SSN Journal of Management & Technology Research Communications

Vol 3 No (4) 2026 CrossRef DOI: https://dx.doi.org/10.21786/mntrc

Published by Society for Science and Nature Bhopal India E-ISSN : 3049-0014

OPEN ACCESS

Effectiveness of an Occupational Therapy Program Combining Core Stability and Proprioceptive Exercises on Balance and Quality of Life in Individuals with Diabetic Neuropathy: A Randomized Controlled Trial

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ABSTRACT

Type 2 diabetes is commonly associated with balance impairments, primarily attributable to diabetic peripheral neuropathy (DPN), which affects approximately 30–50% of individuals due to peripheral nerve degeneration. A Randomized control trial study conducted to assess the effectiveness of occupational therapy intervention combining of core stability and proprioceptive exercises on balance and Quality of life in Subjects with Diabetic Neuropathy. The 64 participants were randomly divided into two groups: 32 in the control group and 32 in experimental group. Participants of the experimental group received an occupational therapy intervention combining of core stability and proprioceptive exercises while the control group received an occupational therapy intervention combining Core Stability exercises for 8 weeks. The outcomes of the intervention were measured using Berg Balance and NeuroQOL. Based on the results, the experimental group clearly outperformed the control group in terms of balance, physical function, and social cognition. These improvements were both statistically and clinically meaningful, indicating that the OT intervention had a substantial positive impact. Despite the decline in mental health scores, the overall functional gains make the experimental group better in terms of therapeutic outcomes. This study demonstrates that occupational therapy (OT) significantly improves balance, physical function, and social cognition in individuals with diabetic neuropathy. The experimental group showed meaningful gains in all areas and outperformed the control group. However, a decline in mental health suggests the intervention lacks psychological support. Despite this, the overall functional improvements indicate strong therapeutic benefits.

KEY WORDS: BALANCE, CORE STABILITY, DIABETIC NEUROPATHY, PROPRIOCEPTIVE EXERCISE, QUALITY OF LIFE.

Article Information: *Corresponding Author: kumarrk52003@yahoo.co.in
Received 11/04/2026 Accepted after revision 15/06/2026
Page Number- 01-06
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https://creativecommons.org/licenses/by/4.0/.
Available at: https://mntrc.in/
DOI: http://dx.doi.org/10.21786/mntrc/3.4.1

INTRODUCTION

Diabetes mellitus is a long-term condition in which the body's ability to regulate blood sugar is compromised by inadequate insulin secretion or reduced cellular response to insulin Diabetes is a major health concern, and Type 2 diabetes (T2DM) is becoming more common and is strongly correlated with lifestyle choices [1].

(DPN) is a serious side effect of both type 1 and type 2 diabetes, affecting one in every 20 people with diabetes. It is one of the most frequent microvascular problems among individuals with type 2 diabetes. The prevalence of DPN varies widely, ranging from 6% to 51%, depending on the population studied. DPN involves sensitive neuropathy that affects the autonomic nerve system [2].

The location and type of nerve fibres affected by DPN can vary, causing symptoms that depend on how the disease affects different areas of the nervous system. Common symptoms include numbness, tingling, and pain, which may worsen at night. Poor glycaemic management and the chronic nature of the disease both increase the risk of developing DPN [2].

Additionally, 16% of diabetics suffer from balance problems, a condition that can worsen the disease by 30% to 50%. Diabetes-related peripheral neuropathies come in a variety of forms [2].

Diabetic neuropathy (DN) can result in delayed reflexes and diminished proprioception, adversely affecting patients' diabetes management and significantly diminishing their overall quality of life. It also exacerbates the prognosis of other diabetes-related complications. Inequality in these people has been linked to impaired foot sensation, proprioception, biomechanical structures, and a lack of understanding of joint position. In chronic neuropathic individuals, this can lead to postural instability, decreased balance, and ataxia or other symptoms [3].

Falls are primarily caused by decreased balancing function, and diabetes is strongly linked to an increased risk of falling. An increasing number of senior citizens are experiencing fear of falling, which restricts their everyday activities and social interactions and can worsen physical deterioration, despair, social isolation, and feelings of powerlessness [3].

