

COMPARISON OF MULTISENSORY EXERCISE AND TIBIAL NERVE MOBILIZATION IN PATIENTS WITH TYPE 2 DIABETIC PERIPHERAL NEUROPATHY

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Abstract

Background: Diabetic peripheral neuropathy type 2 is a prevalent complication which cause nerve damage resulting in pain, poor balance, loss of sensation, and lower quality of life. Physiotherapy intervention such as multisensory exercise and tibial nerve mobilization is frequent and are proven to be effective.

Objective: To determine the comparison of multisensory exercise and tibial nerve mobilization in patients with Type 2 diabetic peripheral neuropathy.

Methods: A randomized controlled trial was conducted on 38 participants divided into two groups. Group A received Tibial nerve mobilization with conventional physical therapy and group B received Multisensory exercise training with conventional physical therapy. Both interventions will be given for 35 minutes 3 session per week for 4 weeks. Data was collected by visual analogue scale, berg balance scale and short form 12 questionnaire to assess pain, quality of life and balance,. Duration of the study was 6 months after the approval of synopsis. Data was analyzed by using SPSS 27.0.

Result: On analysis, the average age was 49.06 ± 6.18 years for Group A and 49.56 ± 6.67 years for Group B. Post-treatment, the Multisensory Exercise Group showed significantly greater improvements in pain (VAS: 3.00 ± 0.77 vs. 3.72 ± 0.90), balance (BBS: 44.72 ± 2.99 vs. 42.06 ± 2.77), physical health-related quality of life (SF-12 PCS: 61.39 ± 5.40 vs. 55.50 ± 6.40), and mental health-related quality of life (SF-12 MCS: 63.06 ± 3.95 vs. 59.22 ± 3.30) in comparison with the Tibial Nerve Mobilization Group ($p < 0.05$).

Conclusion: Based on these findings, multisensory exercise was more effective than tibial nerve mobilization in reducing pain and improving balance and quality of life in patients with diabetic peripheral neuropathy.

Introduction:

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to insufficient insulin production or insulin resistance. The two major types are Type 1 diabetes, in which insulin production by the pancreas is severely reduced or absent, and Type 2 diabetes, in which the body develops insulin resistance. Approximately 15% of people with diabetes develop diabetic neuropathy during their lifetime, with recurrence occurring in a substantial proportion of affected individuals (1, 2) Diabetic Peripheral Neuropathy (DPN) is a common complication of prolonged and poorly controlled diabetes. Chronic hyperglycaemia damages peripheral nerves, particularly those supplying the lower limbs and feet. Factors such as overweight or obesity, smoking, hypertension, kidney disease, and a history of foot infection or ulcers can further increase the risk and severity of DPN (3, 4) DPN often develops gradually and may remain unnoticed because of reduced pain sensation. Common symptoms include numbness, tingling, burning or sharp pain, muscle weakness, and loss of sensation in the hands and feet. As the condition progresses, patients may experience impaired balance and difficulty walking, increasing the risk of unnoticed injuries, infections, and foot deformities (5) In severe cases, DPN can significantly affect quality of life and result in physical, emotional, and financial difficulties. Advanced nerve damage and associated infections may lead to disability or, in extreme cases, amputation. The pathophysiology of DPN involves metabolic, vascular, and inflammatory mechanisms associated with chronic hyperglycaemia. Oxidative stress can damage the blood vessels supplying peripheral nerves, reducing oxygen and nutrient delivery and contributing to nerve injury (6, 7) Chronic hyperglycaemia also disrupts nerve metabolism and contributes to nerve fibre and myelin degeneration, resulting in impaired nerve conduction, sensation, and motor control. In addition, inflammation and impaired immune function may reduce the body's ability to repair damaged nerve tissue, accelerating the progression

of DPN (8) Management of DPN focuses on controlling blood glucose levels, reducing symptoms, and preventing complications. Good glycaemic control can slow the progression of nerve damage, while medications such as anticonvulsants and antidepressants may be used to manage neuropathic pain. Lifestyle modifications, including weight management, smoking cessation, and regular exercise, are also important components of treatment (9, 10)

Foot care is particularly important because reduced sensation increases the risk of unnoticed trauma and infection. Along with conventional management, physiotherapy has emerged as a useful approach for improving functional outcomes in patients with DPN. Physiotherapy interventions may include tibial nerve mobilization and multisensory exercise training to improve nerve function, sensory input, balance, and foot function (11) Tibial nerve mobilization involves specific manual techniques designed to stimulate and mobilize the tibial nerve, which contributes to sensation and movement of the foot. It may help reduce nerve-related pain and discomfort and improve nerve function and lower-limb mobility (12) Multisensory exercise training incorporates activities targeting touch, proprioception, balance, strength, coordination, and functional movement. By improving sensory and motor control, these exercises may enhance foot function, balance, and movement control while reducing the risk of injury. Combining sensory and motor training may therefore provide a useful physiotherapy approach for improving foot health and functional performance in patients with DPN (13).

