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Effectiveness of Proprioceptive Neuromuscular Facilitation, Sensorimotor Training and Conventional Exercise Along With Whole Body Vibrator on Balance in Patients with Diabetic Peripheral Neuropathy

*[1]Jibi Paul
[2]J. Kavitha Lakshmi
[3]P. Sathya

ABSTRACT

Background: Diabetic peripheral neuropathy is one of the most common complications of patients with type 2 diabetes mellitus. The study's objective was to find the comparative effects of proprioceptive neuromuscular facilitation, sensorimotor training, conventional exercise, and whole body vibrator on balance in patients with diabetic peripheral neuropathy.

Methods: This was an experimental study of comparative type with 60 subjects. The study was carried out at the Faculty of Physiotherapy department, Dr. M.G.R. Educational and Research Institute, for eight weeks after its approval from the institution's review board. Clinically diagnosed diabetic mellitus patients aged 45 to 60 years were selected for the study for the last seven years. The selected participants were divided into three groups using a random sampling method. Michigan neuropathy screening instrument, berg balance scale, and Time up and test were used to assess before and after the intervention.

Results: In this study, the comparative effect of Whole Body Vibrator with PNF Training, Whole Body Vibrator with sensory motor Training, and Conventional Training on MNSI, BBS, and TUG4 shows a significant difference in the Post-test of MNSI and TUG but no difference in BBS between Group A, B and C with P value <0.0001. 0.0697 and 0.0014 respectively. Group A was more effective, with mean differences of 3.625, 4.80, and 3.150 on MNSI, BBS, and TUG, compared to Group B and C.

Conclusion: Regarding the statistical analysis of the data collected using MNSI, BBS, and TUG. It can be concluded that PNF, along with whole body vibrator, is a more effective intervention than sensorimotor with WBV and conventional training.

Keywords: Diabetic peripheral neuropathy, PNF, Sensorimotor training, Conventional exercise, Whole body Vibrator, Balance.

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[2]MPT Graduate, Faculty of Physiotherapy, Dr. MGR. Educational and Research Institute, Chennai, Tamil Nadu, India.
[3]Professor cum Principal, Faculty of Physiotherapy, Dayananda Sagar Univesity, Bangalore, Karnataka, India.

CORRESPONDING AUTHOR

*[1]Jibi Paul

Professor, Faculty of Physiotherapy, Dr. MGR. Educational and Research Institute, Chennai, Tamil Nadu, India.
E-mail: jibipaul74@gmail.com

INTRODUCTION

According to the 10th edition, the IDF diabetes atlas estimates that in 2021, 537 million people will be living with diabetes worldwide and 90 million people in the Southeast Asia region, with an 8.3% prevalence of diabetes in Indian adults. Diabetic peripheral neuropathy is the most common complication associated with diabetes mellitus, and its common symptoms are burning pain, electrical or stabbing sensations, paraesthesia, hyperesthesia, deep aching pain, and muscle weakness; the symptoms are most commonly experienced in the feet and lower limbs. Long-standing diabetes has significant deficits in tactile sensitivity, vibration sense, lower limb proprioception and kinaesthesia, and absent ankle reflex, further leading to decreased sensory input sensitivity from the extremities [1-3].

Somatosensory information from the foot and proprioception are key determinants for motor control during balance [6]. Whole body vibration WBV is a therapeutic modality consisting of applying an oscillatory force, where energy is transferred from an actuator. It improves proprioceptive sense, bone density, balance, and motor skills. Vibration may directly stimulate muscle spindles and Golgi tendon organs, and increases in proprioceptive sense have been observed in healthy young adults after WBV. Whole body vibration stimulates the Pacinian corpuscle, increasing vibration perception in patients with DPN [4-7].

Proprioceptive neuromuscular facilitation is a treatment developed in the 1950s by Herman Kabat. The therapeutic intervention is used to facilitate a patient's performance with movement deficits. It aims to increase strength, coordination, and motion control to develop proper balance through proprioception stimulation. PNF technique improves balance by enhancing sensorimotor functions of diabetic neuropathic patients [8,9].

Sensorimotor training comprises facilitating sensory inputs (proprioception and somatosensory inputs), correcting muscle imbalance, and ensuring correct motor program at the central nervous system level. Balance exercises are well-established sensorimotor training of static, dynamic, and functional patient treatment approaches. Post-balance training improved balance measures in DPN patients have been reported in older adults, middle-aged adults, and populations comprising both these age groups; sensorimotor training improves the proprioceptive feedback in patients with diabetic peripheral neuropathy [10-14].

