Innovations

Effect of Proprioceptive Neuromuscular Facilitation (PNF) and Sensory Motor Training on Balance Measures and Nerve Conduction Studies in Individuals Suffering from Diabetic Peripheral Neuropathy: A Cross-Sectional Study

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Abstract: Background & purpose: *Diabetic peripheral neuropathy involves nerve damage in the hands, arms, legs, and feet caused by prolonged high blood sugar levels. It shows signs of nerve problems in a diabetic person after ruling out other causes. This condition may lead to muscle wasting, fat loss, discomfort, tingling, reduced sensory and motor issues in the limbs. The prevalence of this condition is even higher when including. Those without obvious symptoms. Approximately 54% of individuals with Type 1 Diabetes and 45% with Type 2 Diabetes develop nerve complications. The age when diabetes starts and other underlying biological differences contribute to the varying rates of neuropathy among individuals with type 2 diabetes. However, people with both type 1 and type 2 diabetes have similar rates of this complication. In an aging population with more lifestyle-related diseases, peripheral neuropathy in middle-aged individuals is becoming a more significant concern, and women are slightly more prone to it than men. The purpose of the study mentioned is to investigate how proprioceptive neuromuscular facilitation (PNF) and sensory motor training affect nerve function tests and balance in patients with diabetic peripheral neuropathy.* ***Design****: A cross-sectional study.* ***Subjects:*** *A total of thirty individuals with diabetic peripheral neuropathy were assigned, the participants were split into two groups: Group A and Group B.* ***Method****: In this study, patients with diabetic peripheral neuropathy were selected. Group a received proprioceptive neuromuscular facilitation, whereas Group B received sensory motor training for three weeks. The individuals were split into two groups of fifteen each. The outcome measures employed are Neuropathy score measured by (MNSI) and balance by (BBS) and (NCS) for measuring the integrity of nerves. Over course of three weeks, the participants received procedure in a total of twenty-one sessions.* ***Result****: The current investigation has employed descriptive statistical analysis. The mean+SD (min-max) is used to display the results of continuous measurements. Regarding the aspect of balance, the neuropathic screening instrument, alongside the parameters of nerve conduction study (NCS), revealed substantial enhancement ($p < 0.0001$) when subjected to independent t-tests within groups comparison and paired t-tests within groups comparison. However, Group B demonstrated greater improvement than Group A did in these areas, indicating better clinical outcomes for those who received sensory motor training.* ***Conclusion****: The results revealed that proprioceptive neuromuscular facilitation and sensory motor training were equally effective- but that sensory motor training was more effective than proprioceptive neuromuscular facilitation.*

Keywords*: diabetic peripheral neuropathy, sensory motor training, proprioceptive neuromuscular facilitation, NCS, MNSI, BBS.*

Introduction

The American Diabetes Association describes diabetes mellitus as a range of metabolic conditions marked by high blood sugar. This high blood sugar arises from problems with how the body produces or uses insulin, or a combination of both. Persistent high blood sugar caused by diabetes can lead to long-term damage, malfunction, and eventual failure of different organs, particularly the heart, blood vessels, kidneys, eyes, and nerves. A multitude of pathogenic mechanisms can precipitate the onset of diabetes. These range from defects that result in resistance to the action of insulin to autoimmune death of pancreatic beta cells that can lead to insulin insufficiency. The aberrant protein, lipid, and glucose metabolism in diabetes is caused by the poor action of insulin the prevalence of diabetes, a prevalent metabolic condition that has a major negative impact on health, is increasing daily. In 2013, over 382 million people globally had diabetes, and this number is projected to reach nearly 592 million by 2035. A majority (60%) of individuals with diabetes worldwide live in Asia. Southeast Asia alone was estimated to have around 72 million adults with diabetes in 2013, and this figure is predicted to surge to over 123 million by 2035. Between half and 90% of people diagnosed with diabetes develop diabetic peripheral neuropathy (DPN), which is characterized by symptoms or signs of nerve damage in the outer parts of the body. DPN is the most common and debilitating small blood vessel complication linked to diabetes. Once other possible causes were ruled out, individuals with diabetes were not included in a certain context (this last sentence seems incomplete and might need more surrounding information for a full paraphrase).Many studies examining how often diabetic neuropathy occurs in the general population only consider individuals with either type 1 or type 2 diabetes.

