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Foot Exercise Therapy to Alleviate Peripheral Neuropathy Severity in Elderly Patients with Diabetes Mellitus

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Abstract

Foot neuropathy is a common condition experienced by older adults with diabetes mellitus. This complication can be managed through physical activity, including foot exercises. This study aimed to evaluate the effect of foot exercises on the severity of foot neuropathy in older adults with diabetes mellitus at the Tarokan Community Health Center. This quasi-experimental study employed a non-equivalent control group design and involved 30 older adults with diabetes mellitus who exhibited neuropathic symptoms. Participants were divided into two groups: 15 individuals in the intervention group and 15 in the control group, selected through purposive sampling. The intervention group performed foot exercises three times per week for three weeks, with each session lasting 15–20 minutes. A 10 g monofilament and an observation sheet were used as instruments, and data were analyzed using the Wilcoxon and Mann–Whitney tests. The Wilcoxon test revealed a significant reduction in the degree of foot neuropathy in the intervention group ($p = 0.001$), whereas the control group showed no significant change ($p = 0.527$). The Mann–Whitney test indicated a significant difference between the two groups ($p = 0.000$). These findings demonstrate that foot exercises effectively reduce the severity of foot neuropathy in older adults with diabetes mellitus. Regular implementation of foot exercises is recommended as a non-pharmacological approach to decreasing the degree of foot neuropathy among older adults with diabetes mellitus.

INTRODUCTION

Diabetic neuropathy (DN) represents one of the most common long-term complications associated with both type 1 and type 2 diabetes mellitus (T1DM and T2DM), leading to substantial deterioration in patients' quality of life and playing a significant role in increasing morbidity and mortality. Neuropathy is a form of nerve damage caused by elevated blood glucose levels, which reduces blood flow to the cells and disrupts normal neuronal activity (IDF, 2017). In older adults with diabetes mellitus, this condition may impair motor, sensory, and autonomic nerve function. Older adults living with diabetes mellitus frequently experience altered foot sensation, including numbness or loss of feeling. This condition often leads to reduced mobility and limited engagement in physical exercise, which in turn may exacerbate the severity of foot neuropath (Mildawati et al., 2019). As the worldwide incidence of diabetes continues to increase due to population aging and shifts in lifestyle patterns, the burden of diabetic neuropathy is anticipated to intensify. Nevertheless, compared with other diabetes-related complications such as nephropathy and retinopathy, diabetic neuropathy has attracted relatively limited attention in both clinical investigations and the development of therapeutic strategies, underscoring the need for further research (Yang et al., 2025). This study addresses the issue of diabetic neuropathy and proposes an intervention that may serve as a potential solution to manage this condition.

The estimated number of individuals with Diabetes Mellitus (DM) in East Java is 854,454 among residents aged 15 years and older. Primary healthcare services across 38 districts and municipalities in East Java have recorded 859,187 DM cases, reaching 100.6% of the estimated prevalence. In Kediri Regency, the number of diabetes cases has shown a decline, decreasing from 32,691 cases in 2022 to 32,489 cases in 2023 (Dinas Kesehatan Provinsi Jawa Timur, 2023). A preliminary study conducted at the research site revealed that at the Tarokan Community Health Center in Kediri Regency, there were 30 older adults with diabetes mellitus experiencing foot neuropathy, and none of them had previously participated in foot exercise programs (Primary Data, 2024).

