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Comparative Effects of Proprioceptive Training and Swiss Ball Exercises on Balance and Peripheral Neuropathy among Patients with Type 2 Diabetes Mellitus

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KEYWORDS

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DECLARATIONS

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ABSTRACT

Background: Type 2 diabetic patients may suffer from a condition called diabetic peripheral neuropathy, in which patients suffer from peripheral nerves. **Objective:** To evaluate the effects of Swiss ball training and proprioceptive training in patients with neuropathy due to peripheral nerve damage in diabetes mellitus. **Methodology:** A quasi-experimental study was carried out involving 30 individuals diagnosed with diabetic peripheral neuropathy. These participants were selected from the Medical Outpatient Department of the National Hospital Faisalabad and the Faisalabad Diabetic Centre. Only individuals between the ages of 45 and 65 years with a confirmed clinical diagnosis of type 2 diabetes mellitus, as verified using the Michigan neuropathy screening instrument, were included in the study. Those with rheumatoid arthritis, visual and vestibular impairments, non-diabetic peripheral neuropathy, osteoarthritis, uncontrolled high blood pressure, foot ulcers, tumors, fracture or dislocation, thyroid disorders, fibromyalgia or psychological disorders, history of surgery, neurological impairments, pregnant females, participants with uncontrolled diabetes or those having body mass index greater than 25 were excluded. Participants were selected using a non-probability purposive sampling method. Each intervention was carried out over a period of six weeks, with sessions held three times per week. The Michigan neuropathy screening instrument and the star excursion balance test were used as assessment tools. The independent sample t-test was applied to calculate the difference between the two groups and the paired sample t-test for within-group analysis. **Results:** Paired sample t-test results for the proprioceptive training group showed a significant improvement in both balance and neuropathy symptoms. ($p < 0.001$). Results from the paired sample t-test for the Swiss ball exercise group showed a statistically significant improvement ($p < 0.001$). The independent sample t-test revealed no significant difference in post-intervention neuropathy symptoms between the two groups ($p > 0.05$). However, a significant difference was in enhancing dynamic balance ($p < 0.05$), with proprioceptive training showing superior outcomes. **Conclusion:** The findings suggest proprioceptive training may reduce fall risk and improve functional stability, while Swiss ball exercises continue to be an effective option for managing neuropathic symptoms.

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INTRODUCTION

Diabetes mellitus is a disorder in which the body has difficulty using carbohydrates properly. The body faces a problem in managing sugar levels. The pancreas is the organ that is problematic in this condition, and it can not produce enough amount of insulin, or the body can not use the insulin produced by the pancreas appropriately. Insulin is a hormone that plays a major role in absorbing sugar in the body. Uncontrolled diabetes may cause major damage to the human body, affecting the kidneys, feet, eyes, and nerves.[1]The immune system of the human body damages the beta cells of the body, and as a result, they can not produce enough amount of insulin. An immune response that triggers the body's cells causes damage to beta cells. The precise cause of this reaction is unknown. Among all the types of diabetes, these cases are less than 15%. Unlike type 2 diabetes, which affects the adult population, type 1 diabetes affects individuals at a pubescent age.[2]

Gestational diabetes is a condition in which there is an increased level of blood sugar in the female body during pregnancy, and seven out of a hundred women are going through this condition during pregnancy. A woman can suffer from many problems in pregnancy, but gestational diabetes is most common, and if it is not successfully managed, it can cause potential danger to the mother and the neonate's health.[3] Type 2 diabetes mellitus is the most prevalent form of diabetes, characterised by insulin resistance and a gradual decline in beta cell function. It primarily affects adults, but its occurrence is increasing among younger individuals in Western countries, largely due to rising obesity rates and inactive lifestyles. Interestingly, in certain populations such as Asians, diabetes type 2 can develop even in individuals with a relatively lower body mass index compared to those in Western populations.

The clinical features of type 2 diabetes also vary across regions, reflecting significant differences in obesity rates and metabolic risk profiles. Additionally, research indicates that adults with diabetes are more likely to experience sarcopenia compared to those without the condition.[4] Diabetic neuropathy is a complex condition that can impact various regions of the nervous system. Its clinical presentation varies based on the specific nerve fibres and areas affected. The most prevalent form is distal symmetrical neuropathy, also known as diabetic polyneuropathy. This type is marked by impaired blood circulation and the gradual deterioration of nerve fibres, which leads to functional disruptions starting in the peripheral nerves and potentially progressing to more central regions.[5]

