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Effects of Thai Foot Massage on Pain, Ankle Range of Motion and Somatosensory Function in Patients with Type 2 Diabetes Mellitus and Peripheral Neuropathy: A Randomized Controlled Trial

Foot Massage and Diabetic Neuropathy

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Trial registration number: NCT06066944

ABSTRACT:

Objective: To evaluate the immediate and long-term effects of Thai Foot Massage (TFM) on pain intensity, ankle range of motion (ROM), and somatosensory perception in patients with type 2 diabetes mellitus (T2DM) and diabetic peripheral neuropathy (DPN).

Design: Randomized controlled trial.

Setting: Tehsil Headquarters (THQ) Hospital, Sheikhupura, Pakistan.

Participants: Seventy-two patients with T2DM-associated DPN (aged 45–64 years, diabetes duration >5 years) were randomly allocated using lottery method, to intervention (n=37) and control (n=37) groups.

Intervention: The intervention group received 20-minute TFM sessions on each foot on alternate days for 15 days in addition to routine diabetic care. The control group received routine diabetic care. Blinding was not feasible due to the nature of the intervention.

Main Outcome Measures: Pain intensity measured using the Numeric Pain Rating Scale (NPRS), ankle dorsiflexion and plantarflexion ROM measured with a universal goniometer, and somatosensory perception assessed using the Ipswich Touch Test (IpTT). Outcomes were evaluated at baseline, immediately post-intervention, and at 2- and 4-week follow-up.

Results: Repeated-measures ANOVA demonstrated significant improvements in the intervention group across all outcomes. Pain intensity showed a significant time effect (Pillai's Trace=0.953, F=249.699, $p<0.001$), while no significant change was observed in the control group (Pillai's Trace=0.070, F=1.430, $p=0.252$). Significant improvements were also observed in right ankle dorsiflexion (Pillai's Trace=0.764, F=39.983, $p<0.001$), right plantarflexion (Pillai's Trace=0.668, F=24.778, $p<0.001$), left dorsiflexion (Pillai's Trace=0.803, F=50.262, $p<0.001$), left plantarflexion (Pillai's Trace=0.765, F=40.208, $p<0.001$), and somatosensory perception assessed by IpTT (Pillai's Trace=0.773, F=42.007, $p<0.001$). Improvements were maintained at 2- and 4-week follow-up assessments.

Conclusions: Thai Foot Massage produced significant immediate and sustained improvements in pain, ankle mobility, and somatosensory perception in patients with DPN. TFM may be considered a safe and effective complementary intervention to enhance functional outcomes and symptom management in individuals with T2DM-related peripheral neuropathy.

Trial Registration: NCT06066944.

Limitations: The study was conducted at a single center with a relatively short intervention and follow-up period, which may limit generalizability and long-term interpretation of outcomes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- First randomized controlled trial evaluating immediate and follow-up effects of Thai Foot Massage in DPN in this setting and population.
- Multiple clinically relevant outcomes assessed.
- Follow-up conducted at 2 and 4 weeks.
- Single-center design may limit generalizability.
- Blinding of participants not have been feasible.

1. INTRODUCTION AND BACKGROUND

Type 2 diabetes mellitus (T2DM) is a major global health challenge affecting over 463 million adults worldwide, with the number projected to reach 700 million by 2045(Otegenova et al., 2024). Diabetic peripheral neuropathy (DPN) is one of the most common and disabling complications of T2DM, affecting approximately 40–50% of individuals with diabetes (Zhu et al., 2024). DPN results from diabetes-induced peripheral nerve damage and is characterized by pain, numbness, tingling, burning sensations, and progressive sensory loss, particularly in the lower extremities. These manifestations substantially impair physical function and quality of life (Khan et al., 2025).

Burden of T2DM and DPN

The increasing prevalence of T2DM has contributed to a growing global burden of disability, morbidity, and healthcare costs. DPN is associated with chronic pain, impaired mobility, foot ulceration, and increased risk of lower-limb amputation, leading to prolonged hospitalization and long-term disability (Liao and Zhang, 2024). The burden is particularly high in low- and middle-income countries where healthcare resources are limited. Previous studies have reported DPN prevalence ranging from approximately 40% to over 70% among patients with T2DM, emphasizing the need for effective management strategies (Safiri et al., 2022).

Impact of pain, reduced ROM and sensory loss

Pain, reduced ankle range of motion (ROM), and impaired somatosensory function are major clinical manifestations of DPN. These impairments restrict mobility and compromise balance. It also increases the risk of falls and foot ulcers that reduce the ability to perform activities of daily living. Collectively, they contribute to functional disability and diminished quality of life. It highlights the importance of interventions that address multiple aspects of neuropathic dysfunction rather than pain alone.

Limitations of pharmacological management

Current management of DPN primarily focuses on glycemic control, risk-factor modification and pharmacological symptom relief. However, available medications often provide only partial relief of neuropathic pain, may produce adverse effects, and do not affect disease progression. Consequently, effective and safe non-pharmacological interventions are increasingly being explored to complement conventional treatment (Ji et al., 2026).

Evidence supporting massage therapy

Thai Foot Massage (TFM) is a complementary, non-pharmacological intervention that may reduce pain, improve joint mobility and enhance sensory function by promoting circulation and neuromuscular stimulation. Previous studies suggest that massage-based therapies can improve symptoms of diabetic peripheral neuropathy (Utli, 2022). However, available evidence remains limited and fragmented, with most studies evaluating only short-term effects or single outcome measures.

Knowledge Gap

Despite the potential benefits of Thai Foot Massage, limited evidence exists regarding its immediate and prolonged therapeutic effects in patients with T2DM and DPN. Only a few studies have simultaneously examined pain intensity, ankle range of motion and somatosensory rception, particularly among South Asian populations where the prevalence of DPN is high. Addressing these outcomes together provides a more comprehensive understanding of the intervention's clinical effectiveness.

Study Aim and Hypothesis

It was hypothesized that Thai Foot Massage would significantly reduce pain and improve ankle range of motion and somatosensory reception immediately after the intervention and at follow-up compared with baseline measurements

Study Design

This study was a parallel-group, randomized controlled trial (RCT) Reg No: NCT06066944

Study Setting

The study was conducted at the Institute of Nursing, University of Health Sciences, Lahore, in collaboration with the Diabetic Clinic of District Headquarters Hospital Sheikhupura, Pakistan.

2. PARTICIPANTS

Inclusion Criteria

Participants were eligible if they:

- Had diagnosed T2DM for more than five years.
- Were aged 45–64 years.
- Were male or female.
- Were receiving oral hypoglycemic agents and/or insulin therapy.
- Had diabetic peripheral neuropathy confirmed by an Ipswich Touch Test (IpTT) score ≤4/6.
- Were able to understand study procedures and provide written informed consent.

Exclusion Criteria

Participants were excluded if they had:

- Active foot ulcers or foot infections.
- Severe cardiovascular or respiratory disease.
- Pregnancy or lactation.
- Received foot massage or physical therapy within the previous three months.
- Cognitive impairment limiting participation.
- Lower-limb amputation.

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Sample Size Calculation

The sample size was calculated using data from a previous study by Chatchawan et al. with 80% statistical power and a 5% significance level. Based on the expected difference in ankle dorsiflexion ROM, 72 participants were required. After allowing for a 5% attrition rate, the final sample size was increased to 78 participants.

Randomization and Allocation Concealment

Eligible participants were recruited using purposive sampling and randomly assigned to either the intervention or control group using the lottery method

Blinding

Because of the nature of the massage intervention, participants and the therapist could not be blinded.

3. INTERVENTION

Thai Foot Massage Protocol

Participants allocated to the intervention group received standardized Thai Foot Massage in addition to routine diabetic care. The protocol consisted of sequential stimulation of plantar and dorsal foot reflex points and longitudinal massage strokes designed to improve circulation, reduce neuropathic pain, stimulate peripheral nerves, and enhance ankle mobility according to the protocol described by Chatchawan et al.

