral blood flow [10], [11]. From a nursing perspective, this intervention is also consistent with Orem's Self-Care Deficit Nursing Theory because it encourages patients to participate actively in self-management through structured, learnable behaviors [12], [13].

Previous studies have suggested that foot exercise may improve ABI and other lower-extremity outcomes, but implementation in routine primary care remains inconsistent, and many reports use variable protocols, limited theoretical framing, or incomplete descriptions of intervention fidelity. The present study was designed to address this practical and reporting gap by evaluating a standardized, supervised diabetic foot exercise protocol in a primary-care population with T2DM [14], [15].

Its novelty lies not in introducing an entirely new intervention, but in applying a theory-informed and operationalized exercise program with standardized ABI measurement in a local public-health setting where structured foot exercise had not been routinely implemented. Given the quasi-experimental one-group pretest-posttest design, the study was intended to provide preliminary evidence of an association between the intervention and short-term ABI change rather than definitive proof of causal effectiveness [16], [17], [18].

Accordingly, the study tested the following hypotheses: the null hypothesis stated that diabetic foot exercise would not be associated with a significant change in ABI values among patients with T2DM, whereas the alternative hypothesis stated that diabetic foot exercise would be associated with higher ABI values after the intervention period [19],[20].

## 2. RESEARCH METHOD

### 2.1 Study Design and Setting

This study used a quantitative quasi-experimental one-group pretest-posttest design to examine whether ABI values changed after participation in a structured diabetic foot exercise program [21]. This quantitative quasi-experimental study employed a one-group pretest-posttest design to provide preliminary evidence of association between diabetic foot exercise and ankle-brachial index (ABI) change in a resource-limited primary care setting. This design was selected for feasibility as a pilot implementation study at a single public health center lacking established exercise services. However, the absence of a control group limits causal attribution, and findings represent within-sample change rather than definitive effectiveness. The study followed STROBE guidelines for quasi-experimental reporting [22].

The study was conducted at the Simpang Kawat Public Health Center, Jambi City, Indonesia, a setting selected because of its active T2DM patient population and the absence of an established structured diabetic foot exercise service.

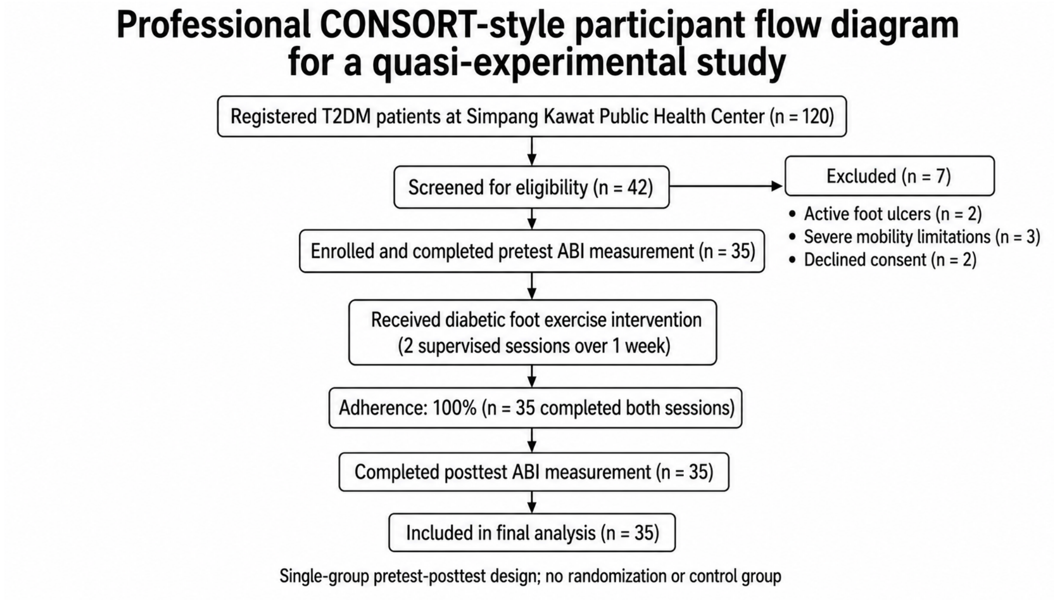


Figure 1: Participant flow diagram (CONSORT) for the quasi-experimental pretest–posttest study

This study used a one-group pretest–posttest design without randomization or a control group. The diagram follows CONSORT principles for transparency but is adapted for a quasi-experimental design. As shown in Figure 1, while enrollment and retention were excellent (100% completion), the absence of a control group and the purposive sampling approach limit causal inference and generalizability [23].