Material and methods

The study was conducted as a randomized clinical trial (RCT) at PulseCore Physio & Rehab Centre, Lahore, Pakistan. The study duration was six months, from March to August 2026, following approval of the synopsis. A sample size of 34 participants was calculated using G*Power, with the Berg Balance Scale (BBS) as the outcome measure and a power of 0.95. After adding a 10% attrition rate, the final sample size was 38

participants, with 19 participants allocated to each group. Non-probability convenience sampling was used for participant recruitment. (30) **Inclusion Criteria were:** Adults aged 40–60 years (30), Diagnosed Type 2 Diabetes Mellitus based on clinical and laboratory tests (30), Physician-diagnosed subclinical diabetic neuropathy, Moderately disturbed balance with a BBS score of 21–40, Both male and female participants (30), Poor glycemic control: HbA1c $\geq 7.5\%$, fasting blood glucose ≥ 130 mg/dl, or random blood glucose ≥ 200 mg/dl (30), No cognitive impairment affecting participation (31), Diabetes duration of less than 10 years (30), Severe diabetic neuropathy with a Toronto Clinical Neuropathy Score < 12 (31), Ability to perform exercises and participate in physiotherapy sessions (31), No history of amputation above the metatarsophalangeal joint (31). **Exclusion Criteria were:** Other systemic diseases, such as autoimmune diseases or rheumatoid arthritis (31), Grade 2 or higher foot ulcers according to the Wagner Ulcer Classification (31), Recent fractures or trauma causing nerve injury within the last year, Neurological disorders such as Parkinson's disease, stroke, multiple sclerosis, or neuropathy due to other causes (31), Visual or cognitive impairments affecting participation (19), Recent vascular complications, lower-limb surgery within the previous six months, or amputation above the metatarsophalangeal joint (31), Leprosy or any skin disease (31), Pregnancy or unwillingness to participate (32). Participants were randomly allocated into two groups, Group A and Group B, using a lottery method. Small slips containing the group assignments were placed in a ballot box, and each participant selected one slip to determine their group. A total of 36 participants were allocated equally, with 18 participants in each group. The study followed a single-blinded randomized controlled trial design, in which the outcome assessor was unaware of the participants' group allocation to reduce assessment bias.

Intervention

After obtaining informed consent, participants were selected according to the predefined

inclusion criteria and randomly allocated into two groups. Group A received multisensory exercise training along with conventional physiotherapy, while Group B received tibial nerve mobilization along with the same conventional physiotherapy. The intervention was provided three times per week for four weeks, and assessments were conducted at baseline and after completion of the intervention.

Both groups received 15 minutes of conventional physiotherapy before the main intervention. This included 5 minutes of TENS using a pulse duration of 150 μ s and a frequency of 80 Hz, with electrodes placed over the affected foot for pain relief and nerve stimulation (36). This was followed by 5 minutes of active ankle range-of-motion exercises, including 10 repetitions each of dorsiflexion, plantarflexion, inversion, and eversion to maintain ankle mobility and reduce stiffness (37). Stretching exercises were also included as part of the conventional physiotherapy protocol.

Participants in Group A received multisensory exercise training in addition to conventional physiotherapy. The training included warm-up activities, visual exercises, somatosensory training, and proprioceptive and vestibular exercises. Warm-up activities included ankle movements, inversion and eversion, short-distance walking, and calf and hamstring stretching. Visual exercises included visual-motor coordination, eye tracking, and visual attention activities. Somatosensory training involved walking on different surfaces, including flat surfaces, mattresses, and foam rubber, to improve tactile feedback and sensory awareness. Proprioceptive and vestibular exercises included single-leg stance, tandem stance, tandem walking, multidirectional walking, and obstacle navigation to improve balance, coordination, proprioception, and functional mobility (38).

