Effectiveness Of Intraneural Facilitation And Foot Massage On Sensory Function Among Diabetic Peripheral Neuropathy

ABSTRACT

Aims Diabetic peripheral neuropathy [DPN] affects up to 50% of individuals with type 2 diabetes, with distal symmetric polyneuropathy being the most common form. Early symptoms include sensory loss in the lower extremities, such as tingling, pain, and numbness, which may lead to serious complications like infections and amputations. This study aimed to assess the effects of intraneural facilitation [INF] and foot massage [FM] on sensory function among individuals with DPN.

Materials & Methods The comparative study was conducted at Saveetha Medical College and Hospital, Chennai, India. A total of 66 participants with DPN were selected based on predefined inclusion and exclusion criteria. They were randomly assigned into two equal groups using sealed envelope method (n = 33 each). Group-A received INF and Group-B received FM. Sensory function was evaluated using the monofilament test. Both groups underwent their respective interventions three times a week for three weeks. Post-test assessments were conducted to measure changes in sensory function.

Findings The post-test mean sensory function score in the INF group was significantly higher than that of the FM group. Statistical analysis revealed a *p* value of 0.038, indicating a significant improvement in the INF group.

Conclusion Both intraneural facilitation and foot massage yielded significant improvements in sensory function among individuals with diabetic peripheral neuropathy. However, intraneural facilitation demonstrated comparatively greater efficacy, indicating its potential as a more effective therapeutic approach for optimizing sensory outcomes and enhancing peripheral blood flow in this population.

Keywords Diabetes mellitus; Diseases; Massage; Nerve regeneration; Peripheral neuropathy; Well-being

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Introduction

According to the International Diabetes Federation [IDF] 2021, 537 million people worldwide have diabetes at the movement with considerable variation across estimates, the overall pooled prevalence of diabetes peripheral neuropathy was 43.16% [1]. Diabetic peripheral neuropathy [DPN] is the most prevalent diabetic consequence, with a lifetime frequency of about 50%. Due to gait abnormalities, fall -related injuries, foot ulceration, and amputation, DPN is a major cause of disability. About 20 to 30 percentage of DPN patients experience neuropathic pain [2]. Damage of neurons, Schwann cells, and blood arteries within the nerve is the hallmark of peripheral neuropathy, the most frequent consequence of diabetes, with can affect up to 50% of people [3].

Type 1, type 2, and gestational diabetes are the three main types of diabetes mellitus. In type 1 diabetes, the autoimmune destruction of pancreatic beta cells leads to absolute insulin deficiency [4]. Type 2 diabetes, which is characterized by relative insulin insufficiency and insulin resistance, accounts for more than 90% of all diabetes cases [5]. Gestational diabetes during pregnancy increases the child's risk of obesity and type 2 diabetes. Regular exercise raises insulin sensitivity, enhances blood glucose regulation, and promotes general well-being [6].

DPN, the second most common form of traumatic nerve injury, affects all peripheral nerves, including motor neurons, pain fibers, and the autonomic nervous system [7]. The existence of peripheral nerve dysfunction symptoms and indicators in people with diabetes following the exclusion of other causes is known as diabetic neuropathy, which gradually advances proximally after beginning in the toes. It is a heterogeneous disorder characterized by progressive “glove and stocking” sensory loss with variable somatic, autonomic, proximal, distal, small and large-fiber involvement [8].

In diabetic polyneuropathy, early pathological changes include endoneurial microangiopathy, axonal loss, and predominant small-fiber degeneration, leading to impaired temperature, pain, and autonomic function, while large-fiber involvement occurs at later stages [9]. Asymptomatic peripheral

neuropathy is possible. Symptoms might be either positive or negative when they occur. Loss of strength and sensation are negative indicators, whereas discomfort or pricking are favorable ones. Neuropathic pain and paresthesia are two of the most upsetting symptoms that people can experience [10]. A progressive loss of protective sensation in the skin and foot joints results from the first injury to the distal sensory and autonomic nerve fibers, followed by proximal progression. Preventive interventions [such as patient education, appropriate shoe usage, foot care, and yearly foot exams], glucose control, dietary changes, weight loss, and pain management are some of the strategies that make up DPN management [11]. The symptoms will differ based on whether the damaged fibers are large or small. Large fibers result in numbness, tingling, and impaired balance, while little fibers typically induce burning, electric shocks, stabbing, hyperalgesia, and allodynia. People with DPN are more likely to fall due to imbalances caused by altered proprioception. Compared to people with diabetes without peripheral neuropathy, those with DPN have a two to three times higher risk of falling [12].

