

Effectiveness of Foot Massage and Exercise on Diabetic Peripheral Neuropathy in Type 2 Diabetes Mellitus

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ABSTRACT

OBJECTIVE: This study aimed to identify the effectiveness of foot massage and foot exercise on diabetic peripheral neuropathy in patients with type 2 diabetes mellitus.

METHODOLOGY: A quasi-experimental pretest-posttest control-group design was employed in this study. The sampling technique used was purposive sampling, consisting of 68 respondents divided into two groups consisting of 34 respondents/group in a provincial hospital of Aceh, Indonesia. Data collection was conducted from May 2023 to April 2024 by using the monofilament test and the Michigan Diabetic Neuropathy Score to identify and measure diabetic peripheral neuropathy. Data analysis used the Mann-Whitney U test and the independent t-test in SPSS version 25.

RESULTS: The pretest results for the intervention and control groups showed $p = 0.293$ (mean ranks 37.01 and 31.99, respectively), indicating no difference in the diabetic neuropathy mean score between the groups. At the same time, the posttest results in both groups showed $p = 0.013$ (mean scores of 15.24 and 19.50, respectively), indicating a significant difference in mean diabetic neuropathy scores between the intervention and control groups.

CONCLUSION: The study's findings indicate foot massage and foot exercise are effective in reducing diabetic peripheral neuropathy (DPN) by restoring sensation, as observed during neurological foot examinations. The interventions enhanced peripheral circulation, alleviated stress, induced relaxation, augmented blood flow, and mitigated pain through the release of endorphins. Emphasis is placed on interventions that patients can incorporate into their routine practice to effectively manage and reduce the symptoms of DPN.

KEYWORDS: Diabetes mellitus, neuropathy, foot massage, foot exercise

INTRODUCTION

As a chronic disease, diabetes mellitus causes an inability of the body to metabolize thus causing metabolic disorders 1. DM is related to the pancreas not producing enough insulin, or to the body's metabolism not using insulin optimally. Impaired insulin secretion causes uncontrolled hyperglycemia, which can damage the body's systems, particularly the nerves and blood vessels. T2DM accounts for 90% of all diabetes cases worldwide².

Globally, in 2024, an estimated 589 million adults (20-79 years) and 853 million in 2050 were living with diabetes, 4/10 adults with diabetes were undiagnosed, 3.4 million deaths due to diabetes in 2024 3, and

747,000 deaths occurred in 2021 4. Based on the results of the 2023 Indonesian Health Survey, the prevalence of DM in the Indonesian population of all ages was 1.7%. Those aged ≥ 15 accounted for 2.2% of the population 5. At the same time, Aceh province is among the top nine provinces in Indonesia with the most people suffering from DM, with an estimated 417,600 sufferers, 8.7% of the total population of Aceh 6.

Data from the DPN in Indonesia study (2010-2024) involving 2,808 participants reported that the prevalence of DPN in T2DM was 76.65%; it was highest in people aged 40-60 years. The prevalence and variation of DPN are very high across regions and demographic groups. 7. DPN is a serious problem in T2DM, causing tingling, pain, numbness, and muscle weakness, which increases the risk of foot wounds and infections⁸.

The high prevalence rate is very important for follow-up management of diabetes mellitus; if not treated properly, it can cause many complications 9. T2DM complications related to ineffective management caused macrovascular complications, resulting in cardiovascular death 10. Microvascular complications caused retinopathy, nephropathy, and neuropathy, and about 60-70% T2DM patients with microvascular complications such as neuropathy in Northeast Ethiopia 11.

Foot massage is a therapy that involves massaging

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the soles of the feet, where the soles of the feet are the nerve endings that could be stimulated with a gentle massage using the hands 12. Giving a foot massage can help smooth and improve blood circulation in the feet. With gentle, superficial massage techniques ranging from light to strong pressure, it causes vasodilation of blood vessels, involving reflexes in the muscles of the arteriole walls¹³. This study used olive oil, which contains antioxidants and unsaturated fatty acids that help fight inflammation and moisturize the skin. The method of foot massage includes effleurage, petrissage, friction, tapotement, and vibration.

