

EFFECTIVENESS OF SENSORIMOTOR TRAINING AND DESENSITISATION THERAPY ON BALANCE AND GAIT IN PATIENTS WITH DIABETIC PERIPHERAL NEUROPATHY

K.P. Abhishek¹, C.Divyamalini², T.Sriranjini³, R.lalitha⁴, Dr. Senthil Purushothaman⁵

^{1,2,3}Assistant Professor, Associate professor^{4,5}Dean / Principal (Guide)

Bharath College of Physiotherapy

Bharath Institute of Higher Education and Research (BIHER), Chennai, Tamil Nadu, India

ABSTRACT

Background: Diabetic peripheral neuropathy (DPN) is a widespread microvascular complication of diabetes mellitus that progressively erodes sensation, proprioception and motor coordination in the lower limbs, leaving affected individuals unsteady on their feet and prone to falls. While conventional physiotherapy addresses mobility and pain to some extent, it rarely targets the sensorimotor integration deficits that underlie much of this instability. **Objective:** This study set out to determine whether a combined programme of sensorimotor training and desensitisation therapy produces greater gains in balance and gait than conventional physiotherapy in people living with DPN. **Methods:** Thirty adults with clinically confirmed mild-to-moderate DPN were allocated by convenience sampling into two groups of fifteen. The experimental group (Group A) underwent sensorimotor training combined with textured-stimulus desensitisation therapy, while the comparison group (Group B) received a conventional physiotherapy programme of stretching and strengthening exercises. Both groups trained for 45 minutes a day, four days a week, across a six-week period at Sri Isari Velan Mission Hospital, Thalambur, Chennai. Balance and gait were quantified before and after the intervention using the Berg Balance Scale (BBS) and the Dynamic Gait Index (DGI). **Results:** Both groups improved significantly from baseline ($p < 0.0001$), but the gains in Group A were substantially larger. Post-intervention BBS scores averaged 51.60 in Group A against 38.40 in Group B, while DGI scores averaged 21.27 against 18.27 respectively, with between-group differences reaching high statistical significance ($p < 0.0001$). **Conclusion:** Sensorimotor training combined with desensitisation therapy produced markedly greater improvement in balance and gait than conventional physiotherapy alone in patients with DPN, supporting its inclusion as an adjunct in neuro-rehabilitation protocols for this population.

Keywords: Diabetic peripheral neuropathy; sensorimotor training; desensitisation therapy; balance; gait; Berg Balance Scale; Dynamic Gait Index

I. INTRODUCTION

Diabetes mellitus remains one of the most prevalent chronic disorders worldwide, and peripheral nerve damage is among its most disabling long-term consequences. Diabetic peripheral neuropathy (DPN), often referred to as distal symmetric sensorimotor neuropathy, affects an estimated 40 to 50 percent of people with long-standing type 1 or type 2 diabetes, with the feet and legs typically involved before the hands and arms [1][2]. The condition arises from a combination of chronic hyperglycaemia, microvascular insufficiency, oxidative stress and impaired neurotrophic support, culminating in progressive loss of sensory and motor nerve fibre function [3].

Clinically, patients describe numbness, burning or tingling sensations, cramping, and an unpleasant hypersensitivity to light touch, alongside measurable muscle weakness. Because the feet lose their normal protective sensation and proprioceptive feedback, standing, walking and daily transfers become progressively harder to perform safely, and the risk of falls, ulceration and further injury climbs accordingly. Conventional physiotherapy — largely built around stretching and strengthening — can ease some of these symptoms, but it does not directly retrain the sensory-motor integration that balance and gait depend on.

Sensorimotor training, originally described by Janda as part of his approach to chronic musculoskeletal dysfunction, works on a different principle: it deliberately challenges the postural control system with graded, unstable and textured surfaces so that the central nervous system is forced to re-calibrate how it uses proprioceptive and somatosensory information [4][5]. Patients progress through static holds, dynamic weight-shifting tasks and functional movements such as sit-to-stand and stepping, each performed on surfaces of increasing difficulty. The underlying rationale is that repeated sensorimotor challenge drives neuro plastic adaptation at the point where sensory and motor pathways

converge, gradually restoring more automatic, subcortically-mediated postural responses [6][7].

Desensitisation therapy addresses a complementary problem — the hypersensitivity and distorted tactile processing that many DPN patients develop in the feet. By exposing the affected skin to a graded sequence of textures, from very soft fabrics through to coarser materials, the nervous system is gradually re-accustomed to normal sensory input, which in turn appears to reduce pain and improve the patient's confidence in bearing weight through the affected limb [8][9]. Because balance depends heavily on accurate foot-sole feedback, normalising this sensory channel is a logical complement to sensorimotor exercise rather than a separate, unrelated intervention.