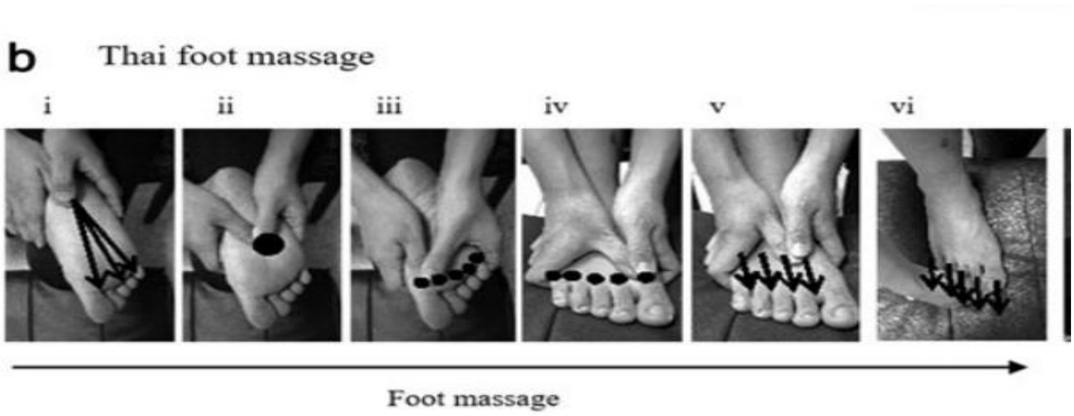

Fig 1: Figuer is taken from the study of Chatchawan et al. after getting permission

Session Duration

Each treatment session lasted **20 minutes per foot** (40 minutes total).

Frequency

Massage sessions were administered on alternate days for **15 days**.

Therapist Qualifications

The intervention was administered by the researcher, who is a qualified nurse and received supervised training and a certificate in Thai Foot Massage before intervention administration.

Control Group

Participants in the control group received routine diabetic care prescribed by their diabetologist, including medication, dietary advice and foot-care.

4. OUTCOME MEASURES

Primary Outcome

1. Pain Intensity

Pain intensity was measured using the **Numeric Pain Rating Scale (NPRS)**, an 11-point scale ranging from 0 ("no pain") to 10 ("worst imaginable pain").

2. A: Ankle Dorsiflexion Range of Motion

Active ankle dorsiflexion ROM was measured in degrees using a universal goniometer.

B. Ankle Plantarflexion Range of Motion

Active ankle plantarflexion ROM was also measured using the universal goniometer.

3. Somatosensory Reception

Somatosensory function was evaluated using the **Ipswich Touch Test (IpTT)** by assessing protective sensation over the first, third, and fifth toes of both feet. Scores ≤4/6 indicated peripheral neuropathy.

Assessment Time Points

Outcome measurements were performed at four time points:

1. Baseline (before intervention)
2. Immediately after the first intervention session (within 30 minutes)
3. Two weeks after initiation of treatment
4. Four weeks after completion of treatment

Statistical Analysis

Data were analyzed using appropriate statistical software.

- Continuous variables were summarized using mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages.
- Normality of continuous data was assessed before inferential analysis.
- Baseline differences between groups were evaluated using appropriate between-group statistical tests.
- Changes over time between intervention and control groups were analyzed using repeated-measures of Anova analysis.
- Effect sizes and 95% confidence intervals were reported where appropriate.
- Statistical significance was established at $p < 0.05$.

Statistical analysis was performed using SPSS software. Data normality was assessed using the Shapiro–Wilk test. Repeated-measures ANOVA was applied to analyse the data across all stages.

Ethics Approval

Ethical approval was obtained from the Institutional Review Board (IRB) and the Advanced Studies and Research Board (ASRB) of the University of Health Sciences, Lahore. Permission was also obtained from the District Headquarters Hospital Sheikhupura. The trial was prospectively registered at **ClinicalTrials.gov (NCT06066944)**. Written informed consent was obtained from all participants prior to enrollment, and confidentiality was maintained throughout the study.

Patient and Public Involvement Statement

Patients and members of the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Results

This chapter presents the findings of the study "Immediate and Prolonged Effects of Thai Foot Massage on Pain, Range of Motion and Somatosensory Reception among Patients with Type 2 Diabetes Peripheral Neuropathy." This chapter consists of two parts: the first is Descriptive Statistics, and the second is inferential statistics

Section 4.1

Descriptive statistics. This section includes the description of sociodemographic variables

Age

Table 4.1 1: Age of the participants

Descriptive Statistics Age					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Intervention Group	40	45	65	56.23	6.212
Control group	40	45	64	54.25	6.029

The average age of participants in the intervention group was 56.23 years (±6.21), while in the control group it was 54.25 years (±6.03). The age range in both groups was similar, from 45 to 65 years in the intervention group and 45 to 64 years in the control group. This shows that participants in both groups were closely matched in terms of age.

Gender

Table 4.1 2 Gender of the participants

Descriptive Statistics of Gender							
	N	**Male**	**%age**	**Female**	**%age**	**Total**	
Intervention Group	40	**22**	**52.4%**	**18**	**47.4%**	40	50%
Control group	40	**20**	**50%**	**20**	**50%**	40	50%
Total	80	**42**	52.5%	**38**	47.5%	80	100%

The study included an equal number of participants in both the intervention and control groups (40 in each). In the intervention group, there were 22 males (52.4%) and 18 females (47.6%). In the control group, there were 20 males (47.6%) and 20 females (52.4%). Overall, out of 80 participants, 42 were male (52.5%) and 38 were female (47.5%), showing a fairly balanced gender distribution across both groups.

Occupation

Table 4.1 3: Occupation of the participants

	Occupation of the participants					
	Office Job	**Labour**	**Own Business**	**House Wife**	**No work**	**Total**
Intervention Group	12	14	2	12	0	40
	57.1%	63.6%	22.2%	44.4%	0.0%	50.0%
Control Group	9	8	7	15	1	40
	42.9%	36.4%	77.8%	55.6%	100.0%	50.0%

Total	21	22	9	27	1	80
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Participants in both the intervention and control groups had a variety of occupations. In the intervention group, most were either laborers (14 participants) or had office jobs (12), followed by housewives (12) and a small number running their own business (2). No participants in this group reported being unemployed. In the control group, the largest group was housewives (15), followed by office workers (9), laborers (8), and those with their own business (7); one participant reported having no work. Overall, the occupational distribution was diverse across both groups, with a relatively balanced representation of different job types.

Education

Table 4.1 4: Education level of the participants

	Education level of the participants				
	No formal education	**High school diploma or equivalent**	**Bachelor's degree**	**Master's degree**	**Total**
Intervention Group	17	12	9	2	40
	53.1%	46.2%	45.0%	100.0%	50.0%
Control Group	15	14	11	0	40
	46.9%	53.8%	55.0%	0.0%	50.0%
Total	32	26	20	2	80
	100.0%	100.0%	100.0%	100.0%	100.0%

Participants in the study had varying levels of education. In the intervention group, 17 had no formal education, 12 had a high school diploma or equivalent, 9 held a bachelor's degree, and 2 had a master's degree. In the control group, 15 participants had no formal education, 14 had a high school diploma, and 11 held a bachelor's degree. None of the control group participants had a master's degree. Overall, most participants had either no formal education or a high school diploma, with only a few having higher education degrees.

Anthropometric measurement

Table 4.1 5: Anthropometric measurement of the participants

	Anthropometric measurements	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Intervention Group	Height	40	152	182	163.725	7.39711
	Weight	40	45	98	73.37	10.51551
	BMI	40	18.5	33.9	27.29	2.81796
Control Group	Height	40	58	185	161.91	18.77576
	Weight	40	42	100	74.665	12.08715
	BMI	40	17.3	39.9	27.6	3.72593

Participants in both groups had similar physical characteristics. The average height in the intervention group was 163.73 cm (±7.40), while in the control group it was slightly lower at 161.91 cm (±18.78). The average weight was 73.37 kg (±10.52) in the intervention group and 74.67 kg (±12.09) in the control group. BMI was also comparable, with a mean of 27.29 (±2.82) in the intervention group and 27.60 (±3.73) in the control group. These values suggest that both groups were relatively similar in terms of height, weight, and BMI.