Foot exercises focus on the legs and consist of several steps. This exercise can be practised easily, with no cost or time required. A previous study stated that foot exercises are an alternative to prevent neuropathy by improving peripheral blood circulation and strengthening the muscles of the lower extremities, thereby preventing complications of diabetic ulcers and foot deformities 4. Those interventions are commonly used, especially among Acehnese people, with olive oil due to its feasibility and effectiveness in increasing blood circulation and preventing peripheral neuropathy in the feet.

The majority of T2DM sufferers suffer from neuropathy related to chronic hyperglycemia and ineffective diabetes self-management, including inadequate information on foot care, foot exercises and foot massage as an effort to prevent DPN. Based on this phenomenon, we aim to demonstrate the effectiveness of foot massage and foot exercises in patients with type 2 diabetes mellitus and diabetic peripheral neuropathy. This study aims to identify the effectiveness of foot massage and foot exercises on diabetic peripheral neuropathy in T2DM patients.

METHODOLOGY

Design, population and sample

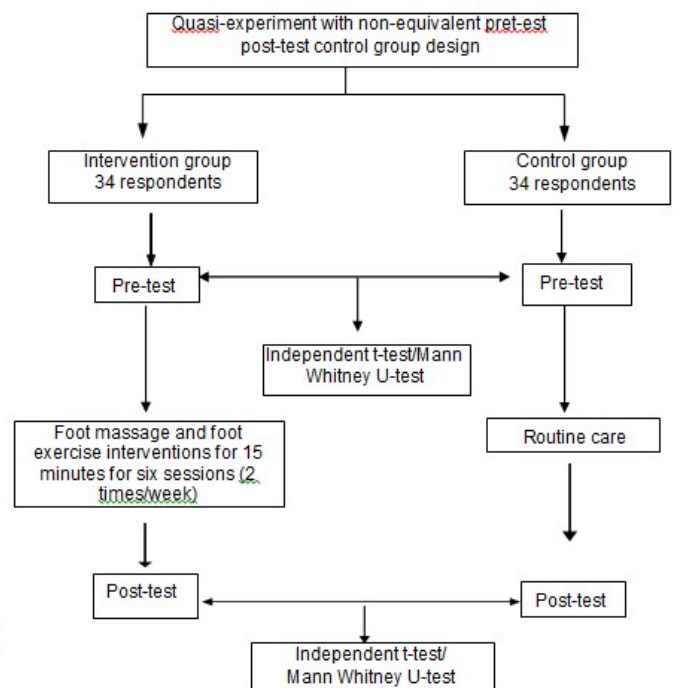
A Quasi-Experiment using a nonequivalent pretest-posttest control-group design was employed. Data was collected in a provincial hospital of Aceh, Indonesia from May 2023 to April 2024. The intervention and control groups were screened for the identification of diabetic peripheral neuropathy. The intervention group consisted of T2DM patients scheduled to attend the Endocrine Polyclinic twice a week, and the control group consisted of patients who attended every week to monitor their health or take diabetic medication. Both groups received different treatments: the intervention group received foot massage with olive oil and foot exercises, and the control group received routine care (standard education and medication management). The intervention group received foot massage and foot exercises every 15 minutes for 6 sessions (2 times/week). Each session involves a foot massage consisting of several techniques, namely: effleurage, petrissage, friction, tapotement and vibration. Foot exercises include several movements such as flexion,

extension, abduction, adduction, rotation, and combination exercises.

The method of foot massage, including effleurage, petrissage, friction, tapotement, and vibration, is applied at points with neuropathy identified during screening. While the foot exercises were performed while sitting upright in a chair, they involved flexing the toes, rotating the ankles, alternately lifting the heels and soles of the feet, and tearing and crumpling newspaper with the feet. Those exercises were performed by the researchers and assisted by three trained nurses at the hospital's Endocrine Polyclinic. The pretest and posttest for each group were conducted immediately at the end of the sessions.