When comparing these groups, people with type 2 diabetes showed a higher rate of neuropathy (6100 cases per 100,000 person-years) compared to those with type 1 diabetes (2800 cases per 100,000 person-years)[7,(8)].Clinical symptoms of peripheral neuropathy are characterized by severity, distribution (symmetric or asymmetric), structure of affected nerve cells (axonal, demyelinated, or mixed neuropathy), and type of neuron affected (autonomic, sensory, or neuronal).[9,10]

Diabetic peripheral neuropathy (DPN), which effects the somatosensory, motor, and autonomic nerves, is the most prevalent consequence of diabetes.[11] Prolonged elevation might cause harm to the hands, arms, legs, and feet's sensory and motor nerves. It is described as "the presence of symptoms and/or signs of peripheral nerve dysfunction in a diabetic patient after excluding other causes." blood sugar levels. It is linked to muscle atrophy with fat infiltration, discomfort, paesthesia, loss of sensation, and malfunction in the limbs.[12]

Given that the worldwide number of people with diabetes is expected to be 472 million by 2030, diabetic peripheral neuropathy could potentially affect as many as 236 million individuals globally, leading to substantial costs. The likelihood of developing DPN rises with long-term illness and poorly managed blood sugar levels. Additionally, 16% of population with diabetes have an imbalance, which can increase up to 30-50% as the severity of the disease increases. In an aging society with lifestyle choices and chronic illnesses, a greater prevalence of peripheral neuropathy in middle-aged individuals will become crucial. Women are somewhat more likely than males to have peripheral neuropathy.[13,14]

Schreiber et al. review. Numerous correlations with PND have been identified, such as microvascular alterations, oxidative and nitrosative stress, and hyperactivity of the polyol system, have been identified. Overactivity of the polyol pathway is one of the many cellular issues caused by a chronic hyperglycaemic conditions. This is believed to result in excessive oxidative and nitrosative stress, which creates reactive oxygen and nitrogen species that further harm neurons. Blood sugar levels rise as insulin resistance increases, which progressively triggers a number of physiological reactions that harm blood vessels and peripheral neurons.[15-17]

The DPN travels proximally gradually, beginning at the toes. Following a classic "glove and stockings" spreading pattern, it causes sensory loss in the upper limbs after it becomes well established in the lower limbs. During the early stages of DPN, significant motor impairments are uncommon. Patients rarely complain of weakness, but when they do, the symptoms are typically sensory. Muscle weakness usually manifests in the later stages of the illness.[18]

These symptoms typically make it harder to fall asleep at night. Along with excruciating sensations during the day, this frequently makes it harder for a person to perform everyday tasks.[19, 20.]

Those who have distal symmetric polyneuropathy have 15–25% lifetime risk of foot injuries, such as ulcers or gangrene. Additionally, unbalanced and unstable walking due to sensory loss and loss of proprioception increases the risk of falls, which can cause traumatic brain injury, fractures, or cuts. In certain people, distal symmetric polyneuropathy may also be asymptomatic; only a comprehensive neurologic examination can reveal symptoms of the condition.[21]

Nerve Conduction Testing: The absence of a valid and widely accepted clinical scale for assessing the degree of diabetic neuropathy is one of the primary issues with this condition. Clinical trials can utilize this measure to evaluate how different treatment approaches affect patients. The most sensitive test for identifying diabetic neuropathy is the nerve conduction velocity (NCV) examination, according to a Dyck study. It also offers certain advantages, such as repeatability. It is also thought of as a specialized test for neurological disorders. He claimed that the drawback of this test is the inability to directly identify neuropathy symptoms and indicators.[22]