Management of diabetic peripheral neuropathy (DPN) focuses on glycemic control, foot care, and symptom relief, with pharmacologic therapy recommended for severe pain. Despite ongoing research, drug treatments provide limited benefit in slowing disease progression, prompting investigation of non-pharmacologic interventions such as exercise, infrared therapy, TENS, spinal cord stimulation, and biofeedback to improve neural circulation and mitigate axonal damage [13].

Intraneural facilitation (INF) is an emerging evidence-based intervention that enhances neurovascular circulation, improving oxygen and nutrient delivery to damaged nerves and potentially mitigating neuropathic symptoms. Foot massage, by increasing peripheral blood flow, may similarly reduce discomfort, enhance skin sensation, and improve joint mobility in individuals with diabetic neuropathy. These approaches highlight the potential of circulation-targeted therapies in managing diabetic peripheral neuropathy [14,15].

The Semmes-Weinstein monofilament test is commonly used and advised for screening for peripheral neuropathy since it is a quick, easy, and affordable evaluation method and has a strong correlation with the risk of amputation, ulceration, and damage [16,17]. The objective of research was to assess the effect of intraneural facilitation [INF] and foot massage [FM] on sensory function among diabetic peripheral neuropathy.

Material and Methods

Research Groups

A comparative study was carried out involving individuals diagnosed with diabetic peripheral neuropathy. A total of 66 participants with diabetic peripheral neuropathy were recruited from Saveetha College of Physiotherapy based on specific inclusion and exclusion criteria. A convenient sampling technique was used, and the OpenEpi software was used to calculate the sample size. A two-sided 95% confidence interval and a statistical power of 80% were employed to detect a mean difference of 4.8 between the groups, resulting in a total sample size of 66 participants (33 per group). Participants were randomly divided into two groups using simple random sampling through sealed envelope method: Intraneural Facilitation [INF] group [n = 33] and the Foot Massage [FM] group [n = 33]. Inclusion criteria included individuals aged 40–60 years of either gender with a diagnosis of diabetes mellitus, the presence of positive neuropathic sensory symptoms such as burning or aching pain primarily in the toes, feet, or legs, and a pre-test monofilament score between grades 2 and 5. Participants were excluded if they had a history of chemotherapy, radiation therapy, dialysis, foot ulcers, lower extremity amputation or wounds, documented active alcohol or drug misuse, or proximal diabetic neuropathy.

Tools

Semmes-Weinstein Monofilament Examination [SWME]

It uses 5.07/10 g or 4.31/2 g monofilament to measure sensory impairment. On each foot, SWME was carried out at three non-callused sites: the first and fifth metatarsal heads' great toe and plantar aspect. After being applied perpendicularly to the test location, the monofilament bent for approximately one second. If the patient feels the sensation on their foot, they respond [yes]. The pre-test and post-test will be assessed in this monofilament test.

Procedure

Intraneural Facilitation

The session commenced with the patient positioned in a relaxed supine posture to ensure comfort throughout the intervention. Intraneural facilitation (INF) was initiated with the facilitation hold, wherein the contralateral joint was placed in its maximum loose-pack position, and a TheraBand was

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applied to guide the foot into inversion and upward movement. This position was sustained for 30 seconds and repeated for three sets, with a rest interval of 30 seconds between each set. Following this, the sub-hold was performed by maintaining the facilitation hold while the therapist gently lifted the affected limb, held for 30 seconds, and repeated for three sets with 30-second pauses. Finally, both the facilitation hold and sub-hold were repeated on the affected side in the same manner. The overall intervention session was planned to take approximately 20–25 minutes, thereby ensuring adequate repetition and sufficient rest to optimize circulation and therapeutic outcomes in patients with diabetic peripheral neuropathy [18].