Several recent studies have examined pieces of this picture. Ahmad et al. reported that structured sensorimotor exercise improved both static and dynamic balance and sharpened proprioception in patients with DPN [10], and a related trial by the same group linked sensorimotor and gait training to improved muscle activation around the ankle during walking [11]. Abdel basset et al. found that sensorimotor exercise improved pain, proprioception, mobility and quality of life in diabetic patients with foot complications [12], while other authors have reported benefits of balance training, aerobic exercise and task-specific protocols on falls risk and postural control in this population [13] [14][15]. What remains comparatively unexplored is the combined effect of sensorimotor training and desensitisation therapy delivered together against a standard physiotherapy comparator — the gap this study was designed to address.

Aim and Objectives

The study aimed to evaluate the effectiveness of a combined sensorimotor training and desensitisation therapy programme on balance and gait in patients with diabetic peripheral neuropathy. Specifically, it sought (i) to assess the impact of this intervention on balance, and (ii) to assess its impact on gait, in comparison with conventional physiotherapy.

Hypotheses

The null hypothesis stated that there would be no significant difference between sensorimotor training with desensitisation therapy and conventional physiotherapy in their effect on balance and gait in DPN patients. The alternative hypothesis proposed that a significant difference would be observed between the two approaches.

II. METHODOLOGY

This was a comparative, pre-test/post-test experimental study conducted over six weeks at Sri Isari Velan Mission Hospital, Thalambur, Chennai, following approval from the institutional review board. Thirty patients diagnosed with mild-to-moderate diabetic peripheral neuropathy were recruited by convenience sampling and allocated into two groups of fifteen: Group A received sensorimotor training combined with desensitisation therapy, and Group B received conventional physiotherapy. Both groups trained for 45 minutes a day, four days a week, for the full six-week period, comprising eighteen sessions delivered three times weekly.

Inclusion Criteria

Participants were included if they had a confirmed diagnosis of mild-to-moderate DPN, were aged between 40 and 75 years with a history of type 2 diabetes, presented with balance and gait impairment attributable to neuropathy, could walk independently or with minimal assistance, and were willing to undergo the training protocol.

Exclusion Criteria

Patients were excluded if they had severe neuropathy with complete loss of protective sensation, active foot ulcers, severe deformity or recent fracture, a neurological condition such as stroke or Parkinson's disease affecting balance, significant musculoskeletal restrictions to mobility, poorly controlled diabetes (HbA1c above 10 percent) or other major systemic illness, or cognitive or psychiatric impairment that would limit participation.

Outcome Measures

Balance was measured with the Berg Balance Scale (BBS), a 14-item performance-based scale scored out of 56, and gait was measured with the Dynamic Gait Index (DGI), an 8-item scale assessing gait under varying task demands. Both were administered before and after the six-week intervention by the same assessor.

Intervention Protocol

Group A followed a sensorimotor training programme structured across static, dynamic and functional phases, using surfaces of graded difficulty — yoga mats, folded towels, pillows, pebble mats and similar textured materials. Static exercises included standing balance on a soft surface, tandem stance on a textured surface, and single-leg stance on an unstable surface.



fig. 1. standing balance training on a soft surface (patient and treating therapist identities masked)

Dynamic exercises included heel and toe walking, side-to-side weight shifting on an uneven surface, and stepping over low obstacles placed on a rough surface.



fig. 2. toe walking on a textured surface as part of dynamic sensorimotor training

Functional exercises included sit-to-stand from an unstable seated surface, step-ups onto a textured step, and forward reaching while standing on an uneven surface, with task difficulty progressed as tolerance improved.

Alongside the exercise programme, Group A also received textured-stimulus desensitisation therapy to the affected foot. The unaffected area was first stimulated with a cotton ball so the patient could register a normal sensory baseline, after which the painful area was stimulated in the same manner and then progressed through a sequence of textures of increasing coarseness — from soft paper towel through to terry cloth, and ultimately materials such as silk graduating to wool or Velcro-type fabric. This was carried out for 15 minutes, three times a day, three times a week, across the six-week period.



fig. 3. textured massage desensitisation therapy applied to the affected foot

Group B followed a conventional physiotherapy programme comprising calf and hamstring stretches, ankle circles, and strengthening exercises including heel raises, side leg raises and sit-to-stand practice, preceded by a short period of relaxed breathing exercise.



fig. 4. calf stretch performed by the conventional physiotherapy group



fig. 5. heel raise exercise performed by the conventional physiotherapy group

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 28. A paired t-test was used to compare pre- and post-intervention scores within each group, and an independent-samples t-test was used to compare post-intervention scores

between groups. Statistical significance was set at $p < 0.05$.