Biochemical measurements

Table 4.1 6: Biochemical measurements

	Groups	N	Minimum	Maximum	Mean	Std. Deviation
Blood glucose level	Intervention	40	108	482	189.98	75.615
	control	40	118	240	187.65	37.187
Last HbA1C	Intervention	40	6.20	11.00	7.8575	.98914
	control	40	5.80	9.40	7.5075	.76103
Duration of Diabetes	Intervention	40	5	15	8.81	2.566
	control	40	5	14	7.99	2.311

Participants in both groups had similar blood glucose and HbA1c levels. The intervention group had an average blood glucose level of 189.98 mg/dL (±75.62), while the control group had a slightly lower average of 187.65 mg/dL (±37.19). The mean HbA1c was 7.86% (±0.99) in the intervention group and 7.51% (±0.76) in the control group. The average duration of diabetes was 8.81 years (±2.57) in the intervention group and 7.99 years (±2.31) in the control group. These findings show that both groups were comparable in terms of glycemic status and diabetes history.

Numbness in the lower extremities of the participants

Table 4.1 7: Descriptive Statistics of Numbness in the lower extremities of the participants

	Numbness in the lower extremities		
	Yes	No	
Intervention	30	10	40
	47.6%	58.8%	50.0%
Control	33	7	40
	52.4%	41.2%	50.0%
Total	63	17	80
	100.0%	100.0%	100.0%

Out of the total 80 participants, 63 (78.8%) reported numbness in the lower extremities. In the intervention group, 30 participants (75%) experienced numbness, while 10 did not. In the control group, 33 participants (82.5%) reported numbness, and 7 did not. The distribution of numbness was fairly similar in both groups.

Muscle Cramps in the Lower Limbs of the Participants

Table 4.1.(ix): Descriptive Statistics of Muscle Cramps in the Lower Limbs of the Participants

Table 4.1 8: Descriptive Statistics of Muscle Cramps in the Lower Limbs of the Participants

Groups	**Muscle Cramps in the Lower Limbs**		**Total**
	Yes	No	
Intervention	34	6	40
	60.7%	25.0%	50.0%
Control	22	18	40
	39.3%	75.0%	50.0%
Total	56	24	80
	100.0%	100.0%	100.0%

Muscle cramps in the lower limbs were reported by a majority of participants. In the intervention group, 34 out of 40 participants (85%) experienced muscle cramps, while only 6 did not. In the control group, 22 participants (55%) reported cramps, and 18 did not. Overall, 56 out of 80 participants (70%) reported experiencing muscle cramps, with a higher frequency in the intervention group compared to the control group.

Muscle strength of the lower limbs of the participants: (Manual Muscle Testing Scale)

Table 4.1 9: Descriptive Statistics of Muscle strength of the lower limbs of the participants

Muscle strength of the lower limbs				
	Movement against gravity	**active movement against gravity without resistance**	**Normal movement**	**Total**
Intervention	4	26	10	40
	50.0%	59.1%	35.7%	50.0%
Control	4	18	18	40
	50.0%	40.9%	64.3%	50.0%
Total	8	44	28	80
	100.0%	100.0%	100.0%	100.0%

Muscle strength in the lower limbs varied across participants. In the intervention group, 4 participants (10%) showed only movement against gravity, 26 (65%) demonstrated active movement against gravity without resistance, and 10 (25%) had normal movement. In comparison, the control group also had 4 participants (10%) with movement against gravity, but a smaller number, 18 (45%), had movement without resistance, while 18 (45%) showed normal strength. Overall, normal movement was more common in the control group, while more participants in the intervention group had moderate strength.

Descriptive Statistics of Blood Pressure of the participants (Sphygmomanometer)

Table 4.1 10: Descriptive Statistics of Blood Pressure of the participants

`			Minimum	Maximum	Mean	Std. Deviation
intervention	**Systolic mmHg**	40	110	160	134.68	11.296
	Diastolic mmHg	40	65	100	82.13	8.020
control	**Systolic mmHg**	40	120	155	131.13	8.262
	Diastolic mmHg	40	68	90	79.10	6.271

The average systolic blood pressure in the intervention group was 134.68 mmHg (±11.30), ranging from 110 to 160 mmHg. In the control group, it was slightly lower at 131.13 mmHg (±8.26), with a range of 120 to 155 mmHg. The mean diastolic blood pressure was 82.13 mmHg (±8.02) in the intervention group and 79.10 mmHg (±6.27) in the control group. Overall, both groups had comparable blood pressure readings.

Although the intervention group showed slightly higher values, the differences between groups were minimal and not clinically meaningful. Statistical analysis indicated that these differences were not significant ($p > 0.05$), suggesting that both groups were comparable in terms of baseline blood pressure.

Section 4.2

Inferential Statistics

Independent T-test for Comparison of Pain between the Control Group and the Intervention Group at different time intervals. Pain was measured with the **Numeric Pain Rating Scale**.

Table 4.2 1: Independent T-test for Comparison of Pain between the Control Group and the Intervention Group at different time intervals

Time intervals	Groups	Mean ± SD	p-value
Before intervention	**Control**	4.05±1.061	p>0.05
	Intervention	4.80±1.067	
Immediately after 1st intervention	**Control**	4.03±1.050	p>0.05
	Intervention	4.10±1.057	
After 2 weeks of 1st intervention	**Control**	3.95±1.085	p<0.05
	Intervention	2.55±0.90	
After 4 weeks of intervention	**Control**	3.95±1.085	p<0.001
	Intervention	1.58±0.636	

Table 4.2.1 shows the comparison between the control and the intervention group. Before the intervention, there was no significant difference between the two groups ($p>0.05$), indicating that they were comparable. There was no significant

difference between the groups immediately following the first intervention (p>0.05), indicating that the initial intervention had modest immediate effects. After 2 weeks, the intervention group had a considerably lower mean of 2.55 ± 0.90 than the control group 3.95±1.085, with a p-value of < 0.05, indicating a favourable impact. After 4 weeks, the Intervention group had a significantly lower mean of 1.58±0.636 than the Control group, 3.95±1.085, with a p-value of <0.001, indicating that the intervention had a substantial and persistent effect over time. In conclusion, while the intervention had no immediate effect, it dramatically improved outcomes after 2 and 4 weeks, with the most significant shift occurring at the 4-week point.

Comparison of Dorsiflexion;

Table 4.2 2: Independent t-test for Comparison of Dorsiflexion at different time intervals between Intervention and Control Group (Right Foot)

Time intervals	Groups	Mean ± SD	p-value
Before intervention	Control	10.52 ± 1.92	p>0.05
	Intervention	11.08 ± 1.92	
Immediate after 1st intervention	Control	10.47 ± 2.01	p>0.05
	Intervention	11.16 ± 1.93	
After 2 weeks of 1st intervention	Control	10.52 ± 1.94	p<0.05
	Intervention	13.53 ± 2.06	
After 4 weeks of intervention	Control	10.15 ± 1.88	p<0.001
	Intervention	15.53 ± 2.54	

Table 4.2.2 shows that before the intervention, there was no significant change in dorsiflexion values between the Control and Intervention groups (Control: 10.52 ± 1.92; Intervention: 11.08 ± 1.92) (p>0.05). Following the initial intervention, dorsiflexion values were comparable between the groups (Control: 10.47 ± 2.01; Intervention: 11.16 ± 1.93), with no significant difference (p>0.05). After two weeks, the Intervention group showed a substantial improvement in dorsiflexion (13.53 ± 2.06) compared to the Control group (10.52 ± 1.94), with a p-value <0.05. In the fourth week, the Intervention group saw a considerable increase in dorsiflexion (15.53 ± 2.54) compared to the Control group (10.15 ± 1.88), with a very significant difference (p<0.001). In conclusion, the Intervention group showed significant gains in dorsiflexion at both the 2- and 4-week marks, whereas the Control group showed little change during the study period.

