

Effect of Sensory Re-Education with Aerobic Training on Sensation and Balance among Diabetic Peripheral Neuropathy Patients: A Pilot Study

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Abstract

Background: People with diabetes have 10 to 30 times higher risk of lower limb amputation than people without the disease. 85% of non-traumatic amputations in diabetic patients begin with a foot ulcer. Therefore, early intervention is necessary to control the symptoms of diabetic peripheral neuropathy and improve balance. Resistance and aerobic training reduce diabetic symptoms by lowering HbA1C levels. In order to restore functional sensibility, improve adaptive functioning, and improve balance, sensory re-education and aerobics are combined. Therefore, the aim of this study is to find out the effect of Sensory re-education and aerobics on sensation and balance among diabetic peripheral neuropathy patients.

Purpose: The Purpose of the study is to determine the effects of sensory re-education with aerobic training on sensory perception and balance in Diabetic peripheral neuropathy patients.

Material and Method: This study included diabetic individuals of both genders between the ages of 45-60, low PAR-Q risk scores and Toronto clinical neuropathy scores (TCNS) between 6 and 11. A total of 20 participants were randomly selected and received sensory re-education with aerobics for six weeks.

Results: Individuals with diabetic peripheral neuropathy experienced statistically significant improvement in TCNS from 9.3 ± 1.25 to 4.5 ± 1.3 , in BBS 48.5 ± 2.70 to 41.7 ± 1.41 , in TUG 8.12 ± 1.28 to 6.95 ± 1.30 , with a P value of < 0.01 .

Conclusion: Sensory re-education with aerobic training for 6 weeks of duration reported improvement in sensory perception and balance among people with diabetic peripheral neuropathy patients.

Keywords: Diabetes, Sensory loss, Sensory re-education, Aerobic training, Balance.

Introduction

One of the most common types of neuropathies in the world, diabetic peripheral neuropathy (DPN), is a frequent consequence of diabetes mellitus. The

International Diabetes Federation, reported that prevalence of diabetes was 9.3% in 2019 and is expected to reach 10.9% by 2045. Patients with DPN experience a variety of symptoms, but the most frequent ones are numbness, tingling, and pain that

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starts in the toes, bottoms of the feet, ankles, and lower shins¹. A stocking and glove distribution of pain, paraesthesia, or lack of feeling is a hallmark of diabetic polyneuropathy. It arises due to prolonged high blood sugar levels, which damage the nerves in the extremities, particularly the feet and legs. As a result, individuals may be unaware of minor injuries, blisters, or wounds on their feet, making them vulnerable to infections and complications. Sensory impairment, coupled with other factors, has a profound impact on balance and contributes to an increased risk of falls among individuals with DPN. Nearly 50% of persons with diabetes may ultimately develop diabetic peripheral neuropathy, which has been associated with significant morbidity such as discomfort, foot ulceration, and lower limb amputation². Similar effects of sensory impairment are seen in the sense of balance, the capacity to recognize one's body's direction and motion in space. This might cause balance and coordination issues, which would increase the risk of falls and accidents.

Diabetic neuropathies can affect any peripheral nerve segment, from nerve roots to nerve ends, producing various patterns of aberrant sensations. Early in the course of the disease, tiny fiber involvement results in positive sensory sensations like pain, putting patients under the care of a physician³. Patients with diabetes who have large diameter fiber involvement have proprioceptive impairments⁴. In DPN, the sensory nerves that provide feedback about joint position and limb movement may be impaired, leading to reduced proprioceptive awareness. This can affect balance and coordination during activities that require weight shifting and precise movements. The fundamental mechanism of balance is compromised when the illness process affects the proprioceptors, which shows itself as delayed postural and righting responses. The diabetic patient's ability to balance is ultimately impaired as a result of these delays. Additionally, balance issues enhance the elderly person's chance of falling⁵. During blood analysis, it was shown that patients with diabetic neuropathy had increased HbA1C values greater than 5.6%. Exercises like resistance training and aerobics have been demonstrated to reduce HbA1C levels, which help to lessen the signs and symptoms of diabetic neuropathy⁶. Aerobic exercises, such as walking, cycling, swimming, and dancing, promote

increased blood flow throughout the body, including the peripheral nerves. Improved blood circulation can provide essential nutrients and oxygen to nerve tissues, potentially slowing down nerve damage and promoting nerve repair. Weight-bearing activities can enhance balance and proprioception, even in individuals with sensory impairments.

The risk of falls and associated injuries can be decreased because of this increase in balance. It has been found that exercise increases lower-extremity balance and strength (force-generating ability) and is useful in preventing falls in older people. The BBS is widely used in clinical settings and in research to assess balance in individuals with diabetic peripheral neuropathy. A lower BBS score suggests a higher risk of falls and impaired balance, while a higher score indicates better balance control and reduced fall risk. A shorter TUG time suggests better balance and mobility, while a longer time indicates potential balance impairments and an increased risk of falls. Generally, a TUG time of 12 seconds or less is considered normal, while times above 20 seconds indicate a higher risk of falling. For people with diabetic peripheral neuropathy, combining the Berg Balance Scale and the Timed Up and Go test might yield a more thorough assessment of balance. Sensory retraining exercises, including activities that focus on proprioceptive awareness, can help individuals compensate for sensory deficits and improve balance control. Concentration and exposure to various sensory stimuli are used in sensory retraining to improve sensory awareness⁸. Using TCNS, the intensity of the symptoms and the degree of sensory loss were assessed both before and after therapy. The TCNS includes motor and sensory-motor symptoms as well as sensory and reflex findings in the lower limbs. This scale may be used to diagnose and categorize diabetic polyneuropathy and is a reliable and accurate instrument⁹. Regular monitoring and prompt treatments can greatly increase balance and lower the chance of falling, improving overall quality of life.