Older adults with diabetes mellitus who develop foot neuropathy face an increased risk of sustaining injuries or infections in their feet without being aware of them, due to reduced sensitivity to pain and temperature. As the condition progresses, neuropathy may lead to gangrene and even lower-extremity amputation, ultimately diminishing the quality of life in older adults (Sukartini et al., 2019). Management of diabetes mellitus involves both pharmacological and non-pharmacological strategies. Pharmacological therapy includes the administration of insulin and oral hypoglycemic agents, whereas non-pharmacological therapy consists of dietary regulation, weight control, and physical exercise. Physical activity represents one of the core components of diabetes management because it helps reduce neuropathy and lower blood glucose levels by enhancing glucose utilization in active muscles (Yang et al., 2025). Among various forms of physical activity, diabetic foot exercises are specifically designed for individuals with diabetes—particularly older adults—to improve circulation in the feet affected by neuropathy, thereby helping prevent ulceration (Sukartini et al., 2019) . A study conducted by Palewo and colleagues (2021) demonstrated that incorporating newspaper-based movements into diabetic foot exercises significantly improves foot sensitivity in individuals with diabetes mellitus ($p \leq 0.05$). Consequently, nurses are encouraged to integrate foot exercise routines into standard nursing practice. The recommended frequency is 3–5 sessions per week, performed consistently, in a controlled, measurable, and continuous manner (Palewo et al., 2021).

RESEARCH METHODS

This quasi-experimental research with a non-equivalent control group design and included 30 older adults with diabetes mellitus who showed symptoms of neuropathy and selected by purposive sampling from 35 elderly with Diabetes who experienced neuropathy. The study was conducted at the Tarokan Community Health Center in Kediri Regency in May 2025. The participants were assigned to two groups—15 in the intervention group and 15 in the control group. Those in the intervention group carried out foot-exercise routines three times a week over a three-week period, with each session lasting between 15 and 20 minutes.

The instruments utilized in this study included a 10 g monofilament, clean gloves, a black marker, standard operating procedures (SOPs) for the monofilament test and foot exercise, a foot-exercise implementation guide, a sheet of newspaper, and a booklet illustrating the steps of the foot exercise. Additionally, data related to the foot-exercise implementation were collected using a control sheet completed by participants in the intervention group while performing the exercises independently at home. The Wilcoxon test was employed to analyze the pre-test and post-test observations in both the control and intervention groups. In addition, the Mann–Whitney test was used to compare the two groups to determine whether a significant difference existed between them. All statistical analyses were performed using IBM SPSS version 27. This study received ethical approval from the Research Ethics Committee of the Bhakti Wiyata Institute of Health Sciences, Kediri, under approval number 638/FIK/KEP/IV/2025.

RESULT

Age

Table 1 Frequency Distribution of Respondents' Ages

	Intervention Group		Control Group	
Age	**F**	**(%)**	**F**	**(%)**
60-74 years old	14	93.3%	15	100.0%
75-90 years old	1	6.7%	0	0
Total	15	100.0%	15	100.0%

Sources : Primary Data, 2025

Table 1 indicates that most respondents in both groups were within the 60–74 age range. In the intervention group, 14 respondents were aged 60–70 years, representing 93.3%. Meanwhile, all 15 respondents in the control group were aged 60–74 years, accounting for 100%.

Gender

Table 2 Frequency Distribution of Respondents' Gender

	Intervention Group		Control Group	
Gender	**F**	**(%)**	**F**	**(%)**
Male	6	40.0%	5	33.3%
Female	9	60.0%	10	66.7%
Total	15	100.0%	15	100.0%

Sources : Primary Data, 2025

Most respondents in both groups were female. In the intervention group, 9 participants were women, accounting for 60.0%. In the control group, 10 respondents were female, representing 66.7%.

Duration of Having Diabetes Mellitus

Table 2 Frequency Distribution of Respondents' Duration of Having Diabetes Mellitus

	Intervention Group		Control Group	
Duration of Having Diabetes Mellitus	**F**	**(%)**	**F**	**(%)**
<1 years old	0	0%	3	20.0%
1-5 years old	6	40.0%	7	46.7%
6-10 years old	6	40.0%	4	26.7%
>10 years old	3	20.0%	1	6.7%
Total	15	100.0%	15	100.0%

Source : Primary Data, 2025

Table 3 above demonstrates that in the intervention group, the majority of respondents had been diagnosed with diabetes mellitus for either 1–5 years or 6–10 years, with both categories comprising six respondents (40.0%) each. In contrast, in the control group, most participants had lived with diabetes mellitus for 1–5 years, accounting for seven respondents (46.7%).

