

Role of Foot Exercise on Healing of Diabetic Foot Ulcer Patients Attending Surgical OPD of Civil Hospital

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DOI: <https://doi.org/10.52403/ijhsr.20261001>

Received: 07/05/2026; Revised: 04/08/2026; Accepted: 28/09/2026

ABSTRACT

Background: Diabetic foot ulcers (DFUs) are a major complication of diabetes mellitus, often leading to disability, amputation, and mortality.

Objective: To assess the effect of foot exercises on the healing of diabetic foot ulcers in type 2 diabetic patients.

Methods: A prospective case-control study was conducted over 1.5 years at PDU Hospital, Rajkot, including 100 Wagner grade 1 or 2 diabetic foot ulcer patients, selected by simple random sampling. Patients were assigned to an exercise group (n=50) receiving supervised non-weight-bearing foot exercises plus standard care, or a control group (n=50) receiving standard care. Wound area, depth, discharge, slough, and granulation were assessed at baseline, 1 month, and 3 months. Data were analysed using MS Excel (2021) and SPSS (v26); $p < 0.05$ was considered significant. Ethical clearance was obtained.

Results: The majority of patients were aged 51–60 years, with a male predominance in both groups. Both groups showed wound healing progression; however, the exercise group exhibited a statistically significant reduction in wound area at 3 months ($p = 0.025$). Discharge absence at 1 month was significantly higher ($p = 0.04$) in the exercise group. Slough reduction and granulation tissue increase were more marked in the exercise group, though not statistically significant.

Conclusion: Foot exercises, as an adjunct to standard care, significantly improve wound area reduction and early discharge control in DFUs, suggesting their practical utility in outpatient diabetic foot management.

Keywords: Diabetic foot ulcer, Foot exercises, Physical therapy, Type 2 diabetes, Wound healing

INTRODUCTION

Diabetes mellitus (DM) is a metabolic condition characterised by persistent hyperglycaemia, which can only be controlled, but not cured is one of the most prevalent chronic illnesses of the twenty-first century, and its global prevalence is increasing at an alarming rate. [1,2]

Long-term poor blood glucose control leads to severe complications, including cardiovascular diseases, stroke, renal failure, blindness, and diabetic foot ulcers (DFUs), which are defined by the International Working Group on the Diabetic Foot (IWGDF) as tissue damage involving ulceration, infection, or destruction, and are further exacerbated by musculoskeletal complications commonly seen in patients with a longstanding history of diabetes that increase the risk of ulcer development. [1-3]

Diabetic foot ulcers (DFUs), typically located on the toes or the plantar aspect of the metatarsal heads, are a leading cause of hospitalisation, amputation, and death among diabetics, usually developing due to peripheral neuropathy, ischaemia, or repetitive mechanical stress, and if left untreated, often progress into chronic, non-healing wounds, significantly increasing both morbidity and mortality. [1,4,5]

Besides pharmacotherapy, physical therapy offers potential benefits in DFU management, as it can enhance blood flow and tissue repair with fewer side effects. [2,6] Despite the recognised role of exercise in diabetes management, its systematic integration into DFU treatment remains limited. [7] Preventive strategies, including glycaemic control, lifestyle modification, foot monitoring, and exercise, can significantly reduce DFU risk and improve quality of life. [8,9]

This study aimed to evaluate the impact of foot exercises on DFU healing in type 2 diabetics.

MATERIALS & METHODS

Sampling method and site:

This prospective case-control study was conducted over 1.5 years in the Department of General Surgery at PDU Hospital, Rajkot, involving a total of 100 patients recruited using a purposive sampling method diagnosed with diabetic foot ulcers.

Sample size:

A total of 100 participants were enrolled in the study and randomly divided into two groups. 50 patients were assigned to the exercise group and 50 to the control group, with every second eligible patient systematically allocated to the control group.

Inclusion and exclusion criteria:

Patients referred to the department with foot ulcers and a known history of diabetes, specifically those with Wagner grade 1 or 2 ulcers, were included in the study. Patients were excluded if they had Wagner grade 3, 4, or 5 ulcers, mental illness, musculoskeletal disorders, heart diseases, neurological conditions, or if the ulcers were secondary to burns.

Data collection procedure and study tool:

The data were collected using a pre-designed, pre-tested, semi-structured questionnaire from both the exercise and control groups. After selecting eligible patients, informed consent was obtained. Detailed data were collected, including medical history, findings from general examination and specific characteristics of the ulcer, such as size, shape, depth, number, position, edges, floor and condition of the surrounding area.

For the intervention group, foot exercises were demonstrated and patients were advised to perform them daily at home along with their routine care. The control group continued only with standard care and after the third follow-up visit, they too were provided with an exercise demonstration and an informational pamphlet.

