

EFFECTS OF TASK-ORIENTED TRAINING WITH OR WITHOUT TEXTURED INSOLES ON BALANCE IN PATIENTS WITH PERIPHERAL DIABETIC NEUROPATHY: A RANDOMIZED CONTROLLED TRIAL

Ayesha Rashid^{*1}, Gulnaz Yamin², Maira Pervez³, Saadia Perwaiz⁴, Mubsirah Qamar⁵,
Muhammad Arslan⁶

¹MSNPT, Superior University

²Vice Principal, Central Park College of Allied Health Sciences

³Senior Lecturer, Ziauddin University

⁴Associate Professor, Akhtar Saeed Medical and Dental College

⁵Lecturer, Akhtar Saeed Medical and Dental College

⁶Physical Therapist, Ali Hospital, Shalamar, Lahore

¹aisharasheed905@gmail.com, ²gulnaz.yamin@cpmc.edu.pk, ³mairaqmc@gmail.com,
⁴s_perwaiz@yahoo.com, ⁵mubsirah@gmail.com, ⁶arslan0524477698@gmail.com

DOI: <https://doi.org/10.5281/zenodo.23053964>

Keywords

Diabetic peripheral neuropathy;
Task-oriented training; Textured
insoles; Balance; Functional mo-
bility.

Article History

Received: 23 June 2026

Accepted: 14 September 2026

Published: 30 September 2026

Copyright @Author

Corresponding Author: *

Ayesha Rashid

Abstract

Background: Peripheral diabetic neuropathy (DPN) is associated with reduced plantar sensation, proprioception, muscle function, balance and functional mobility, and with pain, functional limitation and falls. Task-oriented training improves task performance, but reduced sensory input from neuropathy may impair postural control. Textured insoles may improve plantar sensory feedback and enhance the benefits of rehabilitation.

Objective: To evaluate the effects of task-oriented training with and without textured insoles on balance, functional mobility and foot pain in patients with DPN.

Methods: A single-blind randomized controlled trial was conducted in adults with DPN. Twenty-eight participants were analyzed (14 per group): the Control group (Group A) received task-oriented training and the Experimental group (Group B) received the same training with textured insoles, for six weeks. Balance, functional mobility and foot pain were assessed at baseline and six weeks with the Berg Balance Scale (BBS), Timed Up and Go test (TUG) and Visual Analogue Scale (VAS), respectively. Within-group changes were tested with paired-samples t-tests (BBS, TUG) and the Wilcoxon signed-rank test (VAS); a two-way mixed ANOVA tested differences between groups over time.

Results: Both groups improved in BBS and TUG. BBS rose from 39.07 ± 3.65 to 44.00 ± 3.04 in Group A and from 37.93 ± 2.67 to 46.21 ± 2.94 in Group B, with a significant Time $\times$ Group interaction, $F(1,26) = 54.285$, $p < 0.001$. TUG fell from 13.03 ± 1.95 to 11.30 ± 1.65 s in Group A and from 13.79 ± 2.64 to 10.86 ± 2.54 s in Group B; the interaction was not significant, $F(1,26) = 2.396$, $p = 0.134$, partial $\eta^2 = 0.084$. VAS pain decreased significantly in both groups, with a lower post-intervention score in Group B ($p < 0.001$).

Conclusion: Task-oriented training improved balance, functional mobility and pain in people with DPN. Adding textured insoles gave an additional

benefit for balance and pain, but not for functional mobility, and may be a useful supplement to task-oriented rehabilitation.

Introduction

Diabetic peripheral neuropathy (DPN) is a frequent chronic complication of diabetes, affecting up to 30–50% of individuals with the disease [1]. Its symptoms include numbness, tingling, and shooting or stabbing pain [2]. It involves sensory, motor and autonomic nerve fiber dysfunction, most commonly as distal symmetric polyneuropathy [3]. Axonal degeneration and segmental demyelination of the peripheral sensory and motor nerves [4] lead to impaired sensation and loss of muscle morphology and function [5]. Loss of protective sensation and proprioception makes it difficult to control posture during walking, turning and weight shifting [6], and about 30% of patients report muscle weakness, reduced ankle reflexes, and impaired balance, coordination and gait control [7]. Vestibular and somatosensory deficits worsen this, and many patients rely on compensatory strategies to stand steadily [8].