In diabetic patients, distal symmetrical peripheral neuropathy is assessed using the Michigan Neuropathy Screening Instrument (MNSI). This instrument includes a lower limb examination with two parts: testing of vibration sense and ankle reflexes, along with a fifteen-question survey completed by the patient. To measure the ability of older adults to maintain balance both while standing still and while moving, Katherine Berg developed the Berg Balance Scale (BBS) in 1989. The Berg Balance Scale (BBS) assesses a person's balance by observing their ability to perform everyday tasks that require good posture control. These tasks include reaching, bending, moving from one place to another, and standing. Specific examples of these activities are standing with feet together, apart, or one in front of the other (tandem Romberg) with eyes open or closed.

Other tasks involve bending down to pick up items, sitting, and safely moving between chairs. Each task is scored on a 5-point scale, ranging from 0 (lowest ability) to 4 (highest ability), based on pre-set criteria. The total possible score on the BBS is between 0 and 56. The BBS is known to be consistent when the same person is tested multiple times (intratester reliability), consistent when different people test the same person (intertester reliability), and accurately measures balance as intended (concurrent and construct validity).[24]

Sensorimotor training is considered a global approach to balance training. He emphasized the function of the sensorimotor system as a whole and worked to control movement through central nervous system (CNS) to strengthen sensory inputs and modify recruitment patterns of various muscles to maintain joint stability. Movement disorders are caused by imbalances in the muscles that control posture, which ultimately change the motor program of the central nervous system. Balance activities as part of sensorimotor training have been demonstrated to enhance trunk proprioception in patients with DPN in addition to improving balance and visuospatial gait.(Song CH and others, 2011).

Nevertheless, there is a lack of research on how these activities affect lower extremity muscle activity and nerve function.[25]

A study assessing the impact of PNF patterns on alleviating diabetic neuropathy symptoms has been conducted. Singh et al. (2016) conducted a study. For three months, lower limb PNF patterns (D1 and D2 flexion and extension) were displayed. The PNF oblique pattern is crucial for improving lower limb strength and sensation in diabetic neuropathy patients. Following a three-month regimen, these diabetic patients showed notable improvements. The impact of PNF on core strength in an individuals with type 2 diabetes was examined by Chitra and Das et al. (2015), who reported that the intervention significantly increased core strength. The dynamic nature of PNF exercises may be the cause of this increase in core strength.[26]

Materials and Methodology

The participants in this cross-sectional study were chosen from SGVU in Jaipur, Rajasthan. Those with sensory motor deficits and diabetic peripheral neuropathy were included. The study included both men and women in the 45–70 years age range. There are thirty subjects in all, and convenience sampling is the sampling technique used. The individuals participating in the study provided their signed agreement to participate after being fully informed about it. All participants satisfied the necessary criteria to be included in the research. The participants were made aware of the study's objectives. The procedure for assessing diabetic peripheral neuropathy has been explained to them. Pre- and post- treatment, nerve conduction research was performed to assess the conduction velocity and delay. The patients were separated into two groups, Group A and Group B, with 15 patients in each group. Their neuropathy levels were evaluated using the Michigan Neuropathy Screening Instrument (MNSI), and their balance abilities were assessed using the Berg Balance Scale (BBS) and nerve conduction studies (NCSs). These assessments were conducted both before and after the treatment was administered to the groups.

Diagonal movement patterns used in the study, known as diagonal 1 (D1) and diagonal 2 (D2) patterns, were part of proprioceptive neuromuscular facilitation (PNF) exercises administered to the 15 participants in Group A. For three weeks, the full program—which included 10 repetitions with a five-second hold—was performed once daily.
Group B, which included 15 competitors, received five repetitions of each of the three stages of sensory motor training—static, dynamic, and functional—to complete this exercise. Patients are treated with these three stages of SMT: static, dynamic, and functional exercises every day. The protocol was followed for 5 repetitions, with 5 seconds held for 3 weeks.