The Michigan neuropathy screening instrument assesses distal symmetrical peripheral neuropathy in diabetes. It includes two separate assessments: a 15-item self-administered questionnaire and a lower extremity examination that includes inspection and assessment of vibratory sensation and ankle reflex. It is scored by assigning points for abnormal findings [21, 22]. Berg balance scale was used to evaluate functional balance before and after the intervention. It is a valid and reliable scale with 14 functional tests that quantitatively evaluate balance disorders. BBS completion needs 10-20 min. The score represents the participant's ability to control postural balance. Each test is scored 0-4. The overall score is the sum of the obtained scores for each test. Thus, the maximum overall score is 56, and the minimum is zero [15, 16].

Time up and go is a commonly used reliable test to examine functional mobility in frail older adults. It records the Time taken to stand up from a standard armchair, walk a distance of 3m, turn back to the chair, and sit down. The total Time to complete the circuit was measured using a stopwatch at the nearest 0.01s. Subjects performed the test barefoot, and the best of three experimental trials was used for analysis. The Time required to perform TUG is strongly related to the risk of falls. Healthy adults performing this test in less than or equal to 10s have a lesser risk of falls [17, 18].

Various studies have shown the effects of PNF sensorimotor training in the improvement of balance impairment in patients with diabetic peripheral neuropathy, but the evidence supporting the effectiveness of PNF Vs. Sensorimotor training along with whole-body vibrators in patients with diabetic peripheral neuropathy is scarce. Thus, the study aims to compare the effectiveness of PNF, sensorimotor training, conventional exercise, and WBV in improving balance in patients with DPN.

Need of the study: Diabetic peripheral neuropathy is one of the most common complications of patients with type 2 diabetes mellitus. Diabetic peripheral neuropathy presents symptoms of reduced perception of vibrations, burning sensations in the soles of the feet, abnormal gait, etc., and loss or reduction of somatosensory information of the legs and feet, which leads to balance disturbance. Imbalance increases the risk of falling, significantly worsening the quality of life. The study aims to compare the effectiveness of PNF, Sensorimotor training, and conventional exercise along the WBV to improve balance in patients with DPN.

METHODOLOGY

This comparative pre-and post-study was conducted on a diabetic population selected from ACS Medical College and Hospital, with the study setting in the physiotherapy OPD at Dr. MGR Educational and Research Institute, Velappanchavadi, Chennai. The sample consisted of 60 individuals aged 45 to 60 years who had been clinically diagnosed with diabetes mellitus for at least seven years, scoring >4/13 on the MNSI questionnaire, >2/10 on physical assessments, and were able to stand on both feet.

Participants were selected using a simple random sampling method and divided into three groups (20 each) via lottery. The study duration was three months, with interventions conducted three days a week for eight weeks. Exclusion criteria included cardiovascular or mental diseases, foot ulcers, orthopedic or surgical lower limb issues, other neurological impairments, diabetes-related complications such as nephropathy or retinopathy, balance disturbances, and inability to walk independently.

Outcome measures focused on the severity of neuropathy, balance, and functional mobility, which were assessed using the Michigan neuropathy screening instrument, Berg balance scale, and Time up and test. Independent variables included whole-body vibration, proprioceptive neuromuscular facilitation, sensorimotor training, and conventional exercise.

Procedure: 60 participants fulfilling the inclusion criteria and those who volunteered for this study were selected and divided into three groups, Group A, Group B, and Group C. Subjects in Group A received PNF with whole body vibrator, Group B received sensorimotor training with whole body vibrator, Group C received conventional exercise for three days per week for eight weeks. The severity of neuropathy was measured using the Michigan neuropathy screening instrument; the balance was measured using the Berg balance scale, and functional mobility was measured using the Time up and test. The pre and post-comparative tests were performed before and after the intervention.

Intervention:

Group A (PNF with whole body vibration): Subjects in this group were made to stand on the platform of the vibrator (fig 2) and select the frequency within 15 to 30 Hz and amplitude within 1 to 5 mm for 15 mins. After this 15 minutes, subjects were treated with PNF patterns (fig 3) of diagonal movement as Diagonal 1 moving flexion, D1 moving into extension, D2 moving into flexion, and D2 moving extension for lower limb with three sets of exercises one hour each day with 10 minutes of rest between each set for three days/week for eight weeks.