Table 4.2 3: Independent T-test Comparison of Dorsiflexion between Intervention and Control Group at different time intervals (Left Foot)

Time intervals	Groups	Mean ± SD	p-value
Before intervention	Control	12.05 ± 2.49	p>0.05
	Intervention	12.38 ± 2.52	
Immediate after 1st intervention	Control	12.05 ± 2.49	p>0.05
	Intervention	12.52 ± 2.48	
After 2 weeks of 1st intervention	Control	12.21 ± 2.59	p<0.05
	Intervention	13.86 ± 2.51	
After 4 weeks of intervention	Control	12.21 ± 2.59	p<0.001
	Intervention	14.61 ± 2.33	

On the other hand, Table 4.2. 3 revealed that before the intervention, there was no significant difference in dorsiflexion values between the Control and Intervention groups (Control: 12.05 ± 2.49; Intervention: 12.38 ± 2.52) (p>0.05). After the first intervention, dorsiflexion remained identical in both groups (Control: 12.05 ± 2.49; Intervention: 12.52 ± 2.48), with no significant change (p>0.05). After two weeks of the first intervention, the Intervention group showed a substantial improvement in dorsiflexion (13.86 ± 2.51) compared to the Control group (12.21 ± 2.59), with a p-value <0.05. After 4 weeks of intervention, the Intervention group experienced a substantial increase in dorsiflexion (14.61 ± 2.33) compared to the Control group (12.21 ± 2.59) (p<0.001). Overall, the Intervention group had large and persistent gains in dorsiflexion at 2 and 4 weeks, whereas the Control group exhibited no change over time.

Table 4.2 4: Independent T-test Comparison of Plantarflexion between Intervention and Control Group at different time intervals (Right Foot)

Time intervals	Groups	Mean ± SD	p-value
Before intervention	**Control**	25.97 ± 4.27	p>0.05
	Intervention	26.62 ± 4.08	
Immediate after 1st intervention	**Control**	26.06 ± 4.36	p>0.05
	Intervention	26.78 ± 4.14	
After 2 weeks of 1st intervention	**Control**	26.17 ± 4.43	p<0.05
	Intervention	28.07 ± 4.11	
After 4 weeks of intervention	**Control**	26.18 ± 4.44	p<0.001
	Intervention	29.57 ± 4.08	

Table 4.2.4 shows that before the intervention, there was no significant change in plantarflexion values of the right foot between the Control and Intervention groups (Control: 25.97 ± 4.27; Intervention: 26.62 ± 4.08) (p>0.05). Immediately after the first intervention, plantarflexion values were comparable between the groups (Control: 26.06 ± 4.36; Intervention: 26.78 ± 4.14), with no significant difference (p>0.05). After two weeks, the Intervention group had a significant improvement in plantarflexion (28.07 ± 4.11) compared to the Control group (26.17 ± 4.43), with a p-value <0.05.

In the fourth week, the Intervention group showed a considerable increase in plantarflexion (29.57 ± 4.08) compared to the Control group (26.18 ± 4.44), with a very significant difference (p < 0.001). Overall, the Intervention group demonstrated persistent and significant improvements in plantarflexion at both the 2- and 4-week periods, while the Control group showed only minor changes throughout the research period.

Table 4.2 5: Independent T-test Comparison of Plantarflexion between the Intervention and the Control Group at different time intervals (Left Foot)

Time intervals	Groups	Mean ± SD	p-value
Before intervention	**Control**	26.65 ± 4.46	p>0.05
	Intervention	28.61 ± 4.41	
Immediate after 1st intervention	**Control**	26.71 ± 4.42	p>0.05
	Intervention	28.68 ± 4.36	
After 2 weeks of 1st intervention	**Control**	26.71 ± 4.42	p<0.05
	Intervention	30.42 ± 4.16	
After 4 weeks of intervention	**Control**	26.75 ± 4.42	p<0.001
	Intervention	31.53 ± 3.91	

Table 4.2.5 shows the comparison of before the intervention, there was no significant change in plantarflexion values between the Control and Intervention groups (Control: 26.65 ± 4.46; Intervention: 28.61 ± 4.41) ($p>0.05$). Immediately after the first intervention, plantarflexion values were comparable between the groups (Control: 26.71 ± 4.42; Intervention: 28.68 ± 4.36), with no significant difference ($p>0.05$). After two weeks, the Intervention group showed a significant improvement in plantarflexion (30.42 ± 4.16) compared to the Control group (26.71 ± 4.42), with a p-value < 0.05. In the fourth week, the Intervention group experienced a considerable increase in plantarflexion (31.53 ± 3.91) compared to the Control group (26.75 ± 4.42), with a very significant difference ($p<0.001$). Overall, the Intervention group demonstrated consistent and significant improvements in plantarflexion at both the 2- and 4-week marks, whereas the Control group showed only minor changes throughout the study duration.

Table 4.2 6: Independent T test Comparison of Iptt score between the Intervention and the Control Group at different time intervals

Time intervals	Groups	Mean ± SD	p-value
Before intervention	**Control**	2.78 ± 1.12	$p>0.05$
	Intervention	2.85 ± 0.94	
Immediate after 1st intervention	**Control**	2.73 ± 1.10	$p>0.05$
	Intervention	3.25 ± 0.77	
After 2 weeks of 1st intervention	**Control**	2.75 ± 1.14	$p<0.05$
	Intervention	4.13 ± 0.75	
After 4 weeks of intervention	**Control**	2.78 ± 1.18	$p<0.001$
	Intervention	4.78 ± 0.92	

Table 4.2.6 presents the comparison of the Iptt score between the both groups. Before the intervention, both the Control and the Intervention groups had identical Iptt values (2.78 ± 1.12; 2.85 ± 0.94), with no significant difference ($p>0.05$). Following the first intervention, the Intervention group showed a substantial rise in IPTT (3.25 ± 0.77) compared to the Control group (2.73 ± 1.10), with a p-value < 0.05. After two weeks, the Intervention group had a significantly higher Iptt (4.13 ± 0.75) than the Control group (2.75 ± 1.14), with a p-value less than 0.001. By the fourth week, the Intervention group had a significantly higher increase in Iptt (4.78 ± 0.92) than the Control group (2.78 ± 1.18), with a p-value <0.001. Overall, the Intervention group showed continuous and significant improvements in IPTT at all time points, whereas the Control group showed very minor changes across the research period.

Table 4.2 7: Repeated measure of ANOVA applied to the Pain score of patients in the intervention and Control group.

	Control group		Intervention group	
Descriptive Statistics	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Pain before administration of intervention	4.05	1.061	4.80	1.067
Pain Immediate after 1st intervention	4.03	1.050	4.10	1.057
Pain after two weeks of 1st intervention	3.95	1.085	2.55	.904
Pain after 4 weeks of 1st intervention	3.95	1.085	1.58	.636

Multivariate Tests	Control group			Intervention group		
Effect	**Value**	**F**	**Sig.**	**Value**	**F**	**Sig.**

Pain	**Pillai's Trace**	.070	1.430[b]	.252	.953	249.699[b]	p<0.00
	Wilks' Lambda	.930	1.430[b]	.252	.047	249.699[b]	p<0.00
	Hotelling's Trace	.075	1.430[b]	.252	20.246	249.699[b]	p<0.00
	Roy's Largest Root	.075	1.430[b]	.252	20.246	249.699[b]	p<0.00

In Table 4.2. 7 The analysis showed a clear difference in pain reduction between the control and intervention groups. Initially, pain scores were similar (Control: 4.05 ±1.06; Intervention: 4.80 ±1.07). Immediately after the first intervention, both groups showed a slight decrease. However, by two weeks, the intervention group reported a significant drop in pain (2.55 ±0.90) compared to the control group (3.95 ±1.08). At four weeks, the intervention group's pain further reduced to 1.58 ±0.64, while the control group showed no change. Multivariate analysis confirmed these findings: the control group showed no significant change over time ($p = .252$), whereas the intervention group showed a highly significant reduction in pain (Pillai's Trace = .953, Wilks' Lambda = .047, $F = 249.699$, $p < .001$). These results indicate that the intervention was effective in significantly reducing pain over time.