Proprioceptive system elements support movement and are very crucial for maintaining motor control. Overall, a good body balance is made up with the help of the eyes, inner ear and additional sensors of the body. When the body is moving sensory system of the body transfers the information about the movement and position of body parts. The elderly population need a very strong visual system to preserve stability, and if in case they have impaired input, then they suffer a decrease in steadiness. In old age, people have a decreased position sense related abilities, so the likelihood of falls increases. Training inculcating proprioceptive enhancement may lead to an increase in the sensory role.[6]

There are many exercise-based rehabilitation plans to increase steadiness and reduce the likelihood in patients who are affected by peripheral nerve damage due to diabetes. These rehabilitation plans typically include strength training, aerobic training, and approaches that focus on the balance of the body. A study was conducted, and it stated that rehabilitation programs that include strengthening of lower extremities proved to be the most effective approach to enhancing the balance of the individuals.[7]

The Swiss ball was used as a therapeutic approach to treat the sensory feedback and minimise the non-purposeful movements of the body, aimed to effectively enhance balance. When the participants were asked to sit on the Swiss ball and perturbations were given to them, they tried to maintain their body position and to stop themselves from falling, so it added to their stability. Intrinsic and extrinsic disturbances utilise the anticipatory control strategy to help out in the balance of the body.[8] Three components that add up to a well-controlled balance are the visual system, the hearing system body position sense system. A training protocol that is mainly focused on balance showed a very evident reduction in fall cases and improved a good quality of life. Engaging in balance-oriented training starts up the mechanoreceptors within the muscle spindles, joint capsules and tendons, thereby augmenting sensory output from the whole body and lower

extremity. Repeated and stable gait patterns, especially including ankle and knee, can help improve proprioceptive acuity and somatic awareness.[9]

Good balance control is achieved by the coordination of the body's sense of position, inner ear, and visual system. All these systems are very important for body motions, upright posture, and the preservation of joint integrity. Balance control depends mainly on the input from touch and body-position senses. When the sensory system of the body sends a message to the central nervous system of the body, disturbances may weaken the body's capability to adapt, and as a result, there is poor balance control. The rehabilitation approach may include walking, balance training, strength training and as well as stretching. Highly task-oriented training may improve balance in steady state as well as balance in motion.[8]

Exercise-based interventions show highly therapeutic benefits for people with peripheral nerve damage due to diabetes. A study included a healthy population has stated that many forms of physical training, including body vibrations as a whole, aerobic exercises regime and sensorimotor training, can positively influence the neuromuscular function and may offer similar benefits for those with peripheral nerve damage due to diabetes in the population with a diagnosed condition. These improvements include enhanced proprioception, better balance and fall prevention, decreased muscle loss, along with better control of glucose levels in blood, increased insulin sensitivity and improved lipid and blood pressure levels.[10]

It is important to assess how neuropathic symptoms start and how they progress over time. Distal symmetric polyneuropathy usually develops gradually and worsens slowly. Its symptoms appear suddenly or worsen rapidly, including distal symmetrical neuropathy. Polyneuropathy seems less likely. Alternative diagnoses like radiculoplexus or immune-related conditions like Gullian Barrie syndrome should be explored. Symptom presentations can differ significantly between individuals.[11]

Even when blood sugar levels are controlled, metabolic syndrome and its components can raise the risk of diabetic neuropathy. This highlights how factors like high cholesterol and obesity can damage the nerves of the peripheral nervous system. Yet, high glucose level is an important element; recent clinical and experimental studies highlight the distinct impact of metabolic syndrome and its elements, such as obesity, high blood lipids, and hypertension, as additional contributors to neuropathy, muscle weakness, atrophy, and abnormal walking patterns appear in advanced stages of neuropathy.[12]

This study was conducted to find the effects of Swiss ball training and proprioceptive training in patients with neuropathy due to peripheral nerve damage in diabetes mellitus.

METHODOLOGY

A quasi-experimental study was carried out involving 30 individuals diagnosed with diabetic peripheral neuropathy. These participants were selected from the Medical Outpatient Department of the National Hospital Faisalabad and the Faisalabad Diabetic Centre. Only individuals between the ages of 45 and 65 years who have a confirmed clinical diagnosis of type 2 diabetes mellitus, verified using the Michigan neuropathy screening instrument, were included in the study. Those with rheumatoid arthritis, impairments of visual and vestibular, flexion contracture of knee joint, non-diabetic peripheral neuropathy, osteoarthritis, uncontrolled high blood pressure, severe diabetes that leads to ulcers of feet or deformities of feet, lower limb impairment, tumors, fracture or dislocation, thyroid disorders, fibromyalgia or psychological disorders, history of surgery, neurological impairments like upper motor neuron lesions, stroke, spinal cord injuries, multiple sclerosis, parkinson disease or women who are pregnant, participants with uncontrolled diabetes or those having body mass index (BMI) greater than 25 were excluded.