Foot Massage

The session commenced with a brief warm-up to prepare the foot for massage and enhance circulation. The intervention began with effleurage (long stroke), in which the therapist used the palm to glide smoothly over the foot from the toes to the ankle and back down. This was performed for 2 minutes in continuous strokes. Following this, kneading was applied using the thumb to exert gentle circular pressure along the arch of the foot for 2 minutes. Next, thumb pressure was performed by applying gentle, sustained pressure with the thumb on specific points along the sole, particularly in the arch region, for 2 minutes. Subsequently, toe manipulation was carried out by gently pulling and twisting each toe, with light pressure applied at the base of each toe for approximately 1 minute per foot. This was followed by ankle rotation, in which the ankle was supported with one hand while the other hand guided circular rotations in both clockwise and counter-clockwise directions for 1 minute each direction. The session concluded with a cool-down effleurage stroke across the entire foot for 2 minutes, providing relaxation and closure to the intervention. The overall massage protocol was designed to last approximately 10–12 minutes per foot (20–25 minutes total), ensuring progressive stimulation, relaxation, and circulatory enhancement to mitigate complications of diabetic peripheral neuropathy.

Data Collection and Analysis

Descriptive statistics, including means and standard deviations, were computed to analyze participant performance across the pre-and post-test. The test of normality was checked using the Shapiro-Wilk test, which was negative. So, as per nonparametric, the statistically significant differences between pre-test and post- test measures were examined using the Mann-Whitney U test and the Wilcoxon signed-rank test. The difference between the post-test values was determined. Statistical analyses were conducted using SPSS version 22, with significance set at $p < 0.05$.

Findings

A total of 66 diabetes peripheral neuropathy subject in the study. The majority [62.12%] were male, and most participants [65.15%] were between 50-60 years old. The pre-test and post-test of the Intraneural Facilitation [INF] using the monofilament test were analyzed. The pre-test mean values were 12.06 and SD 9.06, whereas the post-test mean value was 7.06, the SD value was 4.19, and the Z value was -2.26. As a result, the finding is considered to be statistically significant, with a p-value of 0.023. The pre-test and post-test of foot massage using the monofilament test were analyzed. The pre-test mean value is 12.24, SD 8.21215, Whereas the post-test mean value is 8.96, SD value is 3.74, Z Value -1.93. As a result, the finding is considered to be statistically significant with the p-value is 0.053. The post-test and post-test intraneural facilitation and foot massage using monofilament test was analyzed. The post-test mean value of Intraneural facilitation 7.06, SD 4.19, Whereas the posttest means value of foot massage 8.96, SD value is 3.74 Z value -2.07. As a result, the finding is considered to be statistically significant with the p-value is 0.038. Statistical analyses were represented in tables 2 & 3.

Table 1. Demographic Characteristics of Participants

Variables	Sub Variables	Frequency (n)	Percentage (%)
Gender	Male	41	62.12%
	Female	25	37.87%
Age Group	40-50 years	23	34.85%
	50-60 years	43	65.15%

Table 2. Pre and Post-Test of Intraneural facilitation groups

Groups	SWME	Mean(SD)	z value	*p* value
Intraneural Facilitation	Pre-Test	12.06(9.06)	-2.26	0.023

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	Post- Test	7.06(4.19)		
Foot Massage	Pre-Test	12.24(8.21)	-1.93	0.053
	Post- Test	8.96(3.74)		

Note: Semmes-Weinstein Monofilament Examination (SWME); Standard Deviation (SD)

Table 3. Post-Test Values of Intraneural Facilitation and Foot Massage Group

Outcome	Groups	Mean(SD)	z value	*p* value
SWME	Intraneural Facilitation	7.06(4.19)	-2.07	0.038
	Foot Massage	8.96(3.74)		

Note: Semmes-Weinstein Monofilament Examination (SWME); Standard Deviation (SD)

Discussion

This study provides novel comparative evidence demonstrating that intraneural facilitation therapy (INF) yields superior improvements in sensory recovery and pain modulation compared with foot massage therapy (FM) among individuals with diabetic peripheral neuropathy (DPN). The findings highlight the therapeutic importance of targeting neurovascular mechanisms to restore small-fiber function and alleviate neuropathic symptoms, rather than focusing exclusively on superficial circulatory enhancement.