The population of this study was all patients diagnosed with T2DM who were treated at the Endocrine Polyclinic. The number of samples was calculated using Cohen's (1988) sample-size calculation technique. At a 95% confident interval, using a medium effect size with a total sample of 68, and each group consisted of 34 respondents. The sampling technique was purposive sampling. The inclusion criteria: 1) Onset of diabetes ≥ 1 year, 2) having blood pressure (90/60–160/110 mmHg), 3) being able to communicate verbally, 4) screening results showing diabetic peripheral neuropathy, and 5) using oral medication or insulin. The exclusion criteria were: 1) patients who experienced visual and hearing impairments, disability and mental disorders, 2) patients who had dependency on care, such as stroke, immobility due to fracture, and other problems that caused partial or total dependency on care.

The flowchart of the study is shown in Scheme 1 below.



Scheme 1: The study's intervention framework

Instrument

Data collection used measuring instruments, namely the Michigan Neuropathy Screening Instrument (MNSI), which consists of 15 items to assess diabetic peripheral neuropathy (DPN), and the Michigan Diabetic Neuropathy Score (MDNS), which assesses the degree of neuropathy and consists of two parts: neurologic function examination and nerve conduction examination¹⁵. The tools used for neurological examination include the Semmes-Weinstein Monofilament 10 g, 128 Hz tuning fork, pinprick, and reflex hammer. The MNSI level is defined in mild, moderate and severe categories.

Data Analysis

Data analysis included univariate analysis presented in frequency, percentage, mean, standard deviation and mean rank. Normality of the data was tested to determine which statistical test to use: the Mann-Whitney U-test or the independent t-test.

Ethical Considerations

All study procedures adhered to applicable research ethics principles and were approved by the Ethics Committee of Dr. Zainoel Abidin Hospital (Number: 001/ETIK-RSUDZA/2025). All respondents provided written consent before participating in the study.

RESULTS

In this study, the Mann-Whitney U-test was used for the pretest, and an independent t-test was used for the posttest to determine whether the normality assumptions were met. The results of the study are presented in Table 1-4. **Table I** shows that the majority of respondents were male in the intervention and control groups, namely 67.6% and 73.5%, respectively. The mean ages of the respondents were 61 and 57.7 years, respectively. The majority of participants were married in both the intervention and control groups, namely 61.8% and 50.6%, respectively. The last education level was tertiary, namely 58.8% in the intervention and 58.8% in the control group. The majority of respondents' jobs were self-employment: 50% in the intervention group and 64.7% in the control group. The duration of the disease was >10 years in the intervention group, as much as 55.9%, and < 5 years in the control group, as much as 35.2%. The average respondent used insulin, namely in the intervention group as much as 50% and the control group as much as 38.2%.

The average HbA1c value was 7.8 mmol/L in each group, while the average blood glucose levels were 234 mg/dL and 289 mg/dL in the intervention and control groups, respectively.

Table II showed that the majority of pretest results for diabetic neuropathy were moderate levels of neuropathy, as much as 41.2% and 64.7% in the intervention and control groups. Furthermore, in posttest results for diabetic neuropathy in the intervention and control groups, there was a moderate level of neuropathy as much as 61.8% 70.6% respectively.

Table I: Sociodemographic and Clinical Characteristic Data of Respondents

Demographic Data	Intervention group (n=34)		Control group (n=34)	
	f	%	f	%
Age (M±SD)	61±6.98		57.7±6.59	
Gender				
Male	23	67.6	25	73.5
Female	11	32.4	9	26.5
Marital status				
Married	21	61.8	24	70.6
Widow	13	38,2	10	29,4
Education				
Higher	18	58.8	20	58.8
Intermediate	16	41.2	14	41.2
Work				
Laborer	3	8.8	1	2.9
housewife	7	20.6	6	17.6
Retired	7	20.6	5	14.7
Self-employed	17	50.0	22	64.7
Duration of Disease (M±SD)	11±4.64		9.3±5.40	
1- 5 years	7	20.6	12	35.2
6-10 years	8	23.5	11	32.4
> 10 years	19	55.9	11	32.4
Medical history				
Hypertension	6	17.6	4	11.8
Coronary heart	5	14.7	7	20.6
Dyslipidemia	23	67.6	23	67.6
Medication				
Insulin	17	50.0	11	32.4
Oral	10	29.4	13	38.2
Insulin+ oral hypoglycemic agent	7	20.6	10	29.4
HbA1c (Mean)	7.8		7.8	
	mmol/L		mmol/L	
Blood glucose (Mean)	234		289	
	mg/dL		mg/dL	

Table III showed that the pre-test diabetic neuropathy scores in the intervention and control groups were 37.01 and 31.99, respectively, with $p=0.293$, indicating no significant difference in the mean pre-test diabetic neuropathy score between the groups.