Participants in Group B received tibial nerve mobilization along with conventional physiotherapy. The intervention consisted of remote sliders, local sliders, and tensioner techniques. Remote sliders were performed in supine lying with hip flexion, knee extension, and ankle dorsiflexion with eversion, combined with

cervical movements to facilitate neural excursion. Local sliders focused on distal tibial nerve movement through alternating ankle dorsiflexion with eversion and plantarflexion with inversion while maintaining the hip and cervical spine in a neutral position. Tensioner techniques involved progressive hip flexion, knee extension, ankle dorsiflexion with eversion, and cervical flexion to increase neural tension, followed by plantarflexion and cervical extension for release (39).

Both groups received their respective interventions three times per week for four weeks. Each treatment session lasted approximately 45 minutes, consisting of 15 minutes of conventional physiotherapy and the assigned main intervention. Outcome assessments were performed at baseline (Week 0) and after completion of the four-week intervention (40).

Outcome measures

Pain was assessed using the Visual Analogue Scale (VAS), a subjective measure used to determine pain severity on an 11-point numerical scale ranging from 0 to 10, where 0 represents no pain and 10 represents the worst possible pain (23, 24). Balance was defined as the ability to maintain the body's center of gravity within the base of support and involves visual input, perception, neuromuscular control, musculoskeletal strength, and the vestibular system (25). The Berg Balance Scale (BBS) was used to assess both static and dynamic balance during sitting and standing. It consists of 14 functional balance items, with each

item scored on a 5-point ordinal scale. The total score is obtained by summing all items, and the BBS has demonstrated high reliability (0.98) and good validity (0.96) (26, 27). Quality of life was assessed using the SF-12 questionnaire, a 12-item health-related quality-of-life measure covering physical and mental health domains. Scores range from 0 to 100 for both physical and mental health components, with higher scores indicating better health-related quality of life. The SF-12 has demonstrated good reliability (0.910) and validity (0.812) (28,29).

Sample size and ethical consideration

A sample size of 34 participants was calculated using G*Power, with the Berg Balance Scale (BBS) as the outcome measure and a power of 0.95. After adding a 10% attrition rate, the final sample size was 38 participants, with 19 participants allocated to each group. The research was conducted in accordance with the ethical guidelines of the Superior University Ethical Committee, and the rights and privacy of all participants were respected. Written informed consent was obtained from all participants before data collection. Participant information and collected data were kept confidential, and anonymity was maintained throughout the study. Participants were informed about the study procedure, their voluntary participation, and their right to withdraw at any time without any consequences. Every effort was made to protect their privacy, and no identifying information was disclosed in any publication resulting from the study.

Results

Table 1: Independent Sample T test for Balance (BBS) Pre and Post Treatment

Treatment	Groups	Mean± SD	Mean Difference	T value	p-value	Cohen d
BBS Pre-Treatment	Multisensory exercise group	35.11±2.72	.2222	.274	.786	.091
	Tibial nerve mobilization group	34.89±2.11				
BBS Post-Treatment	Multisensory exercise group	44.72±2.99	2.667	2.775	.009	.925
	Tibial nerve mobilization group	42.06±2.77				

Results showed no significant difference in BBS scores at baseline between the Multisensory Exercise Group and the Tibial Nerve Mobilization Group ($p = 0.786$). However, a significant post-treatment difference was observed, with Group A

(44.72 ± 2.99) demonstrating greater improvement in balance than Group B (42.06 ± 2.77) ($p = 0.009$) which indicates more effectiveness of the intervention in Group A.