Group B (Sensori motor training with whole body vibration): Subjects in this group were made to stand on the platform of the vibrator (fig 4) and selected the frequency within 15 to 30 HZ and amplitude within 1 to 5 mm for 15 minutes. After that 15 minutes, each session comprised 10 min warm up, 50 – 60 minutes of exercise, and 5 – 10 minutes of cool down. Warm-up exercise using a cycle ergometer or treadmill at 50% - 60% HRmax where HRmax=206.9-0.69 x age (years). Sensorimotor training comprises wall slides, core exercises (Fig 5), balance exercises on unstable surfaces, and gait training. Cool-down exercises included deep breathing, abdominal breathing, and mild stretch. This was done for three days/week for eight weeks.

Group C (conventional exercise): For subjects in this group, conventional exercises are given for 60 minutes with one minute of rest for every five min of exercises. The program includes the following exercises: relaxed deep breathing exercises, ROM exercises for bilateral ankle joints(fig 7), functional balance training involving sit-to-stand, standing weight shift, functional reach sideway and anterior for touching targets set by the therapist; bipedal heel rise; uni pedal standing with knee bending. Other exercises are wobble board and gait training, including tandem walking and spot marching. This was done for three days/week for eight weeks.

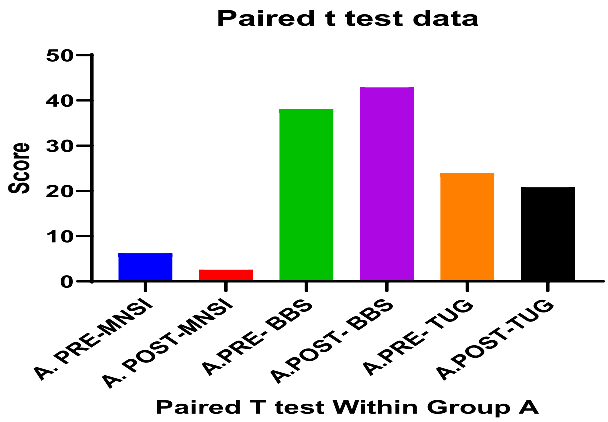
Data Analysis

Group A: Whole Body Vibrator with PNF Training

Table 1: Paired t-test within Group A with Whole Body Vibrator with PNF Training on MNSI, BBS, and TUG.

Group A	Number of Pairs	Mean Diff.	SD, SEM	df	t	P value	Sig. Diff. (P < 0.05)
MNSI Pre-Post Test	20	3.625	0.872 0.195	19	18.6	<0.0001	****
BBS Pre-Post Test	20	4.80	1.152 0.258	19	18.64	<0.0001	****
TUG Pre-Post Test	20	3.150	3.183 0.712	19	4.43	<0.0001	****

The above table 1 shows significant difference in MNSI, BBS and TUG within Group A with P value >0.0001



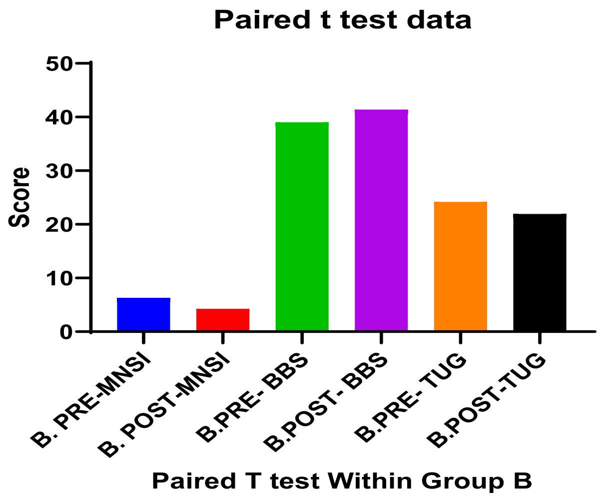
Graph 1: Presentation of MNSI, BBSandTUG within Group A

Group B: Whole Body Vibrator with sensorymotor Training

Table 2: Paired t-test within Group B with Whole Body Vibrator with sensory motor Trainingon MNSI, BBS, and TUG.