Table 4.2 8: Repeated measure of ANOVA applied on the Range of Motion (Dorsi-flexion of Rt foot) score of patients in the intervention and Control group.

Descriptive Statistics	**Control group**		**Intervention group**	
	Mean	Std. Deviation	Mean	Std. Deviation
Range of Motion (Dorsi-flexion of Rt foot) before intervention in degrees	10.525	1.9214	11.088	1.9212
Range of Motion (Dorsi-flexion of Rt foot) soon after 1st intervention in degrees	10.475	2.0126	11.163	1.9361
Range of Motion (Dorsi-flexion of Rt foot) after two weeks of 1st intervention in degrees	10.525	1.9479	13.538	2.0643
Range of Motion (Dorsi-flexion of Rt foot) after four weeks of 1st intervention in degrees	10.150	1.8886	15.863	3.3205

Multivariate Tests		**Control group**			**Intervention group**		
Effect		Value	F	Sig.	Value	F	Sig.
Dorsiflexion	**Pillai's Trace**	.127	1.801[b]	.164	.764	39.983[b]	.000
	Wilks' Lambda	.873	1.801[b]	.164	.236	39.983[b]	.000
	Hotelling's Trace	.146	1.801[b]	.164	3.242	39.983[b]	.000
	Roy's Largest Root	.146	1.801[b]	.164	3.242	39.983[b]	.000

Table 4.2.8 indicated notable improvements in the range of motion (dorsiflexion of the right foot) in the intervention group compared to the control group. At baseline, both groups had similar mean dorsiflexion angles (Control: 10.53 ±1.92; Intervention: 11.09 ±1.92). Minimal changes were observed immediately after the first intervention. However, after two weeks, the intervention group showed a marked increase to 13.5 (±2.06), while the control group remained stable. By the fourth week, the intervention group's dorsiflexion significantly improved to 15.86 (±3.32), whereas the control group slightly declined to 10.15 (±1.89). Multivariate analysis revealed no statistically significant change in dorsiflexion over time for the control group (p

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= .164), while the intervention group showed a highly significant improvement (Pillai's Trace = .764, Wilks' Lambda = .236, F = 39.983, p < .001). These findings suggest that the intervention effectively enhanced ankle dorsiflexion over time.

Table 4.2 9: Repeated measure of ANOVA on the Range of Motion (Planter flexion of Rt foot) score of patients in the intervention and Control group.

Descriptive Statistics	Control group		Intervention Group	
	Mean	Std. Deviation	Mean	Std. Deviation
Range of Motion (Plantar-flexion of Rt foot) before intervention in degrees	25.975	4.2757	26.625	4.0868
Range of Motion (Plantar-flexion of Rt foot) soon after 1st intervention in degrees	26.063	4.3680	26.788	4.1415
Range of Motion (Plantar-flexion of Rt foot) after two weeks of 1st intervention in degrees	26.175	4.4355	28.075	4.1177
Range of Motion (Plantar-flexion of Rt foot) after four weeks of 1st intervention in degrees	26.188	4.4400	29.575	4.0881

Multivariate Tests		Control group			Intervention Group		
Effect		Value	F	Sig.			
Planter flexion	Pillai's Trace	.085	1.151b	.342	.668	24.778b	.000
	Wilks' Lambda	.915	1.151b	.342	.332	24.778b	.000
	Hotelling 's Trace	.093	1.151b	.342	2.009	24.778b	.000
	Roy's Largest Root	.093	1.151b	.342	2.009	24.778b	.000

The findings of Table 4.2.9 revealed significant improvements in the range of motion for plantar flexion of the right foot in the intervention group compared to the control group. At baseline, both groups had comparable plantar flexion angles (Control: 25.98° ±4.28; Intervention: 26.63° ±4.09). Minimal changes were noted immediately after the first intervention. However, at two weeks, the intervention group showed an increase to 28.08° (±4.12), while the control group remained nearly unchanged. By the fourth week, the intervention group further improved to 29.58° (±4.09), whereas the control group remained relatively stable at 26.19° (±4.44). Multivariate tests showed no statistically significant change over time in the control group (p = .342), whereas the intervention group demonstrated a significant improvement in plantar flexion (Pillai's Trace = .668, Wilks' Lambda = .332, F = 24.778, p < .001). These results suggest the intervention was effective in enhancing plantar flexion over time.

Table 4.2 10: Repeated measure of ANOVA was applied on the Range of Motion (Dorsi-flexion of Left foot) score of patients in the intervention and Control group.

Descriptive Statistics	Control group		Intervention Group	
	Mean	Std. Deviation	Mean	Std. Deviation
Range of Motion (Dorsi-flexion of Lt foot) before intervention in degrees	12.050	2.4905	12.388	2.5280
Range of Motion (Dorsi-flexion of Lt foot) immediate after 1st intervention in degrees	12.088	2.5138	12.525	2.4883
Range of Motion (Dorsi-flexion of Lt foot) after two weeks of 1st intervention in degrees	12.213	2.5941	13.863	2.5166

Range of Motion (Dorsi-flexion of Lt foot) after four weeks of 1st intervention in degrees	12.213	2.5941	14.613	2.3383

Multivariate Tests		**Control group**			**Intervention Group**		
Effect		**Value**	**F**	**Sig.**	**Value**	**F**	**Sig.**
Dorsiflexion	**Pillai's Trace**	.244	6.132b	.005	.803	50.262b	.000
	Wilks' Lambda	.756	6.132b	.005	.197	50.262b	.000
	Hotelling's Trace	.323	6.132b	.005	4.075	50.262b	.000
	Roy's Largest Root	.323	6.132b	.005	4.075	50.262b	.000

The results of Table 4.2.10 showed significant improvement in the range of motion (dorsiflexion) of the left foot in the intervention group compared to the control group. Initially, both groups had similar dorsiflexion angles (Control: 12.05° ±2.49; Intervention: 12.39° ±2.53). Minor changes were observed immediately after the first intervention. After two weeks, the intervention group's dorsiflexion increased to 13.86° (±2.52), while the control group showed a slight change. At four weeks, the intervention group improved further to 14.61° (±2.34), whereas the control group remained unchanged at 12.21° (±2.59). Multivariate tests indicated a statistically significant improvement over time in the intervention group (Pillai's Trace = .803, Wilks' Lambda = .197, F = 50.262, p < .001), while the control group showed only modest change (p = .005). These findings suggest that the intervention was effective in enhancing dorsiflexion of the left foot over time.

Table 4.2 11: Repeated measure of ANOVA applied on the Range of Motion (Plantar Flexion of Left foot) score of patients in the intervention and Control group.