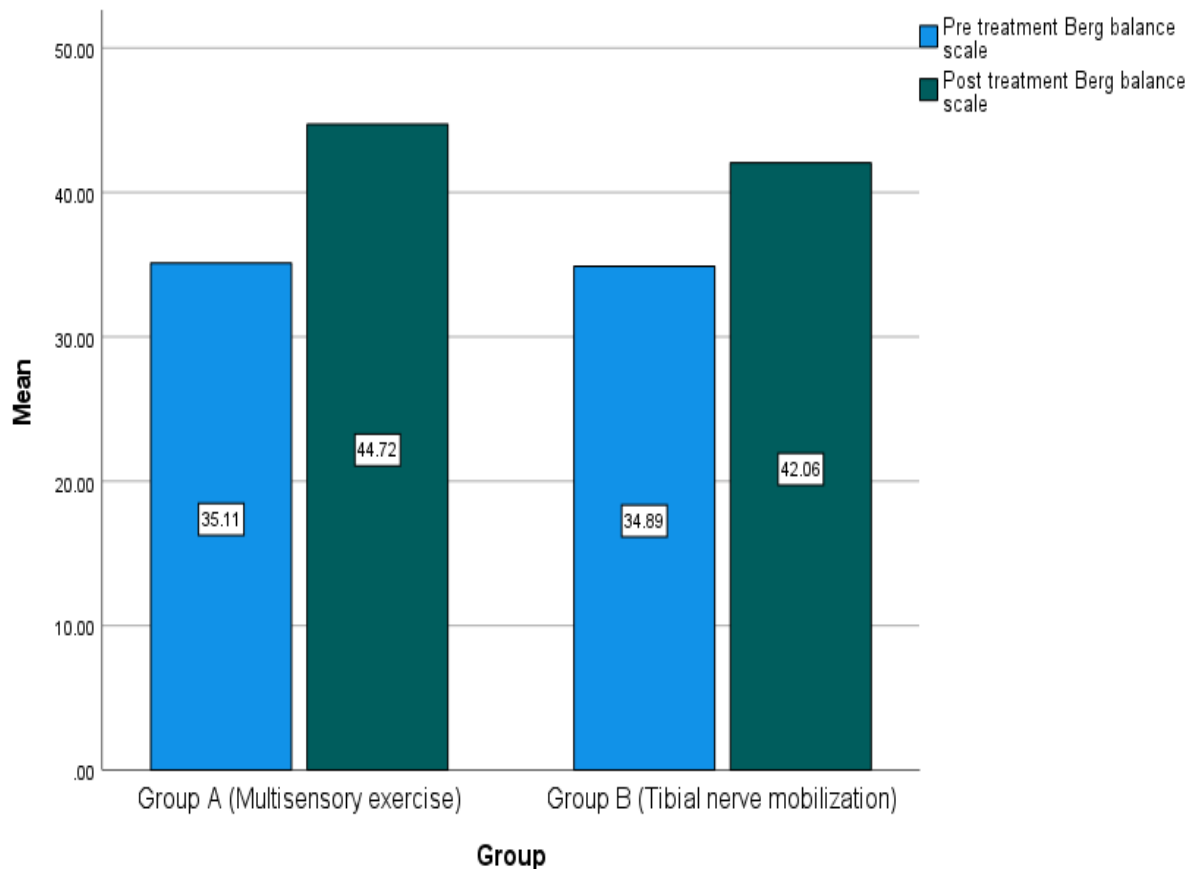


Figure 1: Bar Chart of the effect of Treatment on Balance

Figure 7: It was seen that group A was more effective in improving balance with value of 44.72

in group A and 42.06 in group B after the intervention ($P < 0.05$).

Table 2: Independent Sample T test for Quality of life (SF-12) Pre and Post Treatment

Treatment	Groups	Mean± SD	Mean Difference	T value	p-value	Cohen d
SF-12 PCS Pre-Treatment	Multisensory exercise group	47.33±4.60	1.000	.573	.570	.191
	Tibial nerve mobilization group	46.33±5.80				
SF-12 PCS Post-Treatment	Multisensory exercise group	61.39±5.40	5.889	2.983	.005	.994
	Tibial nerve mobilization group	55.50±6.40				

SF-12 MCS Pre-Treatment	Multisensory exercise group	51.33±4.16	-.2778	-.217	.829	-.072
	Tibial nerve mobilization group	51.61±3.48				
SF-12 MCS Post-Treatment	Multisensory exercise group	63.06±3.95	3.833	3.161	.003	1.05
	Tibial nerve mobilization group	59.22±3.30				

Results showed no significant difference in SF-12 Physical Component Summary (PCS) scores at baseline between the Multisensory Exercise Group and the Tibial Nerve Mobilization Group ($p = 0.570$). However, a significant post-treatment difference was observed, with Group A (61.39 ± 5.40) demonstrating greater improvement in physical health-related quality of life than Group B (55.50 ± 6.40) ($p = 0.005$), indicating more

effectiveness in Group A. Similarly, no significant difference was found in SF-12 Mental Component Summary (MCS) scores at baseline between the two groups ($p = 0.829$). However, after treatment, Group A (63.06 ± 3.95) showed significantly greater improvement in mental health-related quality of life than Group B (59.22 ± 3.30) ($p = 0.003$) which shows that the intervention in Group A was more effective.