Group B	Number of Pairs	Mean Diff.	SD, SEM	df	t	P value	Sig. Diff. (P < 0.05)
MNSI Pre-Post Test	20	2.075	0.568 0.127	19	16.33	<0.0001	****
BBS Pre-Post Test	20	2.400	0.821 0.184	19	13.08	<0.0001	****
TUG Pre-Post Test	20	2.250	0.967 0.216	19	10.41	<0.0001	****

Table 2 shows significant differences in MNSI, BBSandTUG within Group B with P value >0.0001



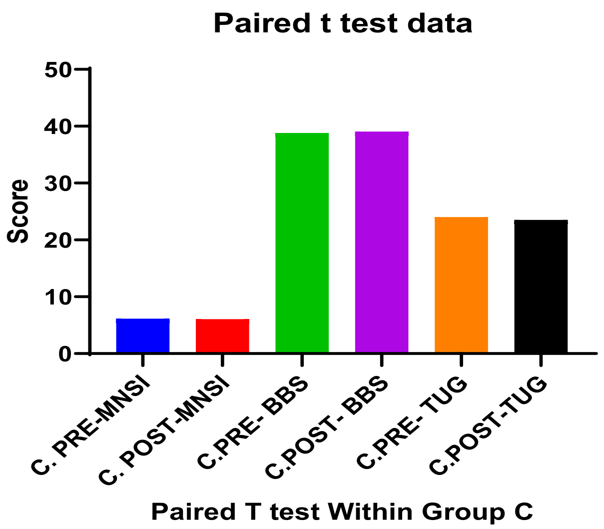
Graph 2: Presentation of MNSI, BBSandTUG within Group B

Group C: Conventional Training

Table 3: Paired t-test within Group C with Conventional Training on MNSI, BBS, and TUG.

Group C	Number of Pairs	Mean Diff.	SD, SEM	df	t	P value	Sig. Diff. (P < 0.05)
MNSI Pre-Post Test	20	0.075	0.1832 0.04096	19	1.83	0.0828	NS
BBS Pre-Post Test	20	0.250	0.55 0.123	19	2.03	0.056	NS
TUG Pre-Post Test	20	0.50	2.439 0.545	19	0.917	0.371	NS

Table 2 shows significant differences in MNSI, BBSandTUG within Group C with P value >0.0001



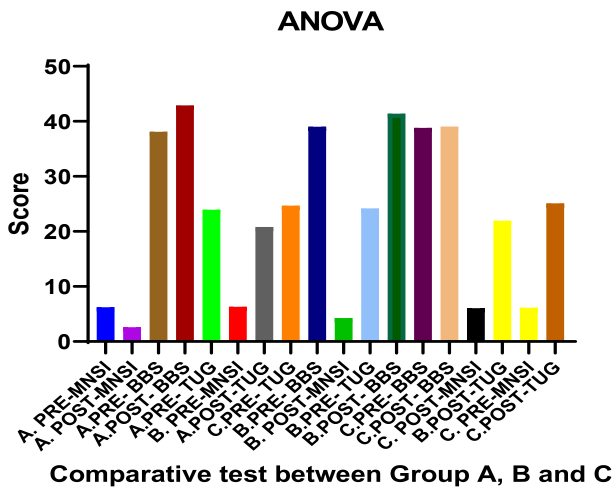
Graph 3: Presentation of MNSI, BBSandTUG within Group C

Comparative Analysis between Groups A, B, and C

Table 4: ANOVA to compare MNSI, BBS, and TUG between Group A, B and C

Outcome Measures	Test Between Groups A, B, and C	R Square	F	P value	Sig. diff. (P < 0.05)
MNSI	Pre-test	0.002	0.063	0.939	NS
	Post-test	0.535	32.75	<0.0001	****
BBS	Pre-test	0.006	0.1631	0.8499	NS
	Post-test	0.089	2.792	0.0697	NS
TUG	Pre-test	0.009	0.265	0.769	NS
	Post-test	0.207	7.434	0.0014	**

Table 4 shows significant differences on the Post-test of MNSI and TUG but no difference in BBS between Groups A, B, and C with P value <0.0001. 0.0697 and 0.0014 respectively.



Graph 4: Presentation of MNSI, BBS, and TUG between Groups A, B, and C.

RESULT

A total of 60 participants of both genders were included in the study based on specific selection criteria with an age group between 45 and 60 years. In this study, the comparative effect of Whole Body Vibrator with PNF Training, Whole Body Vibrator with sensory motor Training, and Conventional Training on MNSI, BBS andTUG4 shows a significant difference in Post-test of MNSI andTUG but no difference in BBS between Group A, B and Cwith P value <0.0001. 0.0697 and 0.0014 respectively. Group A was found to be more effective with a mean difference of 3.625, 4.80, and 3.150, respectively, on MNSI, BBS, and TUG when compared with Group B and C.MNSI; BBS and TUG have increased mean scores of 3.625, 4.80 and 3.150, by Whole Body Vibrator with PNF Training with P value >0.0001. MNSI, BBS, and TUG have increased mean scores of 2.075, 2.250, and 2.400 by Whole Body Vibrator with sensory motor Training with P value >0.0001. MNSI, BBS, and TUG have increased mean scores of 0.075, 0.250, and 0.50 by conventional exercise with P value >0.0001.