Participants were selected using a non-probability purposive sampling method. Written informed consent was obtained from all individuals before inclusion in the study. They were then assigned to two different intervention groups. Each intervention was carried out over a period of six weeks, with sessions held three times per week. Every session consisted of a five-minute warm-up, thirty minutes of training structured as five-minute exercise intervals followed by one-minute rest periods, and concluded with a five-minute cool-down. At the beginning of the study, both groups also participated in weekly awareness lectures on diabetes management. The first group received

proprioceptive training, which was implemented in progressive phases. Exercises like toe walking and heel walking, single-legged squats, partial squats in the first phase, one leg balance, swinging leg forward while knee is in extension, swinging leg backwards while knee is in flexion in the second phase, while blindfolded, one leg balance and side lunges in the last stage.

The proprioceptive training regimen consisted of two sets, with each exercise repeated ten to fifteen times. The second group participated in a Swiss ball training program. While seated on the ball, participants practised maintaining balance and performed various active movements, including flexion, extension, abduction, and adduction of the upper extremities. They also engaged in trunk exercises such as rotation and forward bending, as well as heel and toe raises, resisting external forces, and shifting body weight. In the standing position, exercises included moving the ball up and down using both arms, guiding it along an oblique path, pushing it forward and backwards with the legs, moving it side to side with the lower limbs, and throwing the ball against a wall using the hands. Each Swiss ball exercise was performed for ten repetitions.

The Michigan neuropathy screening instrument and the star excursion balance test were used as assessment tools. The Michigan neuropathy screening instrument was divided into two components. The first section comprised fifteen questions focused on symptoms related to neuropathy in the lower limbs. The second section included physical assessments such as vibration sensation, reflex evaluation, and testing with a monofilament. A total score of two or higher is considered indicative of neuropathy. Elevated scores indicate more severe neuropathy symptoms, while a reduction in scores following the intervention suggests an improvement in those symptoms.

The star excursion balance test was conducted using the participant's dominant leg, with reach distances recorded in the anterior, posteromedial, and posterolateral directions. An increase in reach measurements following the intervention indicated enhanced dynamic balance. Ethical guidelines were strictly observed throughout the research. Statistical analysis was carried out using SPSS version 20. The independent sample t-test was applied to calculate the difference between the two groups and the paired sample t-test for within-group analysis. The p-value ≤0.005 was considered significant.

RESULTS

The analysis of demographic variables revealed that the average age in the proprioceptive training group was 57 years, with a standard deviation of 6.0. In comparison, the Swiss ball training group had a mean age of 57.6 years and a standard deviation of 4.3. Both groups experienced significant improvement in neuropathy symptoms and balance following their respective interventions. Paired sample t-test results for the proprioceptive training group showed a significant improvement in both balance and neuropathy symptoms during exercises such as toe walking, heel walking, single-leg squats, partial squats, one-leg balance, forward leg swings with extended knees, and backwards leg swings with flexed knees ($p<0.001$). These findings support the effectiveness of proprioceptive training in enhancing balance and managing peripheral neuropathy.

During the Swiss ball exercises, participants performed a range of active movements while seated on the ball. These included flexion, extension, abduction, and adduction of the upper limbs, as well as trunk rotation, forward bending, and heel and toe raises, performing upper and lower extremity exercises with a Swiss ball while standing. Results from the paired sample t test showed a statistically significant improvement ($p<0.001$).

The independent sample t-test revealed no significant difference in post-intervention neuropathy symptoms between the two groups ($p>0.05$). However, a significant difference was observed between the two therapies in terms of their effectiveness in enhancing dynamic balance ($p<0.05$), with proprioceptive training showing superior outcomes. These results emphasise the

Table 1: Characteristics of participants

Variables		Proprioceptive training group (n=15)	Swiss ball exercise group (n=15)
Age (years)		57.0±6.1	57.6±4.3
BMI (kg/m^2)		22.9±2.7	22.4±2.6
Gender	Male	9(60%)	9(60%)
	Female	6(40%)	6(40%)