Table IV showed that the mean score of the posttest was obtained for diabetic neuropathy score in the intervention and control groups, with a mean and standard deviation score of 15.24 ± 6.44 and 19.50 ± 7.32 ($p=0.013$).

Table II: Diabetic Neuropathy Levels in Intervention and Control Groups

Diabetic Neuropathy Level	Intervention Group (n=34)		Control Group (n=34)		
	f	%	f	%	
Pretest	Severe	13	38.2	7	20.6
	Moderate	14	41.2	22	64.7
	Mild	7	20.6	5	14.7
Posttest	Severe	2	5.9	5	14.7
	Moderate	21	61.8	24	70.6
	Mild	11	32.4	5	14.7

Table III: Pretest Diabetic Neuropathy Score Analysis in Diabetic Patients

Variables	Group	N	Mean Rank	Sum of ranks	p
Pre-test	Control	34	31.99	1087.50	0.293
	Intervention	34	37.01	1258.50	

Table IV: Posttest Diabetic Neuropathy Score Analysis in Diabetic Patients

Variables	Group	N	Mean	Std. Deviation	p
Posttest	Control	34	19.50	7,321	0.013
	Intervention	34	15.24	6,448	

DISCUSSION

DPN is a serious problem in T2DM, where hyperglycemia causes peripheral nerve damage. Tingling, pain, numbness, and muscle weakness, which increase the risk of foot wounds and infections, are some of the symptoms. Foot massage and exercises can help reduce DPN complications. Foot massage is a nursing care method for 2DM patients to reduce DPN complaints⁸. Meanwhile, foot exercises improve microvascular function and fat oxidation, reduce oxidative stress, and increase neurotrophic factors. Furthermore, foot exercises may improve peripheral perfusion and prevent the worsening of diabetic neuropathy¹⁶.

The data analysis showed no significant difference in the pre-test MDNS score between the control and intervention groups (p=0.293). Before the intervention, reported that 10% of respondents complained of pain when the sheets touched their skin, could not distinguish between hot and cold water when bathing, and had open wounds on the soles of their feet. The results of the study, in line with previous studies, mentioned manifestations of distal symmetrical neuropathy, such as loss of sensation, pain, and paresthesia. Diabetic neuropathy, which causes pain, affects 25% to 30% of diabetic patients¹⁷. The mean pain scores of patients in the foot massage group decreased significantly compared with those in the

control group¹⁸.

A previous study reported that 50% of patients experienced mild neuropathy and 12.5% experienced severe neuropathy¹⁹. The development of diabetic peripheral neuropathy (DPN) is influenced by several factors such as age, onset of diabetes, uncontrolled blood sugar and gender²⁰. Increasing age stimulates the degeneration process and causes nerve damage. These changes occur in large and small nerve fibres, which contribute to elderly susceptibility to neuropathy. The most frequent DPN incidents were experienced at the age of 45-65 years. Another study also found that the prevalence of DPN was 47.5% in patients aged 50-59 years²¹. Nerve damage often occurs with age due to decreased blood flow to peripheral nerves. However, it is possible that peripheral neuropathy can also be found at a young age²².

Furthermore, factors that affect people with peripheral neuropathic diabetes are age, and the aging process will be more visible. Age will affect nerve damage due to diabetic²³. There is a positive correlation between age and the incidence of peripheral diabetic neuropathy. This prevalence increases with age, from 5.6% in those aged <40 years to 51.8% in those aged >60 years²⁴. Furthermore, a study reported that most respondents with diabetes have had diabetes for >10 years (87%), and half have high blood glucose levels (50%). Long-term diabetes and poor glycemic control increase the formation of glycosylation end products, metabolic disorders, endothelial injury, and oxidative stress. Poor glycemic control and chronic hyperglycemia are risk factors for DPN and contribute to microangiopathy, which can lead to neuropathy²⁵.