Data Analysis:
The data was analysed using the Statistical Package of Social Sciences (SPSS, version 20) and Microsoft Excel (Professional Edition 2007, from Microsoft Corporation in Redmond, Washington). In addition to the final comparisons between the group measures of balance, the use of a neuropathic screening tool, and nerve conduction studies among the participants in Groups A and B, baseline values of age, balance, the use of a neuropathic screening tool, and nerve conduction studies was compared using independent t-tests and paired t-tests, which are types of parametric statistical tests. A result was considered statistically meaningful if the probability value (p-value) was less than 0.005.

Results and Interpretation:
Demographic data: The data's means and standard deviations are detailed in the table.

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Table 1: Means and standard deviations of the ages of Group A and Group B

	Mean	S.D.	P value
Group A	55.93	8.353	0.616
Group B	59.27	7.869	

Table 2: Mean and standard deviations of the BBS, MNSI & NCS of Group A and Group B

	Group A	Group B	P value
BBS	26.47±4.927	26.53±4.926	0.971
MNSI	14.27±3.411	15.37±3.598	0.398
Latency Tibial Nerve	5.528±3.83	5.876±1.537	0.746
Latency Peroneal Nerve	5.21±3.11	5.408±2.784	0.858
Amplitude Tibial Nerve	6.280±5.399	6.68±5.659	0.844
Amplitude	4.82±5.61	1.89±1.37	0.06

Peroneal Nerve			
NCV Tibial Nerve	40.09±11.99	42.42±11.29	0.589
NCV Peroneal Nerve	47.60±8.61	48.05±12.99	0.912
Latency Sural Nerve	5.0±3.12	2.84±1.01	0.021
Amplitude Sural Nerve	11.49±10.03	14.48±5.94	0.33
NCV Sural Nerve	39.35±10.95	51.9±8.96	0.002
F wave NCV Tibial Nerve	53.1±16.5	65.82±10.67	0.018
F wave NCV Peroneal Nerve	58.66±7.04	63.35±8.84	0.119
H Reflex Soleus Amplitude	9.11±0.764	8.58±2.47	0.432

Within group comparison

Group A: **Table 3:** Mean and standard deviations of Group A's BBS, MNS, and NCS before and after the test.

	Pre-Test	Post-Test	P value
BBS	26.47±4.927	31.33±4.923	0.000*
MNSI	14.27±3.411	10.20±1.265	0.000*
Latency Tibial Nerve	5.528±3.83	2.778±1.575	0.000*
Latency Peroneal Nerve	5.21±3.11	2.6027±1.68081	0.000*
Amplitude Tibial Nerve	6.280±5.399	12.4567±5.25054	0.000*
Amplitude Peroneal Nerve	4.82±5.61	11.8000±6.02364	0.000*
NCV Tibial Nerve	40.09±11.99	50.6287±6.21204	0.000*
NCV Peroneal Nerve	47.60±8.61	55.3027±7.37513	0.000*
Latency Sural Nerve	5.0±3.12	2.7327±1.09632	0.000*
Amplitude Sural Nerve	11.49±10.03	14.4020±5.85948	0.168
NCV Sural Nerve	39.35±10.95	49.3133±6.25143	0.000*
F wave NCV Tibial Nerve	53.1±16.5	60.6000±8.23980	0.015*
F wave NCV Peroneal Nerve	58.66±7.04	63.0067±6.15693	0.000*

H Reflex Soleus Amplitude	9.11±0.764	10.1733±1.29254	0.000*

Group B: Table 4: Pre and post test means and standard deviations of the BBS, MNSI and NCS of **Group B**