Aim

The Aim of the study is to determine the effects of sensory re-education with aerobic training on sensory perception and balance among Diabetic peripheral neuropathy patients.

Material and Method

This is a pilot study done with 20 Diabetic peripheral neuropathy subjects aged 45-60 years of both genders, from a private hospital in Chennai, during the period of June 2022 and September 2022. Participants were clearly explained about the study procedure, and informed consent was obtained. Samples were randomly selected and allocated to a single group.

Inclusion criteria

- Diagnosed diabetic peripheral neuropathy
- Patients of both genders between the ages of 45 and 60 will be enrolled.
- Diabetes patients who had a Toronto clinical neuropathy score of 6 to 11
- who had low risk in PAR-Q
- Low score in Berg balance scale

Exclusion criteria

- Uncontrolled diabetes,
- Unhealed Foot Ulcers or Infections:
- Cardiovascular Conditions
- Cognitive Impairments

Outcome Measure:

Assessment was done at initial and at the end of the study using

Toronto clinical neuropathy score (TCNS): The TCNS is a questionnaire with a physical examination component. Each TCNS item receives a value between 0 and 2, with higher ratings denoting more severe conditions. The sum of the scores from each of the individual components yields the final score, which ranges from 0 to 19. The questionnaire evaluates the severity of symptoms, including tingling, numbness, discomfort, and motor weakness, as well as how they affect everyday activities^{10,11}.

Berg Balance Scale: The BBS was used to assess functional balancing abilities and consisted of 14 tasks related to everyday living. There is a maximum score of 56 and a scale with five points for each item with a range of 0 to 4. In clinical settings, the test is uncomplicated, secure, and easy to use¹².

Timed Up and Go test: When assessing balance, mobility, and fall risk in people with diabetic peripheral neuropathy, the functional examination known as TUG is frequently employed. In order to pass the test, the subject must get out of a chair, walk three meters at a leisurely speed, turn around, and then walk back to the chair and sit down. The amount of time needed to finish the exam is noted¹³.

Procedure

A Pilot study was conducted at Private hospital in Chennai, and the sample was collected from Neuro IP and physiotherapy OPD. Total Twenty patients with diabetic peripheral neuropathy of both genders, 12 male and 8 female, between the ages of 45-60 years, who scored 6-11 in Toronto clinical Neuropathy score were randomly chosen and assigned to one group based on inclusion and exclusion criteria. Before starting therapy, the subjects are provided with clear and concise written or verbal instructions for therapy procedure. Make sure the patient understands the proper technique and form for each exercise. At the baseline, the TCNS, Berg balance scale, and TUG were used for assessment. The trial lasted for six weeks. Advised the patient to wear comfortable clothing during the sensory re-education sessions that allows free movement and does not restrict their mobility. Suggest appropriate footwear, such as well-fitted, non-slip shoes or socks with grip, to ensure safety during exercises and to avoid slips or falls. Initially, subjects underwent aerobic training, Prior to aerobic exercise, they ensured that the exercise setting is safe and free from obstacles or hazards that may pose a risk during balance exercises or movement activities. Utilize supportive equipment, such as handrails or stable surfaces, to assist the patient during exercises, especially those involving balance training. Subjects were trained with aerobic exercises such as walking, stretching, and stationary cycling. Following sensory re-education, to start the treatment, the subjects were made to sit in a comfortable position, and the treatment area is exposed to give sensory stimulus to the affected region. Sensory re-education techniques such as tapping, fast brushing, quick icing, quick heat, vibration, and position sense were used. The total duration of therapy was 30 sessions, 5 sessions each week for 6 weeks.

Data Analysis

Pre-test and post-test values of Toronto clinical neuropathy score, Berg balance scale, and timed up and go test are analyzed using the Wilcoxon signed-rank-test.

Result

All 20 subjects completed the study successfully. The pre-test and post-test values of TCNS, BBS, and TUG are presented in the following tables 1, 2, and 3. Statistical analysis shows there is a significant improvement from pre-intervention to post-intervention.

Table 1: Comparison of Pre-test and Post-test values of Toronto clinical neuropathy score

Outcome	Pre-test		Post-test		P Value
	Mean	SD	Mean	SD	
TCNS	9.3	1.25	4.5	1.3	<0.01

Table 2: Comparison of Pre and Post-test values of Berg balance scale

Outcome	Pre-test		Post-test		P Value
	Mean	SD	Mean	SD	
BSS	48.5	2.70	41.7	1.41	<0.01

Table 3: Comparison of Pre and Post-test values of Timed up and go test.