Descriptive Statistics	**Control group**		**Intervention Group**	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
Range of Motion (Plantar-flexion of Lt foot) before intervention in degrees	26.650	4.4638	28.613	4.4180
Range of Motion (Plantar-flexion of Lt foot) immediate after 1st intervention in degrees	26.713	4.4230	28.688	4.3614
Range of Motion (Plantar-flexion of Lt foot) after two weeks of 1st intervention in degrees	26.713	4.4201	30.425	4.1657
Range of Motion (Plantar-flexion of Lt foot) after four weeks of 1st intervention in degrees	26.750	4.4289	31.538	3.9148

Multivariate Tests		**Control group**			**Intervention Group**		
Effect		Value	F	Sig.	Value	F	Sig.
Dorsiflexion	**Pillai's Trace**	.184	2.779b	.055	.765	40.208b	.000
	Wilks' Lambda	.816	2.779b	.055	.235	40.208b	.000
	Hotelling's Trace	.225	2.779b	.055	3.260	40.208b	.000
	Roy's Largest Root	.225	2.779b	.055	3.260	40.208b	.000

The data in Table 4.2.11 indicated significant improvement in the plantar flexion of the left foot in the intervention group compared to the control group. At baseline, the intervention group had a slightly higher mean plantar flexion (28.61° ±4.42) than the control group (26.65° ±4.46). Minimal changes were observed immediately after the first intervention. However, after two weeks, the intervention group showed a noticeable increase to 30.43° (±4.17), and further improved to 31.54° (±3.91) at four weeks. In contrast, the control group showed only a slight and gradual increase, reaching 26.75° (±4.43) at four weeks.

Multivariate analysis revealed no significant change over time in the control group ($p = .055$), whereas the intervention group demonstrated a statistically significant improvement in plantar flexion (Pillai's Trace = .765, Wilks' Lambda = .235, $F = 40.208$, $p < .001$). These results confirm the effectiveness of the intervention in improving left foot plantar flexion.

Table 4.2 12 : Repeated measure of ANOVA applied on the Range of Motion (IPTT) score of patients in the intervention and Control group.

Descriptive Statistics	Control group		Intervention Group	
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**
IpTT Score before intervention out of 6	2.50	1.261	2.85	.949
IpTT Score after 1st intervention out of 6	2.70	1.091	3.05	.904
IpTT Score after two weeks of 1st intervention out of 6	2.73	1.176	4.03	.800
IpTT Score after four weeks of the 1st intervention out of 6	2.45	1.395	4.20	1.091

Multivariate Tests[a]		Control group			Intervention Group		
Effect		Value	F	Sig.	Value	F	Sig.
IPTT	**Pillai's Trace**	.049	.629[b]	.601	.773	42.007[b]	.000
	Wilks' Lambda	.951	.629[b]	.601	.227	42.007[b]	.000
	Hotelling's Trace	.051	.629[b]	.601	3.406	42.007[b]	.000
	Roy's Largest Root	.051	.629[b]	.601	3.406	42.007[b]	.000

The IpTT (Intervention-specific Performance Test Tool) scores showed in Table 4.2.(xiii**),** a marked improvement over time in the intervention group compared to the control group. At baseline, scores were slightly higher in the intervention group (2.85 ±0.95) than the control group (2.50 ±1.26). Minimal changes occurred immediately after the first intervention. However, by the two-week follow-up, the intervention group showed a substantial increase in scores (4.03 ±0.80), continuing to 4.20 ±1.09 at four weeks. In contrast, the control group's scores remained relatively stable throughout the study, ending at 2.45 ±1.40. Multivariate analysis confirmed a significant improvement in the intervention group over time (Pillai's Trace = .773, Wilks' Lambda = .227, $F = 42.007$, $p < .001$), while the control group showed no significant change ($p = .601$). These findings suggest that the intervention was effective in enhancing performance as measured by the IpTT score.

CHAPTER 5

DISCUSSION

This chapter provides a thorough description of the conclusions drawn from the current investigation. Presenting the findings within the body of existing literature is the goal of the debate. It evaluates the data' clinical importance and explores the mechanisms underlying the effects that have been seen.

One common and devastating consequence of Type 2 Diabetes Mellitus (T2DM) is DPN. Chronic pain, decreased joint mobility and impaired somatosensory function are common symptoms. The independence and quality of life of patients may be seriously jeopardised by these damages. Furthermore, it raises their risk of foot ulcers and falls. Pharmacological treatment is a component of conservative management. However, drug therapy by itself, frequently provides only partial relief and may have adverse effects. It indicates a need for a comprehensive non-pharmacological treatment.

The purpose of the current study was to assess the short-term and long-term effects of Thai foot massage on three key variables somatosensory function, ankle joint range of motion (ROM), dorsiflexion and plantarflexion and pain severity. The primary objective was to determine whether regular Thai foot massage, as a clinically useful supplement to standard therapy, might enhance these results over a four-week period.

5.1: Demographic Variables

This part of the discussion analyses the demographic variables of participants in the study.

5.1 (i) Age

The participants in this were middle-aged, with a mean age of 54.25 ± 6.02 years. Because it corresponds to a stage of life when chronic illnesses like (DPN) are more frequently identified and clinically apparent, this age group seem like suitable for the purpose of the study. Furthermore, middle age is associated with a somewhat stable physical and mental state, which enable them regular use of intervention strategies like Thai foot massage. This demographic profile supports the credibility of the results because participants had to accurately report symptoms and follow instructions.

Similar age distributions were also observed by similar research, such the one by (Soe et al., 2025), with a mean age of 56.4 ± 6.44 years. This confirms that middle-aged people are representative and appropriate for interventions aimed at DPN

5.1 (ii): **Gender Distribution**

The gender distribution in this study indicates that there were 40 people in each of the two categories. The gender distribution of the control group was equal, with 50% males and 50% females, whereas the intervention group was slightly more masculine, with 55% males and 45% females. Despite a slight imbalance, this distribution does not substantially differ from gender trends at the population level that are commonly seen in Type 2 Diabetes Mellitus (T2DM), where prevalence rates are frequently similar for men and women. The nearly equal distribution promotes the study's internal validity by minimizing gender-based heterogeneity in outcomes. Similar demographic tendencies have been noted in previous clinical research on diabetes populations.(Ghassab-Abdollahi et al., 2023). It reinforces the representativeness of the current sample.

However, in Chatchawan's study, only five male participants (11.1%) were involved, while 40 female participants (88.9%) were enrolled in both the Thai foot massage and control groups, making women the vast majority (Chatchawan et al., 2020). The new study contradicts with this gender distribution. This displays gender representation that is more balanced.

5.1 (iii): Anthropometric Measures and BMI

According to the World Health Organization's classification, the Body Mass Index (BMI) readings in this study fell into the overweight group (WHO, 2020). The intervention group's mean BMI was 27.29 ± 2.81 kg/m², whereas the control group was 27.48 ± 3.93 kg/m². These numbers are consistent with a pattern commonly seen in people with Type 2 Diabetes Mellitus (T2DM), in which being overweight accelerates the onset and progression of problems such diabetic peripheral neuropathy. A similar pattern of BMI was described by (Edlman, 2023), who found an average BMI of 26.5 ± 4.3 kg/m² in individuals with diabetic neuropathy, supporting the representativeness of our study sample. Higher BMI values are often associated with reduced physical activity, joint stiffness, and impaired nerve function, which may influence the outcomes of mobility-focused interventionsIn addition, research by (Tomo et al., 2025) found that neuropathy ratings were significantly higher in obese individuals, indicating a clear relationship between obesity and greater neuropathy severity. These findings are parallel to these investigations and highlight the renal conservative when considering BMI in the evaluation of development and therapy for diabetic neuropathy.

However, in another study it was discovered that new type 2 DM patients at a lower BMI (less than 24 kg/m2) showed worse glycemic control compared to those with a higher BMI by Wang et al. (2017). They also reported a much greater p-value of 0.00 for variations in glucose (mean glucose fluctuation of 6.64 mg/dL for the low BMI group against 5.67 mg/dL for the high BMI group) and even elevated sugar spikes postprandially (Wang et al., 2017). These findings are contrary correspond with the present study, which found poor control associated with higher BMI-it infers that at the early stage of diabetes, lower BMI could also be a risk for blood sugar fluctuation.