Table 3: Paired sample t test of pain, balance and quality of life in Group A

Tools	Group A (Multisensory exercise)		t-value	p-value
	Pre-Treatment	Post-Treatment		
	Mean ± S.D	Mean ± S.D		
VAS	5.78±1.11	3.00±.767	13.42	<0.05
BBS	35.11±2.72	44.72±2.99	-32.79	<0.05
SF-12 PCS	47.33±4.60	61.39±5.40	-22.93	<0.05
SF-12 MCS	51.33±4.16	63.06±3.95	-11.93	<0.05

Group A (multisensory exercise) showed statistically significant improvements in all measured outcomes following the intervention. The mean VAS score decreased from 5.78 ± 1.11 before treatment to 3.00 ± 0.77 after treatment ($t = 13.42$, $p < 0.05$), indicating a significant reduction in pain intensity. The BBS score increased from 35.11 ± 2.72 to 44.72 ± 2.99 ($t = -32.79$, $p < 0.05$), demonstrating a significant

improvement in balance. Similarly, the SF-12 Physical Component Summary score increased from 47.33 ± 4.60 to 61.39 ± 5.40 ($t = -22.93$, $p < 0.05$), while the Mental Component Summary score improved from 51.33 ± 4.16 to 63.06 ± 3.95 ($t = -11.93$, $p < 0.05$). These findings indicate that multisensory exercise significantly reduced pain and improved balance, physical health, and mental health following the intervention.

Table 4: Paired sample t test of pain, balance and quality of life in Group B

Tools	Group B (Tibial nerve mobilization)		t-value	p-value
	Pre-Treatment	Post-Treatment		
	Mean ± S.D	Mean ± S.D		
VAS	5.94±.802	3.72±.895	14.58	<0.05
BBS	34.89±2.11	42.06±2.77	-18.79	<0.05
SF-12 PCS	46.33±5.80	55.50±6.40	-23.51	<0.05
SF-12 MCS	51.61±3.48	59.22±3.30	-15.66	<0.05

Group B (tibial nerve mobilization) showed mean VAS score decreased from 5.94 ± 0.80 before treatment to 3.72 ± 0.90 after treatment ($t = 14.58$, $p < 0.05$), indicating a significant reduction in pain intensity. The BBS score increased from 34.89 ± 2.11 to 42.06 ± 2.77 ($t = -18.79$, $p < 0.05$) showed a significant improvement in balance. Similarly, the SF-12 Physical Component Summary score increased from 46.33 ± 5.80 to 55.50 ± 6.40 ($t = -23.51$, $p < 0.05$), while the SF-12 Mental Component Summary score improved from 51.61 ± 3.48 to 59.22 ± 3.30 ($t = -15.66$, $p < 0.05$). These findings indicate that tibial nerve mobilization significantly reduced pain and improved balance, physical health, and mental health following the intervention.

Discussion

The present study compared the effects of multisensory exercise and tibial nerve mobilization on pain intensity, balance, and health-related quality of life in patients with type 2 diabetic peripheral neuropathy. Both interventions produced improvements; however, multisensory exercise showed greater improvement across the assessed outcomes. This may be because multisensory training addresses sensory integration, postural control, movement confidence, functional mobility, and participation in daily activities.

The findings are consistent with the narrative review by Razieh Mofateh et al. (2023), which included seven studies involving 212 patients with diabetic peripheral neuropathy and reported that multisensory exercise improved balance control. Similarly, the present study demonstrated greater improvement in Berg Balance Scale scores in the multisensory exercise group. Multisensory training may improve the integration of visual, vestibular, and proprioceptive information during standing and movement. Unlike the review, which primarily focused on balance, the present study also assessed pain and health-related quality of life (38).

The findings also support the study by Bhumi Surati et al. (2024), which investigated

multisensory exercise in patients with diabetic neuropathy. Their intervention was performed three times per week for four weeks, similar to the present study, and showed improvement in balance. Although their study found limited effects on sensation, the improvement in balance suggests that patients may compensate for sensory deficits through visual and vestibular information. The present study further examined pain and quality of life and demonstrated improvements in these outcomes following multisensory exercise (13).