Impaired balance is one of the most frequent problems in DPN. Patients show greater postural sway, poorer dynamic balance and unsteady gait, which increase their risk of falls [9, 10]. Balance training improves one-leg stance, postural sway, Timed Up and Go (TUG) and Berg Balance Scale (BBS) performance; although the quality of evidence is generally low and optimal training parameters are not established [11]. Balance is poorer in DPN than in diabetics without neuropathy and is assessed with standardized measures such as the BBS and TUG [12].

Footwear and insole interventions are well documented in the management of plantar pressure in DPN. High plantar pressure, especially at the metatarsal heads, is an important cause of foot pain, restricted movement and ulceration [13], and therapeutic insoles can offload these areas [14]. Insoles can also alter plantar sensory information, which is commonly damaged in DPN [15]. Textured insoles add raised nodules that activate plantar mechanoreceptors and may enhance sensory feedback, postural stability and walking confidence [16]; insole texture or vibration may

therefore improve sensory feedback, muscle activity and postural control in DPN [17].

Because balance impairment in DPN is multifactorial, combining motor and sensory interventions may provide greater benefit. Sensory stimulation approaches include kinesiotaping, electrical stimulation, plantar massage, rough or textured surfaces, vibration and modified footwear, and textured insoles are among the most researched [18]. Task-oriented training (motor) and textured insoles (sensory) address balance in different ways, but they have been studied as separate interventions, and to our knowledge their combination has not been investigated. This study therefore evaluate the effects of task-oriented training with and without textured insoles on balance, functional mobility and foot pain in patients with DPN, to provide evidence for a simple, inexpensive and clinically applicable intervention strategy.

Materials and Methods

Study Design and Setting

This was a single-blind, two-arm, parallel-group randomized controlled trial conducted at Akhtar Saeed Trust Hospital (EME) and Farooq Hospital (Westwood branch), Lahore. The study was completed over six months following approval of the synopsis.

Participants and Sample Size

The sample size was calculated with G*Power for an independent-samples t-test (two-tailed) comparing two groups [19]. The effect size was based on previous data, in which the exercise group (2.4 ± 1.9) and the control group (4.6 ± 2.5) gave a large effect size ($d = 0.99$). With a significance level of 0.05, power of 80% and a 1:1 allocation ratio, the minimum sample was about 28 participants (14 per group). This was inflated by an estimated 15% dropout rate, giving a final sample of 32 participants [20]. Participants diagnosed pre-diagnosed with diabetic neuropathy due to type 2 diabetes mellitus aging 30-75 years old [21] regardless of gender and who were able to walk independently with willing to wear insoles. Participants that were suffering from any

neurological condition other than peripheral diabetic neuropathy. Foot ulcers, structural deformities in lower limbs, used medication that affect balance, or musculoskeletal disorder that affected balance were excluded.

Randomization and Blinding

After baseline assessment, participants were randomly allocated 1:1 to two groups using a computer-generated random number sequence prepared by an independent researcher. Outcome assessment was carried out by a blinded assessor, and written informed consent was obtained before participation. The study was approved by the institutional Research Ethical Committee.

Outcome Measures

Balance, the primary outcome, was assessed with the BBS, a 14-task scale scored 0–4 per task that quantifies functional balance and fall risk (41–56 low risk, 21–40 moderate risk, 0–20 high risk; ICC > 0.96). Functional mobility and fall risk were assessed with the TUG, recorded in seconds. Foot pain, the secondary outcome, was measured with a 10-cm Visual Analogue Scale (VAS), where 0 indicates no pain and 10 the worst imaginable pain. The Michigan Neuropathy Screening Instrument (MNSI), comprising a patient-reported questionnaire and a physical examination, was used at baseline to characterize neuropathy and was not an outcome measure. Demographic and clinical data (age, sex, duration of illness and comorbidities) were also recorded. All assessments were made at baseline and after six weeks by a single experienced physiotherapist.