## 2.2 Population and Sampling

The target population consisted of registered patients with T2DM receiving services at the health center [24]. Participants were selected using purposive sampling based on the following inclusion criteria: diagnosis of T2DM for at least two years, age 40–70 years, ability to perform independent physical activity, and willingness to provide written informed consent [25]. Exclusion criteria were active foot ulcers or wounds, severe musculoskeletal or neurological limitations affecting mobility, uncontrolled hypertension, and acute cardiovascular events [26]. Purposive sampling was used to support feasibility in this pilot context, but it also limited representativeness and external validity [27].

## 2.3 Intervention Protocol

The intervention consisted of a standardized diabetic foot exercise program delivered twice in one week, with a total of two supervised sessions. Each session lasted approximately 15–20 minutes and included three components: warm-up for about 3 minutes using seated ankle rotations and toe stretches, core exercises for about 10 minutes using heel-toe raises, ankle dorsiflexion and plantarflexion with resistance bands, seated marching, and calf stretching, and cool-down for 2–5 minutes using gentle lower-limb massage and breathing relaxation. Exercise intensity was maintained at a moderate level based on Borg Rating of Perceived Exertion scores of 11–13. All sessions were supervised by a trained nurse to maintain consistency of movement instruction and protocol fidelity [28].

## 2.4 Measurement of Ankle-Brachial Index (ABI)

ABI was the primary outcome variable. Measurements were obtained using a calibrated handheld vascular Doppler with an 8 MHz probe and standardized blood pressure cuffs according to a structured measurement procedure. Before measurement, participants rested in the supine position for 10 minutes in a temperature-controlled room. Systolic blood pressure was then measured at the brachial artery and at the dorsalis pedis or posterior tibial arteries of both lower extremities, and ABI was calculated as the ratio of the highest ankle systolic pressure to the highest brachial systolic pressure. The same trained assessor performed all measurements to reduce inter-rater variability, and a preliminary test-retest assessment in a subset of participants produced an intra-rater reliability coefficient of 0.91.

### 2.5 Data Collection and Covariate Verification

Baseline demographic and clinical characteristics, including age, sex, education, occupation, duration of diabetes, smoking status, and hypertension history, were collected through structured interviews and cross-checked against available health records. The pretest ABI assessment was performed before the first exercise session under standardized resting conditions, and the posttest ABI assessment was performed after completion of the second supervised session using the same measurement procedure, equipment, assessor, and room conditions. Intervention adherence was monitored using attendance logs and supervisor checklists, and all 35 participants completed both exercise sessions and both ABI assessments. To reduce potential short-term variability, participants were measured using the same protocol and were asked to follow routine treatment as usual during the brief intervention period; however, medication changes, glycemic fluctuation, dietary variation, and other lifestyle-related confounders were not statistically controlled in the final analysis.

### 2.6 Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics were used to summarize participant characteristics. Normality of the pre-post difference scores was assessed using the Shapiro-Wilk test, and because the assumptions for parametric testing were met, paired-sample t-tests were used to compare mean pretest and posttest ABI values for the right and left extremities. Effect sizes were estimated using Cohen's d, and statistical significance was set at $p < 0.05$. Given the single-group design and absence of analytical control for confounders, findings should be interpreted as evidence of association within this sample rather than proof that the intervention alone caused the observed ABI changes.

### 2.7 Ethical Considerations

Approved by the Health Research Ethics Committee, Faculty of Medicine and Health Sciences, Universitas Jambi. Written informed consent was obtained. Confidentiality, anonymity, and withdrawal rights were guaranteed.