Outcome	Pre-test (Sec)		Post-test (Sec)		P Value
	Mean	SD	Mean	SD	
TUG	8.12	1.28	6.95	1.30	<0.01

Discussion

This pilot study is designed to analyze the outcomes of an integrated intervention involving aerobic exercise and sensory re-education on sensation and balance in individuals with DPN. The study explored the potential benefits of this intervention in improving proprioception, vibration sense, and overall balance control, ultimately reducing fall risk in this vulnerable population.

In this study, 20 subjects underwent sensory re-education and aerobic training for a period of 6 weeks to improve their sensory perception in the foot and balance. After the study period, the subjects were re-assessed for the outcomes gained. TCNS is used to evaluate sensory impairment, which encompasses sensory, motor, and reflex findings of upper and lower extremities. Assessing balance in individuals with diabetic peripheral neuropathy (DPN) is crucial to identifying their risk of falls and implementing appropriate interventions to prevent injuries. Two commonly used tests for evaluating balance in this population, the Berg balance scale and the Timed up and go test, were used in this study. The tasks on the Berg Balance Scale include standing up from a seated position, standing unsupported, reaching forward, turning 360 degrees, standing on one leg, and more. These tasks challenged different aspects of balance, including static and dynamic balance, weight shifting, and proprioception, which were assessed in this study. Timed up and go tests are performed to assess a subject's ability to get up from a chair, move three meters at a comfortable rate, turn around, and return to the chair before sitting down. It is noted how long it took to finish the exam. Morioka and Yagi Training in hardness discrimination was conducted on stroke patients undergoing rehabilitation, and the results showed a considerable improvement in postural control¹⁴. The hard training on discrimination was carried out standing up, which could have affected the outcomes. This is due to the fact that standing for extended periods of time alone has been shown to greatly improve postural control in stroke patients¹⁵. Patients with diabetic peripheral neuropathy had their sensory perception retrained using the re-education theory. It is thought that sensory rehabilitation is one of the most difficult and protracted functioning processes.

Carey L Enhancing sensory discriminating ability requires sensory retraining for at least 6 weeks after 48 weeks following a stroke. Combining sensory re-education with aerobic exercise can lower blood HBA1C levels and enhance feelings in people with diabetic peripheral neuropathy¹⁶. The brain's capacity to rearrange itself and adapt to new sensory inputs is known as neuroplasticity, and it may be influenced by both sensory re-education and aerobic exercise. Re-education is included in various ways

in all rehabilitation models. The sensory retraining strategy in the one study was less successful than therapies for stroke previously stated¹⁷. The repetitive nature of sensory re-education exercises and aerobic training may have induced favorable changes in nerve pathways, leading to enhanced sensory feedback and better integration of sensory information for balance control. Previous research exploring the advantages of aerobic exercise intervention among patients with T2D has found several beneficial changes in metabolic health, composition of the body, and the maximum oxygen absorption^{18,19}. Chronic aerobic exercise dramatically reduces systolic and diastolic blood pressure, fasting glucose levels, lipoproteins with a low density, triglycerides, HbA1c, and body fat percent, according to meta-analytic research²⁰. Although there is evidence that aerobic exercise is effective in treating type 2 diabetes' metabolic symptoms, further research is needed to understand how this sort of exercise affects diabetic peripheral neuropathy and the muscle-mediated activities linked to diabetes. Static and dynamic balance were assessed using the one-leg standing test with eyes open and closed, the Berg balance scale, and the timed-up-and-go test.

According to published research, these straightforward and uncomplicated tests result in a thorough evaluation of the balance system. Suganthirababu P et al., suggest sensitivity tests on the peripheral nerve and management of the nerve disorder can be done with ultrasound therapy²¹. Jannu C et al., stated that therapeutic laser plays a major role in reducing diabetic neuropathic pain²³. Early detection of sensory impairments, combined with targeted interventions such as sensory training, balance exercises, and proper footwear, can help manage balance problems and reduce the risk of falls, ultimately improving overall safety and the standard of living for people with DPN. The results of this pilot study showed promising outcomes in the intervention group, suggesting that sensory re-education with aerobic training has a positive impact on sensation and balance among individuals with DPN, which is clinically significant. Despite the promising results, there are some constraints in this pilot study that should be taken into account. The generalizability of the results is restricted by the small sample size and the absence of a control group. Additionally, the

short duration of the intervention does not allow for long-term assessment of its effects. Future research with larger, randomized controlled trials and longer follow-up periods would be necessary to validate these findings.

Conclusion

This pilot study provides preliminary evidence that combining sensory re-education with aerobic training may have a positive effect on sensation and balance among individuals with diabetic peripheral neuropathy. Improving proprioceptive awareness, vibration sense, and overall balance control could significantly reduce fall risk and improve the quality of life for this vulnerable population. These findings warrant further investigation through larger, controlled studies to establish the effectiveness and long-term benefits of this combined intervention in managing DPN-related sensory impairments and balance issues.

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Conflict of Interest: There was no conflict of interest during this research.

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