The results of this study also proved that both groups have had diabetes for ≥9 years, have high blood glucose levels, with an average in the intervention and control groups of 234 mg/dL and 289 mg/dL, respectively. This is supported by a study stating that the duration of diabetes and poor glycemic control are associated with increased glycosylation, metabolic disorders, endothelial injury, and oxidative products¹³. A study reported a significant association between DPN and duration of diabetes with abnormal HbA1c levels in individuals with type 2 diabetes mellitus (p=0.001)²⁶. Poor glycemic control and chronic hyperglycemia are risk factors for DPN. Chronic hyperglycemia causes microangiopathy, which can lead to neuropathy²⁷. On the other hand, both groups showed a medical history of dyslipidemia (≥67.6%). This condition could potentially lead to peripheral artery disease, a narrowing of the blood vessels in the legs and arms. Furthermore, dyslipidemia is also a risk factor for T2DM and tissue death. Diabetic patients may manage and minimize the risk of DPN complications. These findings align with previous research reporting that dyslipidemia is associated with poorer glycemic control, obesity, cardiovascular disease, and peripheral artery disease²⁸.

The results of the data analysis after the intervention in both groups showed $p = 0.013$, indicating a significant difference in the mean posttest diabetic neuropathy score between the intervention and control groups. Based on the mean posttest diabetic neuropathy score, the intervention group had a lower score than the control group. This result aligns with previous research that reported significant differences in neuropathy levels before and after massage therapy interventions for diabetic neuropathy recovery¹⁷.

A study reported that foot massage significantly reduces peripheral neuropathy in T2DM ($p < 0.001$). This study states that foot massage is a method of providing nursing care for T2DM patients with peripheral neuropathy²⁰. Foot massage involves applying gentle pressure to the soles of the feet to improve blood flow. Good blood flow supports the supply of oxygen and nutrients to nerve cells and reduces the number of symptoms of diabetic peripheral neuropathy²⁹.

LIMITATIONS

Several factors may affect the results of this study, including the small sample size, data collection methods, and nurses' experience in performing foot massage. It is recommended that further studies be conducted using a randomized controlled trial (RCT) design and a longer intervention duration to strengthen the evidence of the effectiveness of foot massage and foot exercise and their impact on the quality of life of diabetic patients.

CONTRIBUTION TO GLOBAL NURSING PRACTICE

The results of this study could be used to enhance scientific literacy, especially for trained professional nurses, to perform and teach this technique routinely to patients in diabetic foot care. This study is expected to provide a guideline for future research.

CONCLUSION

Foot massage and foot exercises with olive oil can improve the strength and flexibility of foot muscles, helping reduce symptoms of diabetic peripheral neuropathy, such as weakness and stiffness. Foot exercises can help improve blood circulation to the feet and reduce symptoms of peripheral neuropathy, such as tingling and numbness. Based on the results of the study, there was no significant difference in the pre-test measurement of the Michigan Diabetic Neuropathy Score between the control and intervention groups. However, in the intervention group, the posttest using the Michigan Diabetic Neuropathy Score showed a lower mean diabetic neuropathy score than in the control group. Patients diagnosed with diabetes are advised to follow a home exercise program, such as diabetic foot exercises, which focuses on maintaining and increasing ankle range of motion.

In addition, through foot exercises, blood supply to the extremities may increase, potentially leading to the formation of new blood vessel structures. Foot

massage and foot exercises are effective, practical, and accessible interventions for managing diabetic peripheral neuropathy. These exercises may reduce neuropathic symptoms, improve foot sensitivity and muscle strength, and improve balance, thereby helping prevent complications such as foot ulcers and falls.

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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Irwansyah: Wrote the protocol and monitored the data collection, collected the data, assisted with statistical analysis, conducted the primary data analysis and drafted the initial manuscript.

Husna C: Wrote the protocol and monitored the data collection, conducted the primary data analysis, drafted the initial manuscript and contributed to the final review of the manuscript.

Darmawati D: collected the data and assisted with statistical analysis, contributed to the final review of the manuscript.

Fithria F: conducted the primary data analysis and drafted the initial manuscript, and contributed to the final review of the manuscript.

All authors approved the final version.

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