Intervention Protocol

Group A (control): participants received structured task-oriented training in their regular footwear, comprising sit-to-stand training, tandem standing, obstacle walking, step-up and step-down training, weight-shifting training, single-leg standing, walking training and reaching activities.

Group B (experimental): participants received the same task-oriented training, with the same

frequency, duration and supervision, and additionally wore textured insoles in their normal shoes. The insoles were custom-made, full-length, and made of flexible green EVA/silicone, with evenly spaced hemispherical nodules 3–5 mm high arranged in a regular grid across the whole plantar surface to provide continuous tactile stimulation during standing and walking. They were worn for 6 hours per day, 6 days per week, and the feet were inspected at each follow-up visit for irritation, redness, blisters or pressure marks.

Both groups trained for three to five supervised sessions per week, each lasting 30–40 minutes, for six weeks.

Statistical Analysis

Data were analyzed using SPSS version 27. Continuous variables were summarized as means and standard deviations and categorical variables as frequencies and percentages. Normality was assessed with the Shapiro-Wilk test. BBS and TUG were normally distributed in both groups at both time points (all $p > 0.05$), whereas VAS was not (Group B $p = 0.002$ pre- and $p < 0.001$ post-intervention; Group A $p = 0.040$ pre-intervention). Within-group changes were therefore tested with paired-samples t -tests for BBS and TUG and the Wilcoxon signed-rank test for VAS. Between-group post-intervention differences were tested with independent-samples t -tests (BBS, TUG) and the Mann-Whitney U test (VAS). A two-way mixed ANOVA (Time $\times$ Group) compared change over time in BBS and TUG. Statistical significance was set at $p < 0.05$.

Results

Twenty-eight participants, 14 in each group, were included in the final analysis. The groups were comparable at baseline for age, duration of illness, neuropathy screening scores, BBS, TUG and VAS (Table 1). Mean age was 53.07 ± 4.84 years in Group A and 55.00 ± 6.49 years in Group B ($p = 0.381$).

Table 1. Baseline characteristics of participants

Characteristic	Group A: Task-oriented training (n=14)	Group B: Task-oriented training + textured insoles (n=14)
Age (years), mean $\pm$ SD (range)	53.07 $\pm$ 4.84 (43–60)	55.00 $\pm$ 6.49 (48–75)
Male, n (%)	8 (57.1%)	5 (35.7%)
Female, n (%)	6 (42.9%)	9 (64.3%)
Duration of illness (years), mean $\pm$ SD	6.02 $\pm$ 0.69	5.86 $\pm$ 0.92
MNSI physical assessment, mean $\pm$ SD	3.50 $\pm$ 1.14	3.68 $\pm$ 1.07
MNSI patient version, mean $\pm$ SD	9.29 $\pm$ 1.68	10.00 $\pm$ 1.36

After six weeks (Table 2), both groups had improved in balance, functional mobility and pain. BBS increased by 4.93 ± 1.27 points in Group A and by 8.29 ± 1.14 points in Group B, and TUG time decreased by 1.73 ± 1.19 s

and 2.93 ± 2.64 s, respectively. VAS pain fell from 4.64 ± 1.28 to 3.29 ± 0.99 in Group A and from 4.71 ± 0.83 to 1.29 ± 0.47 in Group B.

Table 2. Outcome measures at baseline and 6 weeks in both groups (mean $\pm$ SD)

Outcome	Group	Baseline	Week 6	Mean change	p-value
BBS (points)	Group A	39.07 $\pm$ 3.65	44.00 $\pm$ 3.04	+4.93 $\pm$ 1.27	<0.001
	Group B	37.93 $\pm$ 2.67	46.21 $\pm$ 2.94	+8.29 $\pm$ 1.14	<0.001
TUG (s)	Group A	13.03 $\pm$ 1.95	11.30 $\pm$ 1.65	−1.73 $\pm$ 1.19	<0.001
	Group B	13.79 $\pm$ 2.64	10.86 $\pm$ 2.54	−2.93 $\pm$ 2.64	0.001
VAS (0–10)	Group A	4.64 $\pm$ 1.28	3.29 $\pm$ 0.99	−1.35	0.003
	Group B	4.71 $\pm$ 0.83	1.29 $\pm$ 0.47	−3.42	<0.001

Note: Within-group p-values are from paired-samples t-tests (BBS, TUG) and the Wilcoxon signed-rank test (VAS).