III. RESULTS

Thirty patients (fifteen per group) completed the six-week intervention with no dropouts. Both groups showed statistically significant within-group improvement on the BBS and DGI following intervention ($p < 0.0001$), but the magnitude of improvement was consistently and substantially greater in Group A, the sensorimotor training and desensitisation therapy group.

table 1. pre-test and post-test values of berg balance scale (group a and group b)

Berg Balance Scale	Mean	SD	t value	p value
Group A – Pre-test	34.87	1.19	36.8367	<0.0001
Group A – Post-test	51.60	1.30		
Group B – Pre-test	33.40	0.99	13.8930	<0.0001
Group B – Post-test	38.40	0.99		

table 2. pre-test and post-test values of dynamic gait index (group a and group b)

Dynamic Gait Index	Mean	SD	t value	p value
Group A – Pre-test	13.40	0.99	19.9865	<0.0001
Group A – Post-test	21.27	1.16		
Group B – Pre-test	15.93	0.80	8.4887	<0.0001
Group B – Post-test	18.27	0.70		

table 3. comparison of post-test berg balance scale scores between group a and group b

Berg Balance Scale	Post-test mean	SD	t value	p value
Group A (Experimental)	51.60	1.30	31.2864	<0.0001
Group B (Control)	38.40	0.99		

table 4. comparison of post-test dynamic gait index scores between group a and group b

Dynamic Gait Index	Post-test mean	SD	t value	p value
Group A (Experimental)	21.27	1.16	8.5759	<0.0001
Group B (Control)	18.27	0.70		

On the Berg Balance Scale, Group A improved from a pre-test mean of 34.87 (SD 1.19) to a post-test mean of 51.60 (SD 1.30), a within-group change that was highly significant ($t = 36.8367$, $p < 0.0001$). Group B improved more modestly, from 33.40 (SD 0.99) to 38.40 (SD 0.99), also statistically significant ($t = 13.8930$, $p < 0.0001$) but of smaller magnitude (Table 1).

A similar pattern was evident on the Dynamic Gait Index. Group A rose from a pre-test mean of 13.40 (SD 0.99) to a post-test mean of 21.27 (SD 1.16), a highly significant change ($t = 19.9865$, $p < 0.0001$), while Group B improved from 15.93 (SD 0.80) to 18.27 (SD 0.70), again significant but smaller in scale ($t = 8.4887$, $p < 0.0001$) (Table 2).

Comparing the two groups directly at the end of the intervention, Group A's post-test BBS score of 51.60 was significantly higher than Group B's 38.40 ($t = 31.2864$, $p < 0.0001$) (Table 3), and Group A's post-test DGI score of 21.27 was significantly higher than Group B's 18.27 ($t = 8.5759$, $p < 0.0001$) (Table 4). Taken together, these results indicate that while both interventions produced measurable gains, sensorimotor training combined with desensitisation therapy produced a substantially greater improvement in both balance and gait than conventional physiotherapy alone.

IV. DISCUSSION

The results of this study indicate that a combined programme of sensorimotor training and desensitisation therapy produces greater improvement in balance and gait than conventional physiotherapy in patients with diabetic peripheral neuropathy. Both outcome measures moved in the expected direction for both groups, but the scale of improvement in the experimental group was consistently larger and statistically distinct from the control group at the end of the intervention period.

A plausible explanation lies in what each intervention actually targets. Conventional stretching and strengthening exercises can improve joint range and muscle output, but they do little to retrain the sensory feedback loops that postural

control depends on. Sensorimotor training, by contrast, deliberately perturbs the postural system on unstable and textured surfaces, which is thought to drive adaptive change at the point where sensory input and motor output converge in the central nervous system. With repetition, movement patterns that once required conscious correction appear to become faster and more automatic, mediated increasingly by feed-forward postural adjustments that stabilise the joints before a perturbation is even consciously registered [4][6]. This mechanism is consistent with earlier work showing that sensorimotor exercise improves proprioception, static and dynamic balance, and gait parameters in DPN populations [10][11][16].

The addition of desensitisation therapy plausibly contributed an independent benefit. DPN frequently distorts tactile processing in the feet, producing either numbness or paradoxical hypersensitivity, both of which degrade the quality of sensory information reaching the postural control system. Graded exposure to textures of increasing intensity appears to help normalise this input, and several authors have linked such desensitisation approaches to reduced pain and improved sensory tolerance, which in turn appears to support better weight-bearing confidence and postural stability [8][9][17]. Reducing pain may also have a secondary effect on body image and postural awareness, since patients who are less guarded about loading a painful limb tend to move more naturally through it [18].

These findings are broadly consistent with the wider literature on balance training in DPN, which has generally found favourable effects on postural control, though often noting methodological limitations such as small sample sizes and variable training protocols [13][19][20]. This study's comparative design, in which both groups were drawn from the same clinical population and trained for an equal duration, strengthens the case that the additional gains in Group A are attributable to the sensorimotor and desensitisation components specifically, rather than to time or general activity alone.