	Pre-Test	Post-Test	P value
BBS	26.53±4.926	35.00±5.085	0.000*
MNSI	15.37±3.598	9.13±2.167	0.000*
Latency Tibial Nerve	5.876±1.537	3.2185±1.61186	0.000*
Latency Peroneal Nerve	5.408±2.784	2.4323±1.34389	0.000*
Amplitude Tibial Nerve	6.68±5.659	26.1800±46.02315	0.134
Amplitude Peroneal Nerve	1.89±1.37	16.3867±14.93437	0.000*
NCV Tibial Nerve	42.42±11.29	58.5573±6.57265	0.000*
NCV Peroneal Nerve	48.05±12.99	61.9733±8.92364	0.000*
Latency Sural Nerve	2.84±1.01	1.6240±0.92326	0.000*
Amplitude Sural Nerve	14.48±5.94	21.0733±7.03638	0.000*
NCV Sural Nerve	51.9±8.96	61.0300±6.60920	0.000*
F wave NCV Tibial Nerve	65.82±10.67	71.2267±10.60030	0.000*
F wave NCV Peroneal Nerve	63.35±8.84	67.2867±8.02584	0.000*
H Reflex Soleus Amplitude	8.58±2.47	10.9200±1.39140	0.000*

Between the Group Comparison of Michigan Neuropathy Screening Instrument and Berg Balance Scale

Table 5: BBS, MNSI, and NCS means and standard deviations for Groups A and B

	Group A	Group B	P value
BBS	31.33±4.923	35.00±5.085	0.05*
MNSI	10.20±1.265	9.13±2.167	0.111
Latency Tibial Nerve	2.778±1.575	3.2185±1.61186	0.472

Latency Peroneal Nerve	2.6027±1.68081	2.4323±1.34389	0.772
Amplitude Tibial Nerve	12.4567±5.25054	26.1800±46.02315	0.261
Amplitude Peroneal Nerve	11.8000±6.02364	16.3867±14.93437	0.279
NCV Tibial Nerve	50.6287±6.21204	58.5573±6.57265	0.002*
NCV Peroneal Nerve	55.3027±7.37513	61.9733±8.92364	0.034*
Latency Sural Nerve	2.7327±1.09632	1.6240±0.92326	0.006*
Amplitude Sural Nerve	14.4020±5.85948	21.0733±7.03638	0.009*
NCV Sural Nerve	49.3133±6.25143	61.0300±6.60920	0.000*
F wave NCV Tibial Nerve	60.6000±8.23980	71.2267±10.60030	0.005*
F wave NCV Peroneal Nerve	63.0067±6.15693	67.2867±8.02584	0.113
H Reflex Soleus Amplitude	10.1733±1.29254	10.9200±1.39140	0.139

Discussion

The data was analysed using Microsoft Excel (Professional Edition 2007, Microsoft Corp, Redmond, WA) and SPSS (Statistical Package of Social Sciences, version 20). To start, the initial values for age, balance, the use of a neuropathy screening tool, and nerve conduction studies were compared using independent and paired t-tests (which are parametric statistical tests). Additionally, the final measurements of balance, neuropathy screening tool usage, and nerve conduction studies between participants in Group A and Group B were also compared. Any difference found to have a probability value (p-value) less than 0.005 was considered to be statistically significant. The main goal of this study was to compare proprioceptive neuromuscular facilitation with sensory motor training. The outcome measures used to assess balance on the BBS and for the evaluation of neuropathy, the MNSI and NCS, were used. A total of 30 participants suffering from diabetic peripheral neuropathy participated. There was no drop- outs. The discussion that follows aims to clarify the findings and observations produced during this investigation in the context of the scientific data that are currently accessible.

The samples was divided into two groups, each consisting15 subjects. Group A (mean age 55.93±8.353, 15 participants) was treated with proprioceptive neuromuscular facilitation for 3 weeks, and Group B (mean age 59.27±7.869, 15 participants) was treated with sensory motor training for 3 weeks. The score must increase in accordance with the BBS values and decrease in accordance with the MNSI values. In this context, nerve conduction investigations are regarded as a component of the clinical assessment of patients with neuromuscular disorders.

We conducted MNC, F- wave for the tibial and peroneal nerves, SNC for the sural nerve and H- wave for the soleus muscle of the affected side.