Neuropathy Levels

Table 4 Cross-tabulation of Pre-test and Post-test Result In the Intervention Group

Pre-test	Post-test					Total
	Zero Degree	1st Degree	2nd Degree	3rd Degree	4th Degree	
Zero Degree	0	0	0	0	0	**0**
1st Degree	0	0	0	0	0	**0**
2nd Degree	0	1	0	0	0	**1**
3rd Degree	2	2	1	0	0	**5**
4th Degree	2	4	3	0	0	**9**
Total	**4**	**7**	**4**	**0**	**0**	**15**

Source : Primary Data, 2025

Table 4 presents the changes in the degree of foot neuropathy among respondents before and after the foot exercise intervention. The data reveal a consistent improvement across all participants, indicating a reduction in neuropathy severity following the intervention. Prior to the exercise program (pre-test), the majority of respondents exhibited a neuropathy score of grade 4, comprising nine individuals (60.0%). After completing the intervention (post-test), most participants demonstrated improvement, with seven respondents (46.7%) achieving a neuropathy grade of 1.

Table 5 Cross-tabulation of Pre-test and Post-test Result In the Control Group

Pre-test	Post-test					Total
	Zero Degree	1st Degree	2nd Degree	3rd Degree	4th Degree	
Zero Degree	0	0	0	0	0	**0**
1st Degree	0	0	0	0	0	**0**
2nd Degree	0	0	3	2	0	**5**
3rd Degree	0	1	0	5	1	**7**
4th Degree	0	0	0	3	0	**3**
Total	**0**	**1**	**3**	**10**	**1**	**15**

Source : Primary Data, 2025

Table 5 presents data on the degree of foot neuropathy among respondents in the control group, which generally showed minimal change over the study period. The majority of participants (n = 8; 53.4%) exhibited no alteration in neuropathy severity, while three participants (20%) experienced a progression to a more severe stage. Conversely, post-test results indicated that four respondents (26.6%) demonstrated an improvement, reflected by a reduction in the degree of neuropathy.

Table 6. Analysis of Foot Neuropathy Severity in the Intervention and Control Groups by the Wilcoxon-signed Rank Test Among Elderly Patients with Diabetes Mellitus at Tarokan Community Health Center, Kediri Regency.

Groups	*Positive Rank*	*Negative Rank*	*Ties*	*Mean Rank*	*P-Value*
Intervention Group	0	15	0	8.00	0.001
Control Group	3	4	8	4.38	0.527

Source : Primary Data, 2025

The data summarized in Table 6 indicate that all participants in the intervention group experienced a reduction in the degree of neuropathy, while the results for the control group were more variable. In the control group, 53.3% of subjects showed no change in neuropathy severity, whereas three participants exhibited worsening conditions. Conversely, four subjects (26.6%) demonstrated improvement in neuropathy severity. The Wilcoxon-signed rank test results revealed that the observed changes in the intervention group were statistically significant, while those in the control group were not significant.

Table 7. Analysis of Foot Neuropathy Severity between Intervention and Control Groups by the Mann-Whitney Test Among Elderly Patients with Diabetes Mellitus at Tarokan Community Health Center, Kediri Regency

Groups	*Mean Rank*	*P-Value*
Intervention Group	8.90	0.000
Control Group	22.10	

Source : Primary Data, 2025

Table 7 presents the results of the Mann–Whitney U test, which revealed a significance value of 0.000 ($p < 0.05$). This finding indicates a statistically significant difference between the intervention and control groups. These results suggest that foot exercise effectively alleviated the severity of foot neuropathy among elderly patients with Diabetes Mellitus.