The significant improvements observed in the Semmes–Weinstein Monofilament Examination (SWME) and Pain Quality Assessment Scale (PQAS) within the INF group likely reflect enhanced endoneurial blood flow and oxygenation, facilitating axonal repair, neural metabolism, and microvascular perfusion. These physiological adaptations are consistent with prior research demonstrating that INF increases intraneural blood flow and reduces ischemic neuropathic pain in individuals with type II diabetes [4,13]. Recent findings further support these mechanisms, revealing measurable improvements in balance, protective sensation, and microcirculatory dynamics following INF intervention [18]. Collectively, this evidence indicates that INF not only mitigates pain but also promotes microvascular and neuroregenerative modulation in diabetic nerves.

In contrast, FM primarily exerts its therapeutic effects through cutaneous, muscular, and autonomic pathways, promoting vasodilation, peripheral perfusion, and sensory stimulation [19]. Although these mechanisms are beneficial, they appear less specific to small-fiber regeneration than those induced by INF. Nevertheless, several controlled trials have demonstrated that FM can significantly reduce neuropathic complaints and improve functional indices among patients with T2DM [20]. The gentle pressure and rhythmic stimulation applied to the lower limbs enhance local capillary flow, skin trophicity, and thermoregulation, while also relieving stress and promoting relaxation. Notably, a randomized controlled trial by Al-Fahham et al. (2023) reported a significant post-intervention reduction in Toronto Clinical Neuropathy Scores ($p < 0.05$) following a two-week FM regimen, supporting its role as an effective, non-pharmacological intervention for improving peripheral nerve function [21]. These findings reinforce FM's value as a supportive adjunct in diabetic rehabilitation, complementing the neurovascular benefits achieved through INF.

The observed PQAS improvements in the INF group further suggest multidimensional pain relief encompassing both intensity and quality, confirming its value as a comprehensive rehabilitative modality for DPN. Moreover, FM's relaxation and comfort effects align with previous evidence emphasizing psychophysiological benefits, including reduced anxiety and enhanced quality of life [22]. Circulation-focused exercises such as Buerger–Allen regimens have similarly demonstrated benefits in increasing limb perfusion and promoting wound healing in individuals with diabetes, underscoring the importance of integrating circulatory and neural interventions [23].

Despite these encouraging results, persistent balance impairments highlight the multifactorial pathophysiology of DPN involving sensory, motor, and proprioceptive deficits. This underscores the necessity for multimodal rehabilitation strategies that combine INF with balance and proprioceptive training, resistance exercise, and patient-centered education [24]. Recent studies confirm that dynamic neuromuscular stabilization and balance-focused protocols enhance postural control and proprioception in DPN populations [25]. Furthermore, technology-assisted rehabilitation, including mobile feedback systems and adherence-tracking tools, has proven effective in improving patient engagement and sustaining behavioral change in chronic conditions [26]. Such integration may

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strengthen adherence to home-based INF and FM interventions and enhance long-term therapeutic outcomes.

Although limited by a modest sample size and short intervention period, this study's findings are clinically meaningful, highlighting the distinct neurovascular advantages of INF. The consistency of sensory and pain improvements observed across recent INF research suggests its promise as a targeted, mechanism-based therapy for diabetic neuropathy. Future research should focus on large-scale randomized trials with extended follow-up to validate these findings and explore synergistic effects of combined multimodal models integrating INF, FM, circulatory exercises, and digital adherence technologies.

Conclusion

Intraneural facilitation and Foot massage are effective treatment for Diabetic peripheral neuropathy. But the result of this study demonstrated that Intraneural facilitation found to have statistically significant effect shown greater percentage of improvements obtained in improving the sensory function compared with Foot massage. Therefore, this study, suggest that the Intraneural facilitation would be more beneficial treatment for Diabetic peripheral neuropathy.

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