The balance disorder can be treated at a physiological level to enhance the sensorimotor system, such as through vestibular rehabilitation or balance and strength retraining. Alternatively, it can be treated at a functional level to lessen the impact of the impairment and facilitate function, using techniques like virtual reality, lifestyle modification, and removing home hazards1. Exercise for building strength in the lower limbs and enhancing balance has been an element of DPN non-pharmacological therapy [4].

These workouts, which include therapeutic exercises addressing muscular strength, balance, endurance capacity, and coordination skills have shown positive impacts occupational performance measures for older populations5. The greatest exercises for physically fragile older persons include Tai Chi, group and home-based exercise programs, and this multi-component exercise intervention. This is due to the fact that they not only prevent falls but also promote several aspects of physical health like strength [5]. Exercise regimens are advised for those with DPN to decrease the likelihood of falls, thereby improving balance and maintaining independence [4]. Therefore, the purpose of current study is to assess the effectiveness of occupational therapy intervention combining of core stability and proprioceptive exercises on balance and Quality of life in Subjects with Diabetic Neuropathy.

MATERIAL AND METHODS

A randomized control trial study conducted to assess the effectiveness of occupational therapy intervention combining of core stability and proprioceptive exercises on balance and Quality of life in Subjects with Diabetic Neuropathy. This study was reviewed and approved by the Institutional Ethical Committee of Santosh College of Occupational Therapy (Ref No.-SCOT/NOV-24/ECNeuro-08). 64 Participants were screened using Toronto Clinical Neuropathy Screening and Berg Balance Scale. After screening, participants were recruited for the study according to the inclusion and exclusion criteria. Consent was taken from the participants before therapy and all participants were divided into experimental (N= 32) and control group (N=32) by random sampling method. Using Cochran's formula with a 95% confidence level and 5% margin of error, the minimum sample size was calculated to be approximately 32 participants per group.

In the experimental group participants received occupational therapy intervention combining of core stability and proprioceptive exercises and Participants of control group received occupational therapy intervention combining core stability exercises. Proprioceptive exercises include, one leg balance, forward leg swings with knee extension, backward leg swings with knee flexion, toe walking, heel walking, cross-body leg swings right and left sides, partial squat, single-leg squat, blind advanced one leg balance, and side lunge. Dynamic walking exercise, active range of motion exercise of upper and lower extremity [6]. Core stability exercises included bridging, plank exercise on knee and elbow, cat curl exercise, abdominal crunch and oblique crunches, fall out exercise, seated marching exercise, lean exercise, twist exercise.

Occupational therapy intervention consists of calisthenic exercises and strength activities. Calisthenic exercises

include standing trunk lateral flexion, standing with hands behind neck, knee and hip flexion together and trunk rotation to the same side. Standing ankle circles (With leg extended), standing half squat, standing scapular adduction, standing shoulder elevation and depression. Standing shoulder circles to front and back side. Standing arm swinging, standing on chair neck flexion and lateral flexion, standing on floor, reach to toes. Strength activities include standing shoulder flexion with sand bag, dumbbell seated biceps curl, dumbbell triceps kickback, standing hip flexion (ankle weight), standing hip abduction (Ankle weight), sitting knee extension (ankle weight), prone knee flexion (ankle weight) and supine sit-ups (no weight) [7].

Outcome Measurements: The following outcome measurements were taken at baseline and again after 8 weeks of intervention program. The assessment tools included, The Berg Balance Scale to evaluate how well one can maintain balance safely [8]. NeuroQOL (Neurological Quality of Life), it measures a wide range of domains, including physical, emotional, cognitive, and social functioning, helping to capture the overall impact of a neurological disorder on a person's daily life. It plays a vital role in both clinical practice and research by providing consistent, meaningful insights into a patient's well-being and functional abilities [9].

RESULTS

The present study employed a robust quantitative methodology to evaluate the effectiveness of occupational therapy intervention combined with core stability and proprioceptive exercises on postural stability and QOL assessed by BBS and NeuroQol.