5.1 (iv): Glycemic Control and Disease Duration

The study's biochemical results show that both groups had inadequate glycemic control. While HbA1c values were higher than the suggested 7% threshold (7.50% and 7.85%, respectively), fasting blood glucose averages were 187.65 mg/dL in the control group and 189.98 mg/dL in the intervention group. These results are consistent with those of (Lu et al., 2020), who discovered that persistently poor glycemic management considerably raises the risk of diabetic neuropathy, and (Adjei et al., 2025), who revealed that HbA1c ≥ 7% in almost 59% of T2DM patients. The study's higher values suggest the clinical necessity of supportive therapies for patients with chronic hyperglycemia.

The current study reports a mean duration of diabetes mellitus (DM) of 8.81 ± 2.56 years among patients with diabetic peripheral neuropathy (DPN). This duration aligns with findings from a multicenter international study involving 2,733 individuals with type 2 diabetes, which reported a mean diabetes duration of 8.8 years. The study indicated a longer duration of diabetes as an important risk factor for DPN and increasing the odds with each additional year of developing neuropathy (OR: 1.08 per year; 95% CI: 1.06–1.09). (Lu et al., 2020).

In contrast, a study conducted in Ethiopia found that more than half (51.95%) of instances with diabetic neuropathy were identified within six years after the diagnosis of diabetes. It implies that DPN may appear at a comparatively early stage of the illness. Additionally, it was discovered that those with diabetes who have had the disease for fewer than four years are more likely to acquire neuropathy than those who have had it for longer (Kebede et al., 2021).

5.1 (v): **Cardiovascular Parameters**

The cardiovascular indicators in the present study revealed a borderline hypertension. The mean systolic blood pressure (SBP) of 134.68 ± 11.29 mmHg and a mean diastolic blood pressure (DBP) of 82.13 ± 8.02 mmHg are recorded. These findings align with those from a large-scale study in Singapore. This revealed that SBP levels ≥130 mmHg and DBP levels ≥90 mmHg in patients with type 2 diabetes mellitus (T2DM) are associated with increased cardiovascular disease (CVD). (Seng et al., 2023).

5.1 (vi): Neuropathy Symptoms and Muscle Strength

The results indicate a high prevalence of numbness in the control group (82.5%) compared to the intervention group (75%). On the other hand, muscle cramps were reported more frequently in the intervention group (85%) than in the control group (55%). These findings suggest variability in neuropathic symptom presentation among diabetic patients and groups are presenting mixed symptoms.

According to a study conducted by Hans Katzberg et al. (2020) with 269 participants at the University Health Network in Toronto, Ontario, Canada. Muscle cramps were more common and severe in patients with type 2 diabetes (65.2%) compared to those without the disease (45.5%). These cramps were particularly unpleasant for those with type 2 diabetes. Neuropathy and type 2 diabetes were revealed to be a major predictors of muscle cramps (Katzberg et al., 2020). These results corroborate those of the current study, which found that 85% of diabetic individuals experienced muscle cramps. It highlights how closely muscular cramping and diabetic peripheral neuropathy (DPN) are related.

In contrast, a different study from the University of Jinan in China shows that patients with DPN have a relatively reduced occurrence of muscle cramps. The Jinan investigation discovered that only 48% of T2DM patients had muscle cramps during the previous three months, despite the fact that the current study indicated that 85% of the intervention group had them (Hu et al., 2022).

The study under discussion presents that only 25% of participants displayed normal muscle strength. In comparison, 65% of participants could perform active movement against gravity without resistance, and 10% had movement limited to against gravity. It highlights a significant decline in muscle function among patients with diabetic peripheral neuropathy (DPN).

The current study's findings are analogous to those of a study carried out at an outpatient diabetic clinic in Rome. Both studies show that a decrease in muscular function is linked to diabetic peripheral neuropathy (DPN). Patients with DPN demonstrated a 32.4% decrease in endurance time (ET) in the referenced study. Additionally, it also shows decreased muscle strength, which is align with the current study's findings (Orlando et al., 2020).

5.2 (i): Effect on Pain

The present study demonstrates that Thai foot massage (TFM) significantly alleviates neuropathic pain in patients with type 2 diabetes mellitus (T2DM) over a four-week period. While immediate post-intervention pain scores showed no significant difference between the intervention and control groups (4.10 ± 1.057 vs. 4.03 ± 1.050; $p > 0.05$), substantial reductions were observed at subsequent intervals. After two weeks, the intervention group reported a mean pain score of 2.55 ± 0.90 compared to 3.95 ± 1.085 in the control group ($p < 0.05$). By the fourth week, pain levels further decreased to 1.58 ± 0.636 in the intervention group, while remaining unchanged in the control group (3.95 ± 1.085; $p < 0.001$).

These results are consistent with previous research on the effectiveness of foot massage in the treatment of diabetic peripheral neuropathy (DPN). According to a randomised controlled research conducted by (Al-Fahham and Al-Jubouri, 2023), DPN patients who received foot massages for two weeks saw a substantial decrease in neuropathic symptoms as determined by the Toronto Clinical Neuropathy Score. Similarly, diabetic individuals with peripheral neuropathy who had Thai foot massages reported increases in their ability to balance and feel their feet (Chatchawan et al., 2020).

TFM's analgesic effects can be ascribed to a number of physiological processes. It is well established that massage treatment improves local blood circulation, which in turn improves the transport of nutrients and oxygen to peripheral nerves, facilitating nerve function and healing. Additionally, the gate control mechanism of pain modulation may be activated by the stimulation of mechanoreceptors during massage, which would reduce the feeling of pain. Additionally, relaxation brought on by massage might lessen sympathetic nervous system activity, which may lessen stress reactions linked to pain.

The study's findings, taken together, lend credence to the use of Thai foot massage as an additional non-pharmacological treatment for T2DM patients' neuropathic pain. TFM has the potential to improve functional results and quality of life in this population, as seen by the notable pain reductions seen after two and four weeks of treatment.

5.2(ii): Effect on ROM

The results of the study show that over the course of four weeks, the intervention group significantly improved ankle dorsiflexion and plantarflexion range of motion in comparison to the control group. The effectiveness of the intervention in improving ankle mobility was demonstrated by these changes, which were statistically significant at the 2-week and 4-week evaluations.

A. Dorsiflexion Improvements

For the right foot, dorsiflexion in the intervention group increased from 11.08 ± 1.92° at baseline to 13.53 ± 2.06° after 2 weeks ($p < 0.05$), and further to 15.53 ± 2.54° after 4 weeks ($p < 0.001$). In contrast, the control group's dorsiflexion remained relatively unchanged, with values of 10.52 ± 1.92° at baseline, 10.52 ± 1.94° after 2 weeks, and 10.15 ± 1.88° after 4 weeks. Similarly, for the left foot, the intervention group showed an increase from 12.38 ± 2.52° at baseline to 13.86 ± 2.51° after 2 weeks ($p < 0.05$), and to 14.61 ± 2.33° after 4 weeks ($p < 0.001$), while the control group's dorsiflexion remained stable around 12.05 ± 2.49° throughout the study period.

These results are consistent with prior studies that highlight the value of focused therapies in enhancing ankle dorsiflexion. Ankle dorsiflexion was considerably increased in people with gait impairments when Functional Electrical Stimulation (FES) and Model Predictive Control (MPC) were used in a study by Singh et al. (2025), for example. This finding highlights the potential of cutting-edge therapeutic approaches in restoring ankle function. (Singh et al., 2025, Orishimo et al., 2008).

B. Plantarflexion Improvements

In terms of plantarflexion, the intervention group exhibited notable improvements. For the right foot, plantarflexion increased from 26.62 ± 4.08° at baseline to 28.07 ± 4.11° after 2 weeks ($p < 0.05$), and to 29.57 ± 4.08° after 4 weeks ($p < 0.001$). The control group's plantarflexion remained relatively constant, with values around 26.17 ± 4.43° throughout the study. Similarly, for the left foot, the intervention group's plantarflexion improved from 28.61 ± 4.41° at baseline to 30.42 ± 4.16° after 2 weeks ($p < 0.05$), and to 31.53 ± 3.91° after 4 weeks ($p < 0.001$), whereas the control group's values remained around 26.71 ± 4.42°.