To examine whether the results of Group A and Group B were equivalent, a series of paired t- tests were performed for balance, neuropathy and all the parameters of NCS testing within the groups, and an independent t test was used to compare baseline values of age, balance and neuropathy and all the parameters of NCS testing and the final between group measures of balance, neuropathy and all the parameters of NCS testing among the participants in Groups A and B.

An analysis of the outcome measures of the study, revealed that significant improvement was found in both groups, but the sensory motor training exercise, when applied, yielded better results than did proprioceptive neuromuscular facilitation. Therefore, balance, neuropathy and NCS support the experimental hypothesis (H2). As shown in Table 5, a comparison of the differences between the post treatment values of the outcome measures between both groups revealed that sensory motor training had a better effect on management of diabetic peripheral neuropathy. These results agree with findings of some previous studies, which focused on sensory motor training and proprioceptive neuromuscular facilitation.

In 2021, Irshad Ahmad and colleagues conducted a study to investigate how sensorimotor training impacts the walking patterns (spatiotemporal gait characteristics) of middle-aged and older individuals with diabetic peripheral neuropathy (DPN). The researchers simultaneously ran two intervention groups and two control groups. They selected thirty-seven DPN patients based on specific inclusion and exclusion criteria and then randomly assigned them into experimental and control groups, consisting of sixteen middle-aged and twenty-one older adults. For eight weeks, the experimental group engaged in sensorimotor training three times a week, in addition to receiving standard diabetes and foot care. The control group, however, only received diabetes and foot care education. The study measured aspects of their natural and fastest walking speed before and after the eight-week period. The findings indicated that after eight weeks, both middle-aged and elderly DPN patients, regardless of their specific age, experienced similar improvements in their walking patterns as a result of the sensorimotor training.

In 2019, Joong Hyun Park and his team carried out a study to determine if there was a relationship between nerve conduction study (NCS) characteristics and the presence of neuropathic symptoms, as measured by the Michigan Neuropathy Screening Instrument (MNSI). Their analysis looked back at data from patients with type 2 diabetes (DM2), some of whom had neuropathy symptoms and some who did not. For this analysis, they collected clinical lab results, MNSI scores, NCS findings, and patient information. Diabetic peripheral neuropathy (DPN) was diagnosed based on abnormal NCS results and an MNSI score of 3.0 or higher. They used Pearson's correlation coefficient to assess how MNSI scores related to different NCS measurements. The final analysis included 198 patients (115 men and 83 women) with an average age of 62.6 years (plus or minus 12.7 years) and an average duration of diabetes of 12.7 years (plus or minus 8.4 years).

The average MNSI score for the 69 patients (34.8%) diagnosed with DPN was 2.8 (ranging from 0.0 to 9.0). The study found a positive association between MNSI scores and the slowing of signals in the median motor nerve. Conversely, the speed of nerve signals (mean conduction velocity or NCV) in several nerves (motor nerve, ulnar sensory nerve, peroneal nerve, tibial nerve, and peroneal nerve again) was negatively associated with the MNSI score. Recent research suggests that a decrease in the peroneal nerve's conduction velocity is an early indicator of sensory problems in patients with type 2 diabetes.

Conclusion:

Our research led us to conclude that the NCS is a useful tool for assessing individuals with diabetic peripheral neuropathy. Group B was found to be more effective at improving both variables, i.e., the BBS, MNSI and NCS parameters, in diabetic peripheral neuropathy patients. The patient's condition significantly improved, according to the "p" value and standard deviation. Since then, sensory motor training has improved patients' balance measurements. The findings support the experimental hypothesis and show that patients who underwent sensory motor training differ significantly from those in other groups.

Limitation of the Study

The sample size was limited in our study, and larger sample sizes could be used for future research to better generalize the findings. The study may be hampered by the use of outcome measurements, which are subjective scales.

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Conflict of Interest

The study did not contain any conflicts of interest.

Ethics Committee Approval

Ethical committee approval was received from the Institutional NTCC Committee of SGV University, Jaipur, India, with ethical (Approval number SGVU/BPT/2024/December/09)

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