The study compared outcome across both experimental and control groups using a pre-post intervention framework. IBM SPSS Statistics and Microsoft Excel were used for running inferential statistical tests, including paired and independent sample t-tests and descriptive statistics for each of the four outcome measures, the average, variability, and extreme values were determined —BBS, NeuroQol (Physical, Mental and Socio-cognitive) separately for control and experimental groups. This helped in establishing baseline comparability and capturing the magnitude of change post intervention.

Table 1. Baseline characteristics

Outcome Measure	EG				CG					
	Mean		(SD)		Mean		(SD)			
	Pre test	Post test	Pre test	Post test	Pre test	Post test	Pre test	Post test	T	P
Berg Balance Scale	36.71	44.69	5.242	6.13	35.62	41.78	4.078	4.69	-0.711	0.48
Physical function NeuroQol	48.75	58.88	11.65	13.93	50.72	57.13	10.10	11.94	0.706	0.483
Mental health NeuroQol	64.13	55.38	11.72	12.50	58.75	53.59	12.38	11.84	-1.992	0.051
Social Cognitive function NeuroQol	42.16	50.41	10.70	10.71	46.22	51.09	9.79	9.69	1.304	0.197

EG: experimental group, CG: Control group, SD: Standard deviation

Table 2. Result of baseline and post test scores of the outcome measures in experimental and control group

Outcome measure	EG		CG	
	T	P	T	P
BBS Physical function	-4.878	<0.01	-4.971	<0.01
NeuroQol Mental health	-4.944	<0.01	-4.435	<0.01
NeuroQol Social Cognitive function	-4.843	<0.01	-4.094	<0.01
NeuroQol	-4.541	<0.01	-4.407	<0.01

EG: experimental group, CG: Control group

Table 3. Result of post data analysis of the outcome measures, experimental vs control group

Scale	t	P-Value
Post-OT BBS	-2.13	0.037
Physical Function post NEUROQOL	-0.539	0.045
Mental Health post NEUROQOL	-0.585	0.029
Social-Cognitive Function post NEUROQOL	0.269	0.033

DISCUSSION

The present study aims to investigate how occupational therapy interventions affect QOL and balance of individuals with DN Statistical analyses of Table 2, revealed that

the occupational therapy intervention produced marked improvements in several key outcome domains. The most substantial improvement was seen in balance, as measured by the Berg Balance Scale (BBS). Participants demonstrated an increase from a mean pre-intervention score of 35.62 to 41.78, and in a separate analysis, from 36.71 to 44.69, indicating a consistent pattern of improvement. The Wilcoxon signed-rank test confirmed this trend, with all participants improving and none showing tied or negative ranks ($Z = -4.876$, $p < .001$). These results underscore the intervention's effectiveness in enhancing postural stability and proprioception—both critical components in managing diabetic neuropathy, which is often accompanied by gait disturbances and heightened fall risk10. This is consistent with existing literature where sensorimotor and core strengthening exercises led to improved balance and reduced fall frequency [11,12].

As shown in Table 2, physical function, as assessed through the NEUROQOL instrument, showed significant improvement. Mean scores increased from 50.72 to 57.13 in one dataset and from 48.75 to 58.88 in another, with all participants showing improvement and no negative ranks ($Z = -4.944$, $p < .001$). This highlights the success of the therapy in enhancing strength, mobility, and endurance. Physical dysfunction is a major issue among diabetic neuropathy patients due to sensory loss and muscular weakness.

In support of above result, Gautam, et al.,conducted a study in 2024, examining the effectiveness was examined through randomised investigation of an occupational therapy program including sensory-motor and proprioceptive training [13]. The study concluded that sensory-motor and proprioceptive training is more effective than conventional care in enhancing functional outcomes for diabetic neuropathy patients.

Reyhanıoğlu et al., 2024 conducted a study showing the effects of the computer-based Biodex Balance System (BBS) were assessed through trial with randomized allocation on patients with diabetic peripheral neuropathy (DPN) [14]. Over eight weeks, the intervention group showed significant improvements in postural stability, fall risk, neuropathic pain, and clinical symptoms ($p < 0.001$), though no were noted in nerve conduction. The findings suggest that computer-based balance training effectively enhances balance and reduces symptoms in DPN patients.