These findings are in line with previous research that highlights the advantages of particular therapies for improving ankle plantarflexion. Orishimo et al.'s study, for instance, demonstrated how the knee flexion angle affects the Achilles tendon force and ankle joint plantarflexion moment during passive dorsiflexion, indicating that certain interventions can successfully enhance plantarflexion results (Orishimo et al., 2008).

The significant improvements in both dorsiflexion and plantarflexion ROM detected in the intervention group have important clinical implications. Greater ankle mobility is critical for various functional activities, including walking, balance and overall lower limb function. The findings suggest that the applied intervention can be an effective strategy for improving ankle ROM, potentially leading to better functional outcomes for individuals with limited ankle mobility.

The study offers strong proof that, over the course of four weeks, the intervention significantly and consistently increased ankle dorsiflexion and plantarflexion range of motion. Recent research highlighting the value of focused therapy techniques in improving ankle mobility lends credence to these findings. People looking to increase their ankle function and general mobility may benefit from the use of such therapies in therapeutic practice.

5.2 (iii) IpTT Score

The statistical analysis of the Ipswich Touch Test (IpTT) scores shows a significant improvement in protective sensation among participants in the Intervention group compared to the Control group. At reference point, both groups had comparable IpTT scores (Control: 2.78 ± 1.12; Intervention: 2.85 ± 0.94; $p > 0.05$), suggesting similar levels of protective sensation. However, after the administration of the first intervention, the Intervention group displayed a significant increase in IpTT scores (3.25 ± 0.77) compared to the Control group (2.73 ± 1.10; $p < 0.05$). This development continued over time, with the Intervention group reaching 4.13 ± 0.75 at two weeks (Control: 2.75 ± 1.14; $p < 0.001$) and 4.78 ± 0.92 at four weeks (Control: 2.78 ± 1.18; $p < 0.001$). These findings propose that the intervention had a sustained and significant positive effect on protective sensation over the study period.

These findings are unswerving with previous research on treatments meant to enhance protective feeling in peripheral neuropathy patients. For example, high-frequency (10 kHz) spinal cord stimulation (SCS) intensely enhanced protective sensation in patients with painful diabetic neuropathy. According to a randomized controlled trial conducted by Argoff et al. (2024). Compared to those experiencing traditional medical management, participants receiving 10 kHz SCS showed more sensate areas, and these improvements continued for 24 months (Argoff et al., 2024). The potential for certain remedies to progress sensory function and lower the risk of foot ulcers in diabetic patients is emphasized by this study.

These results are also supported by existing literature highlighting the effectiveness of tactile stimulation in enhancing protective sensation in diabetic peripheral neuropathy (DPN). A study by (Chatchawan et al., 2020) on traditional Thai foot massage found similar outcomes, reporting significant improvement in pressure threshold and tactile sensitivity in diabetic patients after a two-week massage protocol. Their findings emphasize that regular application of manual pressure and reflexology points on the feet can promote nerve conduction and blood flow, which are critical for the recovery of damaged sensory nerves.

Moreover, the IpTT has been accepted as a valid and useful instrument for assessing protective sensory loss (Alsararatee et al., 2025). The accuracy of the IpTT in detecting loss of protective feeling in diabetic individuals without a history of foot ulcers was evaluated in a research by Chatzistergos et al. (2023). According to (Chatzistergos et al., 2023), the IpTT's excellent sensitivity and specificity validate its use as a screening tool in a variety of clinical settings. This supports the validity of measuring changes in protective sensation over time using IpTT scores.

5.3 Conclusion

This study concludes by presenting that Thai foot massage considerably enhances clinical results for individuals with peripheral neuropathy Type 2 Diabetes Mellitus. Participants who received the massage showed notable improvements in sensorimotor function as evaluated by the Ipswich Touch Test, substantial increases in ankle joint mobility (both dorsiflexion and plantarflexion) and a significant reduction in pain over the course of four weeks. The effectiveness of targeted, Thai foot massage was further supported by the control group's minimal changes across all measures. According to these results, Thai foot massage may be a useful integration to conventional diabetes treatment, encouraging physical function, pain management and sensory restoration, ultimately improving patients' quality of life and lowering the risks of diabetic peripheral neuropathy problems.

5.4: Outcome Utilization

The results of this study can be used in the following areas

- A clinically meaningful reduction in neuropathic pain was attained by Thai foot massage, notable improvements were seen as early as the second week and continued into the fourth.

- In contrast to the control group, which did not display any discernible change, participants in the intervention group had enhanced ankle joint mobility, specifically in both dorsiflexion and plantarflexion.
- A consistent improvement in Ipswich Touch Test (IpTT) scores, which indicates fractional sensory recovery. It suggests that the massage intervention helped to enhance somatosensory function.
- Thai foot massage is a safe supplemental treatment for (DPN), as no harmful side effects have been documented.
- The intervention group's continuous improvement over time reveals the value of regular, scheduled massage treatments as a constituent of an integrative diabetes treatment program.
- In order to manage pain and flexibility concerns, Thai foot massage may assist lessen reliance on pharmaceutical therapies.
- The results of the study offer credibility to the inclusion of non-invasive, culturally based treatments such as Thai massage in standard diabetic neuropathy treatment..

5.5: Implications For Future Research

Future research can explore the following areas in relation to this study

- In order to evaluate sustainability and relapse rates in pain and flexibility outcomes, future studies should explore the long-term effects of Thai foot massage beyond four weeks.
- Validating the generalizability of findings across various age groups, ethnicities, and comorbidities requires studies with larger and diverse populations.
- To determine relative effectiveness, comparative research should compare Thai foot massage to other non-pharmacological treatments like acupuncture or physiotherapy.
- In depth, the molecular processes behind the noted changes may be possible by using objective neurophysiological evaluations such as nerve conduction investigations.
- Establishing thorough management plans may be facilitated by investigating ways to integrte Thai foot massage with lifestyle or physical therapies.
- There is a need for **cost-effectiveness analysis** to support the integration of Thai foot massage into public health approaches and clinical practice guidelines

5.6: Recommendations

There are a few recommendations concerning the nonpharmacological treatment of DPN.

- In order to reduce pain, increase in mobility and sensory function in patients with diabetic peripheral neuropathy, Thai foot massage should be considered as a complimentary therapy in normal clinical management.
- To administer organized therapies safely and effectively, healthcare providers should either work with skilled practitioners or experience basic training in therapeutic foot massage techniques.
- To encourage self-management and improve quality of life in diabetic treatment, non-pharmacological approaches such as foot massage should be included in patient education programs.
- For patients with neuropathy, hospitals and diabetic treatment facilities should integrate massage-based interventions into multidisciplinary rehabilitation strategies.
- Policy support and clinical guidelines are necessary for the further integration of Thai foot massage into clinical protocols, particularly in the areas with high prevalence.

5.7: Strengths of the Study

The following points make the strength of the study

- A randomized controlled design was used in the study, which improved the results' internal validity and reliability.
- Well-matched control and intervention groups were included to assure baseline clinical and demographic equivalence.
- The effects of the intervention were methodically evaluated using a multi-dimensional outcome assessment that included joint range of motion, somatosensory function and pain score.

- The study established Thai foot massage's therapeutic potential by showing statistically significant improvements in all key clinical outcomes.
- The accuracy and repeatability of the results were enhanced by using validated clinical tools such as the Ipswich Touch Test (IPTT) and regular assessment intervals.

5.8 Limitations of the Study

Limitations of this study are as follows:

- Due to the study's very brief four-week follow-up period, evidences regarding the long-term sustainability of treatment benefits was limited.
- Its small sample size and single setting design may have limit the applicability to larger populations.
- It was not possible to blind participants or therapists, which may have introduced response bias into subjective outcome reporting.

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