The present findings are also comparable with those of Sidra Khurshid et al. (2025), who reported significant improvements in balance, postural stability, functional mobility, walking speed, and pain following multisensory and motor-based exercise in individuals with diabetic peripheral neuropathy. Similar improvements in the present study may be related to enhanced proprioceptive processing, lower-limb strength, weight-shifting ability, stepping strategies, and functional confidence. However, Khurshid et al. used an eight-week intervention, whereas the present study used four weeks and additionally assessed physical and mental quality of life (30).

The findings regarding tibial nerve mobilization are consistent with Sharma et al. (2023), who reported improvements in vibration perception, balance, mobility, and gait following tibial nerve mobilization combined with balance and gait training in individuals with subclinical diabetic neuropathy. Neural mobilization may improve nerve mobility, reduce mechanosensitivity, enhance intraneural circulation, and support sensory and motor nerve function. The present study similarly demonstrated improvements in pain, balance, and quality of life following tibial nerve mobilization, although the improvements were greater with multisensory exercise (41).

The present findings also relate to the study by Madhu Goyat et al. (2022), who investigated tibial and common peroneal nerve mobilization and reported potential improvements in ankle range of motion and plantar pressure distribution following three sessions per week for four weeks.

Their findings suggest that neural mobilization may improve peripheral nerve function and ankle mobility. The present study supports the potential benefits of tibial nerve mobilization while extending the assessment to pain, functional balance, and quality of life (40).

Muhammad Azharuddin et al. (2026) reported that neural mobilization combined with resistance exercise improved tibial and sural nerve conduction, muscle activation, and muscular co-contraction in patients with diabetic peripheral neuropathy. These findings support the potential neurophysiological and muscular benefits of neural mobilization. The present study also found improvements following tibial nerve mobilization, although multisensory exercise produced greater improvements in the assessed outcomes. Unlike Azharuddin et al., who used an eight-week intervention and assessed nerve conduction and muscle activity, the present study evaluated pain, balance, and health-related quality of life over four weeks (42).

Overall, both multisensory exercise and tibial nerve mobilization demonstrated beneficial effects in patients with type 2 diabetic peripheral neuropathy. The greater improvements observed with multisensory exercise may be related to its combined focus on sensory integration, proprioception, balance, functional mobility, and postural control, along with potential benefits for pain and health-related quality of life (13,30,38).

The study had several limitations that may have influenced the treatment outcomes. Some participants missed treatment sessions due to transportation difficulties, personal commitments, medical appointments, and fluctuations in their health condition. Fatigue, pain severity, changes in blood glucose levels, and fear of falling may also have affected their performance during treatment and functional assessments. In addition, factors such as medication use, dietary habits, glycaemic control, sleep quality, physical activity, and home-based exercises were not strictly controlled. Participant adherence to instructions and activities performed outside supervised sessions could also not be completely monitored.

Future studies should consider flexible treatment schedules, transportation support, and regular reminders to improve participant adherence and reduce missed sessions. Objective neurological assessments, such as nerve-conduction studies, monofilament testing, vibration-perception testing, and electromyography, should be included to provide more comprehensive evaluation. Further research should also assess outcomes such as gait speed, muscle strength, proprioception, functional mobility, fall risk, plantar sensation, and activities of daily living. Multisensory exercise may also be incorporated into physiotherapy rehabilitation programs for patients with type 2 diabetic peripheral neuropathy to address balance, sensory, and functional impairments.

Conclusion

Based on the findings, both multisensory exercise and tibial nerve mobilization were effective in reducing pain and improving balance, physical health, and mental health-related quality of life in patients with diabetic peripheral neuropathy. However, multisensory exercise showed greater improvements across all measured outcomes compared with tibial nerve mobilization.

Declaration

Abbreviations

BBS:	Berg balance scale
PCS:	Physical Component Summary
MCS:	Mental Component Summary
SF-12:	Short Form Health Survey

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Institutional Ethics Committee of the University Institute of Physical Therapy, The University of Lahore, Lahore, Pakistan. The study was conducted in accordance with the ethical standards of the institutional research committee and with the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants before participation.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed in the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

I.H. and A.H. conceived and designed the study.

I.H., R.N., and I.A. were involved in data collection and participant recruitment.

M.A. assisted with clinical supervision and data organization.

R.N. performed the statistical analysis and interpreted the results.

O.K. and M.A.A. drafted the initial manuscript.

All authors critically reviewed the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

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