Table 2: Paired sample t-test for within-group analysis

Variables		Proprioceptive training group			Swiss ball exercises group		
		Pre-treatment Mean±SD	Post-treatment Mean±SD	p-value	Pre-treatment Mean±SD	Post-treatment Mean±SD	p-value
MNSI	Part 1	7.51±1.45	5.45±1.46	0.001	7.39±1.34	6.13±1.31	0.001
	Part 2	7.06±1.68	5.13±1.36	0.001	6.34±1.45	5.14±1.34	0.001
SEBT anterior direction	Right limb	6.34±0.97	4.21±1.15	<0.001	6.65±0.91	5.61±0.83	<0.001
	Left limb	6.14±1.07	3.88±0.98	0.001	6.88±0.84	5.66±1.05	0.001
SEBT posteromedial direction	Right limb	7.88±0.92	5.54±0.65	0.001	7.89±0.92	6.41±0.83	0.001
	Left limb	7.68±0.98	5.46±0.65	0.001	8.01±0.92	6.48±0.82	0.001
SEBT posterolateral direction	Right limb	8.52±0.92	5.32±0.91	<0.001	8.32±0.73	6.88±0.98	0.001
	Left limb	8.41±0.83	5.61±1.23	0.001	8.32±0.91	6.88±0.98	0.001

Table 3: Independent t-test for between-groups analysis

Variables		Pre-treatment Mean±SD			Post-treatment Mean±SD		
		Proprioceptive training group	Swiss ball exercise group	p-value	Proprioceptive training group	Swiss ball exercise group	p-value
MNSI	Part 1	7.52±1.44	7.4±1.35	0.797	5.32±1.53	6.12±1.31	0.135
	Part 2	7.08±1.65	6.33±1.44	0.209	5.12±1.34	5.12±1.34	1.001
SEBT anterior direction	Right limb	6.33±0.96	6.67±0.91	0.339	4.21±1.15	5.61±0.83	0.001
	Left limb	6.13±1.06	6.87±0.84	0.044	3.86±0.98	5.68±1.05	0.001
SEBT posteromedial direction	Right limb	7.87±0.91	7.88±0.91	0.001	5.54±0.65	6.41±0.83	0.003
	Left limb	7.67±0.97	8.01±0.93	0.345	5.48±0.65	6.48±0.84	0.001
SEBT posterolateral direction	Right limb	8.53±0.91	8.33±0.72	0.512	5.32±0.91	6.88±0.98	0.001
	Left limb	8.40 ± 0.82	8.33 ± 0.91	0.834	5.61 ± 1.23	6.86 ± 0.99	<0.005

superior effectiveness of proprioceptive training in improving balance, which could contribute to a reduced risk of falls in this population. At the same time, Swiss ball exercises continue to be a suitable option for managing neuropathic symptoms. Consequently, including proprioceptive exercises in rehabilitation programs may provide additional benefits for enhancing functional stability in individuals with type 2 diabetes.

DISCUSSION

A study compared joint position sense training and physio ball exercises in individuals with non-insulin-dependent diabetes. Baseline and follow-up values are assessed by the star excursion balance test. Proprioceptive training significantly improved balance, while both interventions were similarly effective in reducing neuropathy symptoms. These results suggest that proprioceptive exercises may offer additional benefits in enhancing balance and preventing fallresults suggest that proprioceptive exercises may offer additional benefits in enhancing balance and preventing falls.

A 2025 study explored the effectiveness of a new 3-month proprioceptive rehabilitation program in improving the stability of posture among patients with diabetic peripheral neuropathy. A total of 112

respondents were randomly assigned to either the novel program or a standard balance and strength training regimen. Researchers assessed their sensory-integrated balance at the beginning and end of the trial. Results showed that those in the proprioceptive group experienced significant improvements, while the control group improved only when their eyes were open. Results clearly showed that proprioceptive training offers superior benefits than the placebo group.[13]

A 2024 study from India examined how Swiss ball exercises compared to wobble board routines in improving balance and mobility in individuals with diabetes induced neuropathy. Thirty participants were assessed using the balance scale and the timed up and go test. The Swiss ball group showed greater gains in stability. These findings suggest that Swiss ball training may be more effective in enhancing balance and reducing fall risk in neuropathy patients.[14]

A group of sixteen football players took part in a study exploring how a 2-month proprioceptive practice could affect their lower limb stability. Ventro-dorsal and mediolateral stability was assessed by the Biodex system. Those who trained just 10 minutes a day, five times a week, saw clear advancement in balance, especially in multiple directions by the end of the eighth week. But without continued training, their forward-backwards stability started to decline by week 16, while side-to-side control improved more. This shows that regular proprioceptive training can really boost balance, but staying consistent is key to keeping those gains.[15]

CONCLUSION

This study concludes that proprioceptive training shows significantly better improvement in dynamic balance when measured by the star excursion balance test. Both interventions are equally effective in managing neuropathic symptoms, based on the Michigan Neuropathy Screening Instrument. The findings suggest proprioceptive training may reduce fall risk and improve functional stability, while Swiss ball exercises continue to be an effective option for managing neuropathic symptoms.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.