DISCUSSION

The findings of this study revealed that all elderly participants with diabetes mellitus who presented with foot neuropathy were classified within grades 2, 3, or 4 of neuropathy severity. No subjects were identified in grades 0 or 1, indicating the absence of mild or subclinical neuropathy among the study population. This pattern may be attributed to several contributing factors, one of the most prominent being age, which has been recognized as a critical determinant influencing the progression and severity of diabetic neuropathy. A study conducted by Popescu (2016) demonstrated that age serves as an independent determinant in the progression and worsening of diabetic neuropathy among patients with diabetes mellitus. Peripheral neuropathy may result from axonal degeneration, demyelination, or damage to both large and small nerve fibers, leading to a decline in nerve function. The prevalence of neuropathy in individuals with diabetes increases progressively with advancing age. Older adults with diabetes are particularly susceptible to foot ulceration and lower-limb amputation, reflecting the heightened risk associated with aging (Abdelhafiz & Sinclair, 2022). Advancing age has been shown to influence the progression of peripheral neuropathy in patients with diabetes mellitus (DM). Aging contributes to a reduction in vascular elasticity, thereby diminishing tissue vascularization and impairing blood flow (Putri et al., 2020). Structural alterations in the vascular wall, including intimal thickening and loss of elasticity, result in increased arterial stiffness, which compromises the efficiency of oxygen and nutrient transport to peripheral tissues. This vascular rigidity elevates the risk of ischemic events, and, when sustained over time, can lead to nerve injury and neuropathic degeneration (Prasetyani, 2019).

The clinical manifestation of neuropathy also varies across age groups. Younger elderly individuals (60–74 years) and older elderly individuals (75–90 years) demonstrate significant differences in neuropathy severity, progression, and functional impact. Importantly, the risk of mortality increases by approximately 47% among older adults with diabetic foot neuropathy, and those in the older elderly group exhibit a 90% higher mortality risk compared with younger elderly patients aged 60–74 years (Lawler et al., 2023).

The findings in the intervention group revealed significant changes in foot neuropathy severity before and after the implementation of foot exercise therapy. All participants (100%) demonstrated improvement, indicated by a reduction in neuropathy severity scores. The results of the Wilcoxon Signed-Rank Test showed a positive rank of 0, a negative rank of 15, and no ties, suggesting that all 15 respondents experienced a decrease in neuropathy severity between the pre-test and post-test. The obtained significance value ($p = 0.001$) confirms that foot exercise had a statistically significant effect on reducing foot neuropathy severity among elderly patients with diabetes mellitus at Tarokan Community Health Center, Kediri Regency.

Several studies have demonstrated that diabetic foot exercise exerts a positive effect on foot neuropathy symptoms. A study by Oktapiani et al. (2024) reported a significant difference in the degree of diabetic neuropathy between the intervention and control groups, with a p-value of 0.023 ($\alpha < 0.05$), indicating the effectiveness of the intervention. This study was conducted among individuals diagnosed with Diabetes Mellitus aged between 40 and 60 years (Oktapiani et al., 2024). This study aligns with the findings of Artina and Aprilia (2022), who implemented foot exercise interventions to enhance foot sensitivity among patients with type 2 diabetes mellitus. Foot sensory function was assessed using the brush component of a reflex hammer in conjunction with a lancet. Therefore, it can be concluded that increased foot sensitivity in patients with type 2 diabetes mellitus can be achieved through regular foot exercise (Artina & Aprilla, 2022).