Follow-up assessments were conducted every 30 days for a total of three months. The exercise protocol emphasized non-weight-bearing movements, including range of motion exercises like plantar flexion, dorsiflexion, inversion, eversion, circumduction and toe flexion and extension, to be repeated 10–15 times each session.

Data were systematically entered into Microsoft Excel (MS Office 2021) and subsequently analysed using both Microsoft Excel and SPSS software (version 26) to ensure accurate and reliable statistical interpretation.

Ethical clearance:

The study obtained ethical clearance from the institutional ethics committee (PDUMCR/IEC/13/2023). Participants provided informed consent in their preferred language with signed consent forms. Confidentiality and anonymity were preserved through private interviews and data presentation without identifiers.

Statistical Analysis

The data were entered and analysed using Microsoft Excel (Version 2021) and SPSS software (Version 26). t test and Chi-Square test were performed for data analysis. A p-value of less than 0.05 was considered statistically significant.

RESULT

A total of 100 participants were enrolled in the study, equally distributed between the case group (n=50) and control group (n=50). The gender distribution indicated a predominance of males (61%) compared to females (39%). The participants had a mean diabetes duration of 7.68 ± 5.12 years, ranging from 1 to 25 years. Additionally, 34% (n=34) of the population reported hypertension as a comorbid condition.

The educational background of participants was comparable across groups, with the majority having attained primary education (38%), followed by secondary education (20%) and illiteracy (22%). Graduate-level education was least common, accounting for only 10% of the participants.

Anthropometric measures were also comparable at baseline between groups, as detailed in **Table 1**. The mean height and weight did not differ significantly between cases and controls ($p=0.295$ and $p=0.553$, respectively). Baseline wound area and depth measurements showed no significant difference, confirming group comparability at the start of the study.

Wound healing progress over three months was assessed through serial measurements of wound area and depth (**Table 2**). Although both groups demonstrated reductions over time, the case group exhibited a statistically significant decrease in wound area by the third month ($p=0.025$). However, wound depth did not differ significantly at any point, suggesting similar depth reduction trends across both groups.

Wound bed characteristics such as slough, granulation tissue, and discharge were evaluated and are presented in **Table 3**. Although the reduction of slough and increase in granulation tissue approached significance at 3 months ($p=0.08$ and $p=0.07$, respectively), only the absence of discharge at 1 month reached statistical significance ($p=0.04$), favouring the case group.

Loss to follow-up was noted at each visit: 7 participants by the first month, 11 by the second, and 12 by the third month. In the case group, the mean number of exercise days was 40 ± 13.7 (range 15–70). Pearson correlation analysis revealed a non-significant relationship between exercise frequency and wound area or depth reduction, suggesting limited influence on wound healing.

Table 1: Baseline Characteristics of Study Participants

Variable	Group	N	Mean $\pm$ SD / n (%)	Test Applied	Test Value (df)	p-value
Gender (Male)	Both Groups	100	61 (61%)	—	—	—
Gender (Female)	Both Groups	100	39 (39%)	—	—	—
Diabetes Duration (years)	Both Groups	100	7.68 $\pm$ 5.12	—	—	—
Hypertension Presence	Both Groups	100	34 (34%)	—	—	—
Educational Status	Both Groups	100	Primary: 38%, Secondary: 20%, Illiterate: 22%, Graduate: 10%	—	—	—
Height (cm)	Case	50	158.6 $\pm$ 10.26	Independent t-test	t(98) = -1.054	0.295
	Control	50	160.7 $\pm$ 9.26			
Weight (kg)	Case	50	66.6 $\pm$ 9.59	Independent t-test	t(98) = 0.595	0.553
	Control	50	65.4 $\pm$ 9.24			

Table 2: Comparison of Wound Area and Depth Over Time

Time Point	Parameter	Group	Mean $\pm$ SD	Test Applied	Test Value (df)	p-value
Baseline (0 month)	Area (cm ²)	Case	18.9 $\pm$ 15.4	Independent t-test	t(98) = -1.59	0.114
		Control	23.5 $\pm$ 13.5			
	Depth (cm)	Case	1.26 $\pm$ 0.56	Independent t-test	t(98) = 1.091	0.278
		Control	1.14 $\pm$ 0.57			
1 Month	Area (cm ²)	Case	18.0 $\pm$ 15.3	Independent t-test	t(98) = -1.62	0.108
		Control	22.8 $\pm$ 13.6			
	Depth (cm)	Case	1.18 $\pm$ 0.56	Independent t-test	t(91) = 0.615	0.540
		Control	1.11 $\pm$ 0.53			
2 Months	Area (cm ²)	Case	17.6 $\pm$ 14.8	Independent t-test	t(98) = -1.8	0.076
		Control	23.1 $\pm$ 13.9			
	Depth (cm)	Case	1.07 $\pm$ 0.50	Independent t-test	t(87) = -0.352	0.726
		Control	1.11 $\pm$ 0.52			
3 Months	Area (cm ²)	Case	15.2 $\pm$ 13.7	Independent t-test	t(98) = -2.27	0.025*
		Control	21.9 $\pm$ 13.8			
	Depth (cm)	Case	0.89 $\pm$ 0.42	Independent t-test	t(98) = -0.485	0.629
		Control	0.94 $\pm$ 0.49			