At week 6 (Table 3), post-intervention BBS was numerically higher in Group B (46.21 ± 2.94) than in Group A (44.00 ± 3.04), but the difference was not statistically significant ($p = 0.061$). TUG time was likewise not significantly

different (11.30 ± 1.65 s in Group A vs 10.86 ± 2.54 s in Group B, $p = 0.589$). Post-intervention VAS pain was significantly lower in Group B ($p < 0.001$).

Table 3. Between-group comparison at week 6

Outcome	Group A: week 6	Group B: week 6	Between-group p-value
BBS	44.00 $\pm$ 3.04	46.21 $\pm$ 2.94	0.061
TUG (s)	11.30 $\pm$ 1.65	10.86 $\pm$ 2.54	0.589
VAS	3.29 $\pm$ 0.99	1.29 $\pm$ 0.47	<0.001

Note: Independent-samples t-test (BBS, TUG); Mann–Whitney U test (VAS).

A two-way mixed ANOVA (Table 4) showed a significant main effect of time on BBS ($F = 841.068$, $p < 0.001$, partial $\eta^2 = 0.970$) and insignificant main effect of group ($F = 0.218$, $p = 0.645$, partial $\eta^2 = 0.008$). Importantly, the Time $\times$ Group interaction was significant ($F = 54.285$, $p < 0.001$, partial $\eta^2 = 0.676$), indicating that BBS improved more in Group B

than in Group A. For TUG, the main effect of time was significant ($F = 36.083$, $p < 0.001$, partial $\eta^2 = 0.581$), but neither the group effect ($F = 0.044$, $p = 0.836$) nor the Time $\times$ Group interaction ($F = 2.396$, $p = 0.134$, partial $\eta^2 = 0.084$) was significant, indicating a similar improvement in both groups.

Table 4. Two-way mixed ANOVA for BBS and TUG

Outcome	Effect	df	F	p-value	Partial η^2
BBS	Time	1, 26	841.068	<0.001	0.970
	Time $\times$ Group	1, 26	54.285	<0.001	0.676
	Group	1, 26	0.218	0.645	0.008
TUG	Time	1, 26	36.083	<0.001	0.581
	Time $\times$ Group	1, 26	2.396	0.134	0.084
	Group	1, 26	0.044	0.836	0.002

The table 05 showed the estimated marginal means (95% CI) for BBS rose from 39.07 (37.32–40.83) to 44.00 (42.36–45.64) in Group

A, a gain of 4.93 points, and from 37.93 (36.17–39.69) to 46.21 (44.57–47.86) in Group B, a gain of 8.29 points.

Table 5: Estimated Marginal Means for BBS by Group and Time

Group	Time	Mean	Std. Error	95% CI Lower	95% CI Upper
Control	Pre-intervention	39.071	0.855	37.315	40.828
Control	Post-intervention	44.000	0.799	42.358	45.642
Treatment	Pre-intervention	37.929	0.855	36.172	39.685
Treatment	Post-intervention	46.214	0.799	44.572	47.857

Discussion

Both groups improved after six weeks of intervention, but the pattern differed between outcomes. Balance (BBS) improved in both groups, with a significantly greater improvement in the Experimental group (task-oriented training plus textured insoles), as shown by the significant Time $\times$ Group interaction. Functional mobility (TUG) also improved in both groups, but the interaction was not significant, so textured insoles added no measurable benefit for mobility. Foot pain (VAS) decreased in both groups, with a lower post-intervention score in the Experimental group.