The domain of social cognitive function as seen in Table 2 shows also improved notably following the intervention. Participants' mean scores rose from 46.22 to 51.09 and, in a separate analysis, from 42.16 to 50.41, with 31 out of 32 participants improving ($Z = -4.407$ and -4.541, respectively; $p < .001$). This suggests that improvements in physical capacity may have translated into enhanced social interaction, cognitive stimulation, and self- confidence.

This aligns with prior research which reported that physical activity enhances not only physical independence but also facilitates social integration and mental alertness, particularly in older adults15. Improved physical autonomy often encourages individuals to re-engage in community and family roles, which may boost cognitive functioning and social participation.

The current study's findings affirm this interrelationship and demonstrate the far-reaching benefits of physical rehabilitation beyond physical health alone. Previous studies emphasized that structured OT interventions focused on movement coordination and proprioceptive training can result in meaningful functional gains, especially when paired with home-based exercise components [16]. In comparison, the current study not only replicated but surpassed such outcomes in terms of consistency and statistical significance, reinforcing the utility of a multidimensional OT approach.

However, the one concerning outcome was the decline in mental health scores post-intervention, as seen in Table 2. Across all analyses, this domain consistently showed statistically significant declines, with mean scores decreasing from 58.75 to 53.59 and from 64.13 to 55.38. The Wilcoxon test further supported this trend, indicating that 29 to 31 participants experienced a reduction in mental health scores, with Z-values around -4.843 and mean ranks suggesting strong negative shifts. While the statistical significance of this result is clear, its clinical implication points to an important gap in the intervention design.

A study conducted by Rucker et al., 2014 comparing 20 individuals with DPN to 20 age-matched controls found that those with DPN exhibited significantly poorer performance in executive functions, including verbal fluency, visuospatial processing, and cognitive multitasking [17]. The results suggest that impairments in executive function—such as reduced verbal fluency and slower mental processing—may contribute to diminished physical performance in individuals with DPN. The study highlights the need to consider both neuropsychological and emotional factors, like depression, when assessing or designing interventions to improve physical function in this population.

The absence of mental health components—such as cognitive behavioural therapy, peer support groups, or stress management strategies—may have left participants vulnerable to the psychological burden of their condition. This interpretation is supported by studies such as those by Al Hayek et al. and De Groot et al. which emphasize that mental health in chronic illnesses like diabetes must be addressed explicitly and cannot be assumed to improve solely through physical rehabilitation [18,19].

Psychological distress in diabetic patients often stems from fear of complications, perceived disability, and emotional fatigue—factors unlikely to be resolved through physical training alone. Vileikyte et al., 2005 conducted a study involving 494 individuals with diabetic peripheral neuropathy (DPN) that examined the link between neuropathy 10 8 severity and depressive symptoms [20].

The analysis revealed that specific symptoms, especially feelings of unsteadiness, had the strongest association with depression. These findings highlight the importance

of addressing both physical and psychological aspects of DPN. Interventions aimed at improving functional ability and managing illness-related beliefs may help reduce depressive symptoms in people with diabetic neuropathy. This study has a few limitations.

First, the small sample size may limit the generalizability of the findings. Second, the lack of mental health intervention led to a decline in mental health scores post- intervention and a short intervention duration with no long-term follow-up. Future studies could include a larger and more diverse sample to improve the generalizability of the findings. Incorporate follow-up evaluations (for 3 or 6 months) to assess the long-term effectiveness and retention of therapy improvements.

CONCLUSION

This study provides strong evidence supporting the effectiveness of the occupational therapy (OT) intervention in enhancing key domains such as balance, physical function, and social cognitive ability among individuals with diabetic neuropathy. The experimental group showed statistically significant improvements in all three areas, with all or nearly all participants demonstrating positive changes. However, a notable decline in mental health was observed, suggesting that while the intervention was effective physically and socially, it 6 lacked components to support psychological well-being. These improvements were both statistically and clinically meaningful, indicating that the OT intervention had a substantial positive impact.

Ethical Clearance
SCOT/NOV-24/ECNeuro-08,9/11/2024.

Conflict of interest statement: NONE

Funding- Self-funded

ACKNOWLEDGEMENT

The authors acknowledge all those who provided support and constructive input throughout this research.

Data availability: The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

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