(*p<0.05: statistically significant)

Table 3: Comparison of Wound Characteristics - Slough, Granulation, and Discharge

Time Point	Parameter	Group	Absent	Present	Test Applied	Test Value	p-value
1 Month	Discharge	Case	36	11	Chi-square Test	$\chi^2(1) = 4.22$	0.04*
		Control	26	20			
3 Months	Slough	Case	37	7	Chi-square Test	$\chi^2(1) = 3.06$	0.08
		Control	30	14			
3 Months	Granulation Tissue	Case	6	38	Chi-square Test	$\chi^2(1) = 3.29$	0.07
		Control	13	31			

(*p<0.05: statistically significant)

DISCUSSION

This study investigated the efficacy of foot exercises in promoting the healing of diabetic foot ulcers (DFUs) among patients attending a surgical outpatient department. A case-control design was employed, with 50 patients in each group, facilitating a

balanced comparison between those receiving foot exercises (intervention group) and those under standard care (control group). This methodology aligns with current recommendations for robust clinical trials in diabetic foot research. [10]

Demographic Analysis The gender distribution exhibited a male predominance (61% vs. 39% female), consistent with trends observed in recent DFU studies [11]. Educational levels were relatively evenly distributed across both groups, with a substantial proportion of patients having primary education or being illiterate. This demographic information is crucial, as health literacy may impact diabetes self-management and ulcer outcomes.

Diabetes Duration and Comorbidities The mean duration of diabetes mellitus was 7.68 ± 5.12 years (range: 1-25 years). This wide range is noteworthy, as diabetes duration is a known factor influencing ulcer healing [12]. Hypertension was present as a comorbidity in 34% of patients, aligning with recent literature indicating a high prevalence of hypertension among DFU patients [13].

Anthropometric Measurements No statistically significant differences in height or weight were observed between the intervention and control groups ($p > 0.05$). This baseline comparability is crucial, as body mass index (BMI) has been associated with DFU outcomes in previous studies [14].

Wound Characteristics and Healing Progression

Wound Area: Longitudinal analysis of wound area revealed a statistically significant difference between groups at the 3-month mark ($p = 0.025$), with the intervention group demonstrating smaller wound areas. This delayed effect is consistent with findings from other intervention studies in diabetic foot care [15].

Wound Depth: No statistically significant differences in wound depth were observed between groups at any time point ($p > 0.05$). This finding contrasts with some studies that have reported correlations between exercise interventions and changes in wound depth [5].

Slough Presence: A trend towards statistical significance in slough presence was observed at the 3-month mark ($p = 0.08$).

This suggests that the foot exercise intervention may influence wound bed characteristics, consistent with theories positing improved circulation and tissue oxygenation through exercise [16].

Granulation Tissue: A trend towards increased granulation tissue in the intervention group was observed at 2 months ($p = 0.092$) and 3 months ($p = 0.07$). This aligns with recent studies suggesting that targeted exercises can accelerate the healing process of wounds [17].

Wound Discharge: Statistically significant differences in wound discharge were observed at 1 month ($p = 0.04$) and a trend at 2 months ($p = 0.053$), with the intervention group exhibiting less discharge. This could indicate accelerated progression through the inflammatory phase of wound healing in the exercise group.

Exercise Duration and Wound Healing. The mean duration of exercise in the intervention group was 40 ± 13.7 days. Notably, the correlations between exercise duration and wound characteristics (depth and area) were weak and predominantly non-significant. This lack of strong correlation suggests that factors beyond exercise duration alone may influence wound healing outcomes, reflecting the complex, multifactorial nature of DFU healing elucidated in recent literature.

CONCLUSION

This study contributes to the growing body of evidence supporting the integration of foot exercises in DFU management. The observed benefits in wound area reduction and trends in other wound characteristics suggest that incorporating targeted foot exercises into standard DFU care could potentially enhance healing outcomes. However, the complex nature of DFU healing and the limitations of this study underscore the need for further research to fully elucidate the role of exercise in DFU management and to optimize exercise protocols for maximal therapeutic benefit.

Declaration by Authors

Ethical Approval: Approved

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Patel S, Juneja I, Patel N. Role of foot exercise on healing of diabetic foot ulcer patients attending surgical OPD of Civil Hospital. *Int J Health Sci Res.* 2026; 16(10):1-7. doi: [10.52403/ijhsr.20261001](https://doi.org/10.52403/ijhsr.20261001)