## 3. RESULTS AND ANALYSIS

### 3.1 Participant Characteristics

Thirty-five participants completed both intervention sessions and ABI assessments. Demographic and clinical profiles are summarized in Tables 1–7. Table 1 presents the age distribution of respondents.

Table 1: Distribution of Respondents by Age Group

| **Age Group (years)** | **Frequency ($f$)** | **Percentage (%)** |
|---|---|---|
| 40–49 | 3 | 8.57 |
| 50–59 | 9 | 25.71 |
| 60–69 | 17 | 48.57 |
| ≥70 | 6 | 17.14 |
| Total | 35 | 100.00 |

Based on Table 1, Most respondents (48.57%) were in the 60–69 years age group, indicating that the majority were older adults who are at higher risk of developing peripheral vascular complications.

Table 2: Distribution of Respondents by Gender

| **Gender** | **Frequency ($f$)** | **Percentage (%)** |
|---|---|---|
| Male | 18 | 51.43 |
| Female | 17 | 48.57 |
| **Total** | **35** | **100.00** |

Based on Table 2, The gender distribution was relatively balanced, with slightly more male respondents (51.43%) than female respondents (48.57%).

Table 3: Distribution of Respondents by Educational Background

| Education Level | Frequency ($f$) | Percentage (%) |
|---|---|---|
| No formal education | 1 | 2.86 |
| Elementary School | 1 | 2.86 |
| Junior High School | 10 | 28.57 |
| Senior High School | 9 | 25.71 |
| Higher Education | 14 | 40.00 |
| Total | 35 | 100.00 |

Table 3 presents most respondents (40%) had completed higher education, suggesting a relatively good understanding of diabetes management and health information.

Table 4: Distribution of Respondents by Occupation

| No | Occupation | Frequency ($f$) | Percentage (%) |
|---|---|---|---|
| 1 | Daily laborer | 4 | 11.43 |
| 2 | Entrepreneur | 5 | 14.29 |
| 3 | Driver | 1 | 2.86 |
| 4 | Farm laborer | 1 | 2.86 |
| 5 | Retired civil servant | 12 | 34.29 |
| 6 | Civil servant | 3 | 8.57 |
| 7 | Housewife | 9 | 25.71 |
| T | otal | 35 | 100.00 |

Based on Table 4 regarding occupational history, The majority of respondents were retired civil servants (34.29%), followed by housewives (25.71%) and entrepreneurs (14.29%).

Table 5: Distribution of Respondents by Duration of Diabetes Mellitus

| Duration of DM | Frequency ($f$) | Percentage (%) |
|---|---|---|
| $<$ 2 years | 1 | 2.86 |
| $\geq$ 2 years | 34 | 97.14 |
| Total | 35 | 100.00 |

Table 5 shows that Most respondents (97.14%) had lived with diabetes mellitus for more than two years, indicating long-term exposure to metabolic and vascular changes.

Smoking Status

Table 6: Distribution of Respondents by Smoking Status

| Smoking Status | Frequency ($f$) | Percentage (%) |
|---|---|---|
| Active smoker | 4 | 11.43 |
| Non-smoker | 31 | 88.57 |
| Total | 35 | 100.00 |

Based on Table 6, The majority of respondents were non-smokers (88.57%), which may contribute positively to vascular health.

Table 7: Distribution of Respondents by Hypertension History

| Hypertension History | Frequency ($f$) | Percentage (%) |
|---|---|---|
| Yes | 17 | 48.57 |
| No | 18 | 51.43 |
| Total | 35 | 100.00 |

As shown in Table 7, Respondents were nearly evenly distributed between those with (48.57%) and without (51.43%) a history of hypertension, indicating that almost half of the sample had an additional cardiovascular risk factor.

## 3.2 Bivariate Analysis

Mean ABI values increased after the intervention in both lower extremities. In the right extremity, the mean ABI increased from 0.89 ± 0.06 before the intervention to 0.94 ± 0.05 after the intervention, with a statistically significant mean difference on paired analysis ($p < 0.001$) and a large effect size (Cohen's d = 1.39) as shown on Table 8.