The significant within-group improvements in BBS, TUG and pain in the Control group are consistent with earlier reports that task-oriented exercise improves activity-specific balance,

proprioception and lower-limb function in diabetic neuropathy [22,23]. Systematic reviews likewise show that exercise and balance training in DPN improves BBS, TUG, postural sway and one-leg stance performance [24,25]. Ghazal et al. found that patients given task-oriented training had better dynamic, anticipatory and reactive balance than those given traditional balance training [26]. The reduction in TUG time in our Control group (13.03 to 11.30 s) is in line with these findings.

The most important finding was the significant Time $\times$ Group interaction for BBS, indicating an added benefit of textured insoles on top of task-oriented training. This is biologically plausible, because DPN reduces plantar sensation, proprioception and postural responsiveness. Paton et al. reported that patients with DPN wearing textured insoles had

better static balance than those wearing plain smooth insoles [27]. Thenmozhi and Rajarajeswari found that adding sensory augmentation to targeted balance training improved postural control [28], which agrees with our results. Hatton et al. reported that four weeks of textured insoles significantly improved postural sway in DPN, with no significant between-group differences in gait-based measures [29]; this mirrors our finding of an added benefit for static balance but not for dynamic mobility on the TUG.

The findings also fit the view that multimodal rehabilitation may be superior to single-component training in DPN. A randomized study found that multisystem exercise (balance, proprioception, strength, reaction time) produced greater improvements than conventional exercise in BBS, TUG, walking speed and pain [30]. Sensory-based approaches such as vibration, plantar massage, kinesiotaping, vibromedical insoles and mechanical noise benefit balance and postural control, although there is no clear consensus on the superiority of one strategy [29]. Daily in-shoe mechanical stimulation increased vibration perception, mediolateral sway control and gait velocity in DPN [31], and acute vibrating insoles improved gait speed and postural balance, particularly when the whole plantar surface was stimulated, although some effects were small and of uncertain clinical significance [32]. Protocol work also suggests that footwear enhancing the plantar sensory environment, including textured insoles, may be a practical self-management strategy for balance and walking impairments in DPN [33, 34].

The TUG results need careful interpretation. Time was significant in both groups (Group A 13.03 to 11.30 s; Group B 13.79 to 10.86 s), but the Time $\times$ Group interaction was not ($F(1,26) = 2.396$, $p = 0.134$), so the improvement in mobility did not differ significantly between groups and cannot be attributed to the insoles. The combined intervention was therefore superior for balance but not for functional mobility during the study period. This may be because the TUG is a composite of sit-to-stand transfer, gait initiation, turning and gait speed, whereas the

BBS samples controlled balance tasks more directly.

Overall, task-oriented training improved balance, mobility and pain in patients with DPN, and adding textured insoles gave a further benefit for balance but not for TUG performance. This is consistent with previous evidence on exercise in DPN and on direct plantar sensory stimulation, and suggests that combined sensory-motor interventions may be more effective than simpler ones when balance is the target.

Limitations

This study has several limitations. The sample was small (28 analyzed participants) and recruited by convenience sampling, which may introduce selection bias and limits generalizability. Participants could not be blinded because they could see which insoles they wore, so performance bias is possible, and there was no smooth-insole or sham control to separate nonspecific effects from the effect of texture. The intervention lasted only six weeks with no long-term follow-up. Only BBS, TUG and VAS were measured; plantar pressure, postural sway, sensory function, gait parameters and fall incidence were not.

Clinical Implications

Textured insoles are inexpensive, require no specialized equipment, and can be added to a standard task-oriented programme to improve balance and reduce foot pain in patients with DPN. Because no additional benefit was shown for functional mobility, they should be regarded as a supplement to, rather than a replacement for, task-oriented training, and foot condition should be checked regularly during use.

Conclusion

This randomized controlled trial showed that task-oriented training significantly improved balance, functional mobility and foot pain in people with DPN. Adding textured insoles produced a significantly greater improvement in BBS, as reflected by the significant Time $\times$ Group interaction, suggesting that increased plantar sensory stimulation adds to the postural-control benefit of task-oriented

rehabilitation. Although TUG time decreased more in the Experimental group, the Time × Group interaction was not significant, so no additional benefit for functional mobility was demonstrated. Textured plantar stimulation is a potentially viable rehabilitation tool for people with DPN, but larger, long-term and methodologically robust studies are needed to confirm its clinical efficacy.