Competing interests: None

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REFERENCES

1. Kumar R, Saha P, Kumar Y, Sahana S, Dubey A, Prakash O. A review on diabetes mellitus: type 1 & Type 2. World Journal of Pharmacy and Pharmaceutical Sciences 2020; 9(10): 838–50. https://doi.org/10.20959/wjpps202010-17336

2. Janež A, Guja C, Mitrakou A, et al. Insulin therapy in adults with type 1 diabetes mellitus: a narrative review. Diabetes Therapy 2020; 11(2): 387–409. https://doi.org/10.1007/s13300-019-00743-7

3. Modzelewski R, Stefanowicz-Rutkowska MM, Matuszewski W, Bandurska-Stankiewicz EM. Gestational diabetes mellitus—recent literature review. Journal of Clinical Medicine 2022; 11(19): 5736. https://doi.org/10.3390/jcm11195736

4. Gracia-Sánchez A, López-Pineda A, Nouni-García R, Zúnica-García S, Chicharro-Luna E, Gil-Guillén VF. Impact of Exercise Training in Patients with Diabetic Peripheral Neuropathy: An Umbrella Review. Sports Medicine Open 2025; 11(1): 75. https://doi.org/10.1186/s40798-025-00863-4

5. Heidari M, Zolaktaf V, Ghasemi G, Nejadian SL. Integrated exercise and glycemic and peripheral sensation control in diabetic neuropathy: A single-blind, randomised controlled trial. International Journal of Preventive Medicine 2021; 12: 169. https://doi.org/10.4103/ijpvm.IJPVM_306_20

6. Sluga SP, Kozinc Ž. Sensorimotor and proprioceptive exercise programs to improve balance in older adults: a systematic review with meta-analysis. European Journal of Translational Myology 2024; 34(1): 12010. https://doi.org/10.4081/ejtm.2024.12010

7. 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 Ageing 2024; 19:1325–39. https://doi.org/10.2147/CIA.S459492

8. Kanaganapalli HB, Mallikarjunaiah H, Kunduru S. Blindfolded balance training versus

Swiss ball exercises on static and dynamic balance in subjects with diabetic neuropathy. International Journal of Advanced Educational Research 2023; 8: 11–4.
9. Ghazavi N, Sadat S, Rostaei N. Effect of Proprioceptive Exercises on Lower Extremity Proprioception in Patients with Diabetic Neuropathy. Journal of Clinical Care and Skills 2021; 2(4): 201–5. https://doi.org/10.52547/jccs.2.4.201
10. Streckmann F, Balke M, Cavaletti G, et al. Exercise and neuropathy: systematic review with meta-analysis. Sports Medicine 2022; 52(5): 1043–65. https://doi.org/10.1007/s40279-021-01596-6
11. Oh J. Clinical spectrum and diagnosis of diabetic neuropathies. The Korean Journal of Internal Medicine 2020; 35(5): 1059-1069. https://doi.org/10.3904/kjim.2020.202
12. Elafros MA, Andersen H, Bennett DL, et al. Towards prevention of diabetic peripheral neuropathy: clinical presentation, pathogenesis, and new treatments. The Lancet Neurology 2022; 21(10): 922–36. https://doi.org/10.1016/S1474-4422(22)00188-0
13. Malwanage K, Liyanage E, Weerasinghe V, Antonypillai C, Nanayakkara I. Improving postural stability with proprioceptive rehabilitation in patients with diabetic polyneuropathy: a double-blind randomised controlled trial. BMJ Open Sport & Exercise Medicine 2025; 11(2):e002466. https://doi.org/10.1136/bmjsem-2025-002466
14. Rani S, Jagga V. Wobble board-based exercises and Swiss ball-based exercises in improving balance and mobility in patients with diabetic neuropathy. Korean Journal of Physiology and Pharmacology 2024; 28(1): 318-322. https://doi.org/10.25463/kjpp.28.1.2024.45
15. Rhodes D, Leather M, Birdsall D, Alexander J. The effect of proprioceptive training on directional dynamic stabilisation. Journal of Sport Rehabilitation 2020; 30(2): 248–54. https://doi.org/10.1123/jsr.2019-0346