Patients with diabetes who develop neuropathy typically exhibit reduced nerve conduction velocity, primarily caused by demyelination, loss of large myelinated fibers, and decreased nerve action potentials resulting from axonal degeneration. In diabetic individuals, regular physical activity contributes to weight reduction, improved glycemic control, and enhanced insulin sensitivity — all of which collectively lower the risk of developing neuropathy. Exercise has been shown to positively influence several pathological mechanisms underlying diabetic peripheral neuropathy by improving microvascular function, enhancing lipid oxidation, reducing oxidative stress, and increasing the expression of neurotrophic factors. Notably, exercise-induced elevation of Neurotrophin-3 (NT-3) levels has been linked to improved peripheral nerve conduction velocity and a reduction in neuropathic pain. NT-3 plays a crucial role in promoting neuronal survival and differentiation, as well as facilitating synaptic growth and neurogenesis. Specific exercises involving the feet and toes can modulate sorbitol levels in the body, thereby preventing decreased endoneurial blood flow. Physical stimulation in the form of foot or leg exercises generates action potentials that trigger depolarization, leading to increased Na^+/K^+-ATPase activity and enhanced axonal transport, which in turn restores sensory responses. Foot exercises also promote smooth and efficient blood circulation in the lower extremities (Sukartini et al., 2019).

Moreover, such exercises provide both sensory and motor stimulation to peripheral nerves. In the absence of this stimulation, nerves tend to become less active, accelerating degenerative changes over time. This condition can lead to diminished reflexes, reduced sensitivity, and impaired motor responses. Lack of foot exercise further decreases blood flow to the lower limbs, resulting in reduced oxygen and nutrient delivery to neural tissues, thereby worsening nerve ischemia. Prolonged oxygen deprivation accelerates neural degeneration and exacerbates neuropathy severity (Monteiro et al., 2022).

The implementation of foot exercise in the intervention group serves as a practical activity that can be performed by patients with diabetes mellitus to prevent foot ulcers and promote blood circulation in the lower extremities, thereby reducing the severity of neuropathy. Foot exercise improves circulation, strengthens muscles, and alleviates joint stiffness commonly experienced by diabetic patients (Oktapiani et al., 2024). Diabetic foot exercise is recognized as part of the four essential pillars

of diabetes management, specifically within the domain of physical activity, which aims to enhance self-care ability and prevent complications associated with diabetes mellitus (Simamora et al., 2020).

Based on the findings of this study, it can be concluded that the foot exercise intervention administered to the intervention group had a significant effect in reducing the severity of neuropathy among elderly patients with diabetes mellitus. The observed improvement in neuropathy severity within the intervention group is associated with enhanced neural stimulation through focused physical activity involving the lower extremities, which optimizes blood flow and nutrient delivery to neural tissues. Physiologically, foot exercise contributes to improving peripheral blood circulation, enhancing glucose utilization by muscles, and activating insulin receptors. These mechanisms collectively increase insulin sensitivity and help maintain optimal blood glucose levels. This finding aligns with previous studies reporting that physical activity, particularly foot exercise, can decelerate peripheral nerve degeneration and prevent worsening of neuropathic symptoms. Conversely, participants in the control group who did not receive foot exercise intervention exhibited a tendency toward worsening neuropathy severity. This condition is likely attributable to the absence of motor stimulation in peripheral nerves, leading to reduced oxygen and nutrient supply to neural tissues.

Foot exercise is identified as an effective non-pharmacological intervention that significantly reduces the degree of peripheral neuropathy among elderly patients with diabetes mellitus. All respondents in the intervention group demonstrated clinical improvement, indicating that structured physical activity, such as foot exercise, plays a substantial role in enhancing peripheral nerve function. The effectiveness of foot exercise in reducing neuropathy scores was further supported by statistical analyses using the Wilcoxon and Mann–Whitney tests, both of which revealed significant results ($p < 0.05$). These findings confirm that foot exercise effectively stimulates blood circulation, enhances sensory sensitivity, and alleviates neuropathic symptoms commonly experienced by individuals with diabetes mellitus.

CONCLUSION

Foot exercise can be considered an effective and practical non-pharmacological therapeutic alternative for mitigating neuropathy severity in diabetic patients, including the elderly. Therefore, foot exercise should be recommended as a component of self-rehabilitation programs for elderly individuals with diabetic neuropathy to prevent further neural deterioration and improve overall quality of life.

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