REFERENCES

- Perveen W, Ahsan H, Shahzad R, Fayyaz S, Zaif A, Paracha MA. Prevalence of peripheral neuropathy, amputation, and quality of life in patients with diabetes mellitus. *Scientific Reports*. 2024;14(1):14430.
- Krueger A. A systematic literature review on the benefits of biofeedback therapy as a treatment for diabetes mellitus induced chronic peripheral neuropathy. 2025.
- Strand N, Anderson MA, Attanti S, Gill B, Wie C, Dawodu A. Diabetic neuropathy: Pathophysiology review. *Current Pain and Headache Reports*. 2024;28(6):481-7.
- Reeves ND, Orlando G, Brown SJ. Sensory-motor mechanisms increasing falls risk in diabetic peripheral neuropathy. *Medicina*. 2021;57(5):457.
- Hicks CW, Selvin E. Epidemiology of peripheral neuropathy and lower extremity disease in diabetes. *Current Diabetes Reports*. 2019;19(10):86.
- Alam U, Riley DR, Jugdey RS, Azmi S, Rajbhandari S, D'Août K. Diabetic neuropathy and gait: A review. *Diabetes Therapy*. 2017;8(6):1253-64.
- Ahmad I, Hussain E, Singla D, Verma S, Ali K. Balance training in diabetic peripheral neuropathy: A narrative review. *JSM Diabetology and Management*. 2017;2(1):1002.
- Buetti B, Luxon LM. Vestibular involvement in peripheral neuropathy: A review. *International Journal of Audiology*. 2014;53(6):353-9.
- Thukral N, Kaur J, Malik M. A systematic review and meta-analysis on efficacy of exercise on posture and balance in patients suffering from diabetic neuropathy. *Current Diabetes Reviews*. 2021;17(3):332-44.
- Dixit S, Maiya A, Shasthry BA, Kumaran DS, Guddattu V. Postural sway in diabetic peripheral neuropathy among Indian elderly. *Indian Journal of Medical Research*. 2015;142(6):713.
- Køhler E, Dalgas U, Buhl CS, Brincks J. Content and effects of balance training in people with diabetic peripheral neuropathy: A systematic review and meta-analysis. *Physiotherapy Theory and Practice*. 2025;41(5):1083-94.
- Iliescu B, Herascu A, Gaita L, Avram VF, Timar B. Associations between diabetic neuropathy and balance impairments in patients with type 2 diabetes: A cross-sectional study. *Journal of Clinical Medicine*. 2025;14(23):1-17.
- Boulton AJM. Diabetic neuropathy and foot complications. *Handbook of Clinical Neurology*. 2014;126:97-107.
- Ahmed S, Barwick A, Butterworth P, Nancarrow S. Footwear and insole design features that reduce neuropathic plantar forefoot ulcer risk in people with diabetes: A systematic literature review. *Journal of Foot and Ankle Research*. 2020;13(1):1-13.
- Collings R, Freeman JA, Latour J, Vickery PJ, Glasser S, Lepesis V. INSoles To Ease Pressure (INSTEP) study: A multicentre, randomised controlled feasibility study to compare the effectiveness of a novel instant optimised insole with a standard insole for people with diabetic neuropathy: A study protocol. *BMJ Open*. 2019;9(3):e029185.
- Spolaor F, Guiotto A, Ciniglio A, Sawacha Z. The effect of custom insoles on muscle activity in diabetic individuals with neuropathy. *Applied Sciences*. 2023;13(4):2326.