Table 8: Comparison of ABI Values Before and After the Intervention

| Variable | Mean | SD | Min | Max | 95% CI | p-value | Effect Size (d) |
|---|---|---|---|---|---|---|---|
| Pre-test | 0.89 | 0.06 | 0.79 | 1.00 | 0.87–0.91 | | |
| Post-test | 0.94 | 0.05 | 0.86 | 1.00 | 0.92–0.96 | < 0.001 | 1.39 |

In the left extremity, the mean ABI increased from 0.89 ± 0.05 to 0.94 ± 0.05, also with a statistically significant paired difference ($p < 0.001$) and a large effect size (Cohen's d = 1.28) as shown in Table 9.

Table 9: Comparison of ABI Values Before and After the Intervention

| Variable | Mean | SD | Min | Max | 95% CI | p-value | Effect Size (d) |
|---|---|---|---|---|---|---|---|
| Pre-test | 0.89 | 0.05 | 0.79 | 1.00 | 0.87–0.91 | | |
| Post-test | 0.94 | 0.05 | 0.86 | 1.00 | 0.92–0.95 | < 0.001 | 1.28 |

The Shapiro-Wilk test indicated that the pre-post difference scores were normally distributed for both the right ($p = 0.18$) and left ($p = 0.22$) extremities, supporting the use of paired t-tests.

## 3.3 Discussion

This study found that mean ABI values were higher after completion of a short supervised diabetic foot exercise program than before the intervention in this sample of patients with T2DM. The direction of this finding is consistent with previous reports suggesting that lower-extremity exercise may support peripheral circulation in people with diabetes. The improvement observed in both extremities also supports the practical plausibility of the intervention as a structured self-care activity that may be feasible in primary-care settings.

The findings can be interpreted in relation to both nursing theory and exercise physiology. From the perspective of Orem's Self-Care Deficit Nursing Theory, diabetic foot exercise may function as a supportive-educative strategy that enables patients to participate actively in the management of chronic disease. From a physiological perspective, repeated ankle and calf movement may enhance venous return, stimulate the skeletal muscle pump, and support local perfusion. However, these mechanisms remain explanatory rather than directly tested in the present study.

The results should be interpreted cautiously because the study used a one-group pretest-posttest design without a control group. Under this design, the observed ABI increase cannot be attributed solely to the exercise program because alternative explanations remain possible, including short-term variation in vascular tone, medication adherence, recent physical activity, dietary intake, glycemic fluctuation, and regression to the mean. Although the study attempted to improve measurement rigor through standardized ABI assessment, a single assessor, and supervised intervention delivery, these precautions reduce measurement error but do not eliminate design-related threats to validity.

However, the one-group pretest-posttest design without control comparison precludes causal attribution. Observed changes may reflect natural variation, measurement acclimation, unmeasured confounders (glycemic fluctuations, hydration status, recent physical activity), or regression toward the mean. The short one-week timeframe demonstrates acute response but not durability, while single-site purposive sampling ($n = 35$) limits external validity to similar resource-constrained settings.

Several limitations should be emphasized. Key limitations include: (1) lack of control group, preventing isolation of intervention effects from secular trends or placebo; (2) brief intervention duration (one week), insufficient for chronic vascular adaptation; (3) unadjusted confounders including glycemic control (no HbA1c), medications, and lifestyle factors; (4) single-center generalizability constraints; and (5) modest sample size. These design choices prioritized implementation feasibility over experimental rigor, appropriate for pilot data but requiring validation.

## 4. CONCLUSION

In this sample of patients with T2DM, ABI values were higher after a short supervised diabetic foot exercise program than at baseline. These findings suggest that diabetic foot exercise may be a feasible supportive strategy for circulation-focused diabetes self-management in primary care, but the study design does not permit a definitive causal conclusion. Because the study used a one-group quasi-experimental approach with a short follow-up period and limited control of confounding variables, the results should be viewed as preliminary. Larger controlled studies are needed before this intervention can be recommended as an evidence-based standard practice for improving peripheral circulation.

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