DISCUSSION

Diabetic peripheral neuropathy is one of the most common complications of diabetes mellitus. Up to 50% of elderly diabetes patients with more than ten years of history of diabetes have diabetic peripheral neuropathy, which leads to distal to proximal deterioration of the nervous system in the lower extremity that disrupts an important sensory system contributing to postural control. Lack of proprioception and vibration in the lower extremity resulted in postural instability during different situations. Those patients are at high risk for falling with its life-threatening consequences.

This experimental study was conducted to determine the effectiveness of PNF, sensorimotor training, conventional exercise, and whole body vibrator on balance in patients with diabetic peripheral neuropathy. Most of the patients were affected by balance due to decreased proprioception and sensation. The study started with 80 subjects with a history of diabetes. Of these 80 subjects, 65 were selected based on inclusion criteria, and 15 were excluded. Subjects were allocated by lottery sampling methods and divided into three groups. Due to the specific reason of 5 subjects they withdraw from the study.

The study was pursued with 60 subjects and 20 in each group. The outcome measures used to measure the variables are the Michigan neuropathy screening instrument, Berg Balance Scale, and Time Up and Go test. Proprioceptive neuromuscular facilitation exercises mainly consist of diagonal movement patterns that are close to the natural movement patterns of our bodies. The PNF approach improves the muscle strength and sensations of the lower limbs of diabetic neuropathy patients. It improves the balance of diabetic neuropathic patients and reduces fall history. A study is also found to be relevant to the present study. He assessed the effect of PNF techniques on patients' gait parameters and functional mobility.

The PNF techniques helped improve these patients' gait and mobility by improving sensorimotor function [16]. A study shows improved proprioception and muscle strength. The author and his colleagues observed better balance performance after balance training in patients with DN, independent of the neuropathy's severity. A study observed the following balance training in the diabetic group showed significant improvement in proprioception, decreased sway, and reduced fall risk. This study correlates with a present study that helps to improve proprioception, balance, and postural control in diabetic neuropathy [17-18].

The result of this study shows statistical improvement in balance and posture, which correlates with the "effect of sensory training over two different surfaces on the balance and gait in persons with diabetic neuropathy." A study supported the present study. They studied the effect of PNF in improving sensorimotor function in patients with DPN affecting lower limbs. The results show significant improvement in DNE scoring with P<0.05. The study showed that WBV training improves balance control and sit-to-stand performance in the middle. The concluded WBV training improves proprioception and vibration sensation in the lower extremities to maintain balance [19-21].

A study proved the accuracy of MNSI scoring, which makes it a useful screening test for finding the severity of diabetic neuropathy. It has high specificity, likelihood ratios over 5, and a moderate to good post-test probability, giving a high diagnostic impact for MNSI scoring [22]. The study showed BBS's high validity and reliability, a testing tool used to measure balance [23, 24]. A study showed TUG highly correlates with other proven tests that measure pure gait speed. It is a reliable, cost-effective, safe, and time-efficient way to evaluate overall functional mobility [25,26]. The present study was conducted to determine the effect of PNF, sensorimotor training, conventional exercise, and whole body vibrator on balance in patients with DPN. The study uses MNSI, BBS, and TUG as parameters to demonstrate the effects of interventions on DPN balance. A total of 60 patients were included in this study and randomly allocated into three groups.

CONCLUSION

The statistical analysis was done from the data collected using MNSI, BBS, and TUG. In this study, the comparative effect of Whole Body Vibrator with PNF Training, Whole Body Vibrator with sensory motor Training, and Conventional Training on MNSI and BBS and TUG shows a significant difference in Post-test of MNSI andTUG but no difference in BBS and between Group A, B and C with P value <0.0001. 0.0697 and 0.0014 respectively. Group A was more effective with a mean difference in MNSI, BBS, and TUG than Group B and C. It can be concluded that PNF, along with whole body vibrator, is a more effective intervention than sensorimotor with WBV and conventional training.

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