- Alaee SJ, Barati K, Hajiaghahi B, Ghomian B, Moradi S, Poorpirali M. Immediate effect of textured insoles on the balance in patients with diabetic neuropathy. *Journal of Diabetes Investigation*. 2023;14(3):435-40.
- Grewal GS, Schwenk M, Lee-Eng J, Parvaneh S, Bharara M, Menzies RA. Sensor-based interactive balance training with visual joint movement feedback for improving postural stability in diabetics with peripheral neuropathy: A randomized controlled trial. *Gerontology*. 2015;61(6):567-74.
- Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the behavioral, biomedical, and social sciences. *Behavior Research Methods*. 2007;39(2):175-91.
- Title: Effects of Computer-based Balance Exercises on Balance, Pain, Clinical Presentation and Nerve Function in Patients With Diabetic Peripheral Neuropathy: A Randomized Controlled Study. *JMNI*. 2024;
- Parmar P, Rakholiya S. Effectiveness of Foam Texture Versus Sand Texture on Balance with Diabetic Polyneuropathy Patients: A Comparative Study. *Exec Ed*. 2020;11(7):659.
- Whaval KS, Satralkar A. Effectiveness of task oriented training on activity specific balance, proprioception and lower limb function in patients with diabetic neuropathy. *International Journal of Health Sciences and Research*. 2023;13(5):208-15.
- Salsabili H, Bahrpeyma F, Esteki A. The effects of Task-Oriented Motor Training on gait characteristics of patients with type 2 diabetes neuropathy. *J diabetes Metab Disord*. 2015;15(1):14
- Ma R, Xu S, Kang J, Liu X, Liu M. Exercise training and balance function in middle-aged and older adults with diabetic peripheral neuropathy: A GRADE-based systematic review and meta-analysis. *Frontiers in Public Health*. 2026;14:1756867.
- Alissa N, Shipper AG, Zilliox L, Westlake KP. A systematic review of the effect of physical rehabilitation on balance in people with diabetic peripheral neuropathy who are at risk of falling. *Clinical Interventions in Aging*. 2024;1325-39.
- Ghazal J, Malik AN, Amjad I. Task oriented training improves the balance outcome & reducing fall risk in diabetic population. *Pakistan Journal of Medical Sciences*. 2016;32(4):983.
- Paton J, Glasser S, Collings R, Marsden J. Getting the right balance: Insole design alters the static balance of people with diabetes and neuropathy. *Journal of Foot and Ankle Research*. 2016;9(1):40.
- Thenmozhi M, Rajarajeswari A. Augmented targeted training to improve balance in diabetic neuropathy patients. *International Research Journal of Multidisciplinary SCOPE*. 2024;5(4):1423-9.
- Hatton AL, Chatfield MD, Gane EM, Maharaj JN, Cattagni T, Burns J. The effects of wearing textured versus smooth shoe insoles for 4-weeks in people with diabetic peripheral neuropathy: A randomised controlled trial. *Disability and Rehabilitation*. 2025;47(3):751-61.
- Khurshid S, Saeed A, Kashif M, Nasreen A, Riaz H. Effects of multisystem exercises on balance, postural stability, mobility, walking speed, and pain in patients with diabetic peripheral neuropathy: A randomized controlled trial. *BMC Neuroscience*. 2025;26(1):16.
- Giri HS, Borkar P. Effects of sensory stimulation on balance and postural control in diabetic neuropathy: Systematic review. *International Journal of Research in Medical Sciences*. 2021;9(7):2090.

Kang GE, Zahiri M, Lepow B, Saleem N, Najafi B. The effect of daily use of plantar mechanical stimulation through micro-mobile foot compression device installed in shoe insoles on vibration perception, gait, and balance in people with diabetic peripheral neuropathy. *Journal of Diabetes Science and Technology*. 2019;13(5):847-56.

Orlando G, Brown S, Jude E, Bowling FL, Boulton AJM, Reeves ND. Acute effects of vibrating insoles on dynamic balance and gait quality in individuals with diabetic peripheral neuropathy: A randomized crossover study. *Diabetes Care*. 2024;47(6):1004-11.

Hatton AL, Gane EM, Maharaj JN, Burns J, Paton J, Kerr G. Textured shoe insoles to improve balance performance in adults with diabetic peripheral neuropathy: Study protocol for a randomised controlled trial. *BMJ Open*. 2019;9(7):e026240.