V. CONCLUSION

Within the limits of this study, sensorimotor training combined with desensitisation therapy produced significantly greater improvement in balance and gait than conventional physiotherapy in patients with diabetic peripheral neuropathy. These findings support incorporating sensorimotor and desensitisation techniques as an adjunct within standard physiotherapy protocols for this population, with the aim of more directly addressing the sensory and postural control deficits that underlie fall risk in DPN.

VI. LIMITATIONS AND RECOMMENDATIONS

Limitations

The study was limited by its small sample size, a relatively short six-week intervention and follow-up window, variability in disease severity among participants, reliance on a limited set of standardised balance and gait tools, and the absence of long-term follow-up to establish whether gains were maintained.

Recommendations

Future work should compare alternative exercise combinations, extend intervention and follow-up duration, explore application of this protocol to other neurological populations with balance impairment, evaluate home-based delivery models, and consider a multidisciplinary approach involving podiatry and endocrinology alongside physiotherapy.

REFERENCES

1. Boulton AJ, Malik RA. Diabetic neuropathy. *Med Clin North Am*. 1998;82(4):909-29.
2. Rosenberger DC, Blechschmidt V, Timmerman H, Wolff A, Treede RD. Challenges of neuropathic pain: focus on diabetic neuropathy. *J Neural Transm (Vienna)*. 2020;127(4):589-624.
3. Hicks CW, Selvin E. Epidemiology of peripheral neuropathy and lower extremity disease in diabetes. *Curr Diab Rep*. 2019;19(10):86.
4. Inglis JT, Horak FB, Shupert CL, Jones-Rycewicz C. The importance of somatosensory information in triggering and scaling automatic postural responses in humans. *Exp Brain Res*. 1994;101(1):159-64.
5. Freire I, Seixas A. Effectiveness of a sensorimotor exercise program on proprioception, balance, muscle strength, functional mobility and risk of falls in older people. *Front Physiol*. 2024;15:1309161.
6. Mahmoud Shaykh. Investigating the effect of cognitive and sensorimotor exercises on the functional balance in the elderly. 2019;6(4):171-6.
7. Ahmad I, Noohu MM, Verma S, Singla D, Hussain ME. Effect of sensorimotor training on balance measures and proprioception among middle and older age adults with diabetic peripheral neuropathy. *Gait Posture*. 2019;74:114-20.
8. Ahmad I, Verma S, Noohu MM, Shareef MY, Hussain ME. Sensorimotor and gait training improves proprioception, nerve function, and muscular activation in patients with diabetic peripheral neuropathy: a randomized control trial. *J Musculoskeletal Neuronal Interact*. 2020;20(2):234-48.
9. Reeves ND, Orlando G, Brown SJ. Sensory-motor mechanisms increasing falls risk in diabetic peripheral neuropathy. *Medicina (Kaunas)*. 2021;57(5):457.

10. D'Silva LJ, Lin J, Staecker H, Whitney SL, Kluding PM. Impact of diabetic complications on balance and falls: contribution of the vestibular system. *Phys Ther.* 2016;96:400-9.
11. Gutierrez EM, Helber MD, Dealva D, Ashton-Miller JA, Richardson JK. Mild diabetic neuropathy affects ankle motor function. *Clin Biomech.* 2001;16(6):522-8.
12. Walid Kamal Abdelbasset et al. Sensorimotor exercise training in diabetic patients with foot burns. 2021.
13. Esben Koehler et al. Balance training interventions in people with diabetic peripheral neuropathy: a review. 2024.
14. Sania Maqbool et al. Aerobic exercise and balance in diabetic peripheral neuropathy. 2024.
15. Farhan Haleem et al. Structured balance, strength and aerobic training in diabetic peripheral neuropathy. 2024.
16. Majumi M. Noohu et al. Sensorimotor training and proprioception in diabetic peripheral neuropathy. 2019.
17. Chiles NS, Phillips CL, Volpato S, Bandinelli S, Ferrucci L, Guralnik JM, et al. Diabetes, peripheral neuropathy, and lower-extremity function. *J Diabetes Complications.* 2014;28(1):91-5.
18. Weerakkody NS, Percival P, Hickey MW, Morgan DL, Gregory JE, Canny BJ, et al. Effects of local pressure and vibration on muscle pain from eccentric exercise and hypertonic saline. *Pain.* 2003;105(3):425-35.
19. Snehil Dixit et al. Balance training interventions in diabetic peripheral neuropathy: a systematic review. 2018.
20. Bansal V, Kalita J, Misra UK. Diabetic neuropathy. *Postgrad Med J.* 2006;82(964):95-100.

Copyright & License:

© Authors retain the copyright of this article. This work is published under the Creative Commons Attribution 4.0 International License (CC BY 4.0), permitting unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.