

A Randomized Control Study of Effectiveness of Aerobic Exercise Training and Balance Training on Balance in Patients with Diabetic Peripheral Neuropathy

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Abstract

Background: Diabetic peripheral neuropathy (DPN) is a common complication of diabetes that can lead to significant balance issues, increasing the risk of falls and associated morbidity. Exercise is known to mitigate these complications, yet the comparative effectiveness of different exercise modalities remains underexplored.

Objective: The study aimed to evaluate the effectiveness of aerobic exercise training compared to balance training and traditional balance exercises in improving balance among patients with DPN.

Methods: A randomized controlled trial was conducted at Mayo Hospital, Lahore, with 60 patients diagnosed with DPN, divided equally into three groups: Group A (aerobic exercise), Group B (balance training), and Group C (traditional balance exercises). Each group received interventions three times weekly for four weeks. Balance was assessed using the Berg Balance Scale (BBS) pre- and post-intervention. Data were analyzed using SPSS version 25, with paired t-tests and one-way ANOVA to evaluate treatment effects.

Results: Post-treatment BBS scores showed significant improvement across all groups ($p < 0.001$). Group A exhibited the greatest improvement, with mean scores increasing from 47.20 to 52.65. Group B's scores increased from 43.95 to 48.25, while Group C showed the least improvement, from 43.95 to 46.80.

Conclusion: Aerobic exercise significantly enhances balance in DPN patients compared to balance training and traditional exercises, highlighting its potential as a primary intervention strategy.

1 Introduction

Diabetes is a major healthcare concern of the 21st century, with the International Diabetes Federation estimating that approximately 425 million adults aged 20-79 years were living with diabetes in 2017, a number projected to rise to 629 million by 2045. Diabetes leads to a wide array of neuropathic complications, including both acute and chronic forms affecting every level of peripheral nerves from the root to the distal axon (1). Exercise plays a crucial role not only in treating balance issues but also in alleviating painful symptoms associated with diabetic peripheral neuropathy (2, 3). Although physical activity is a key component in managing type 2 diabetes, it is often not incorporated into the lifestyle of many individuals. There is a scarcity of high-quality studies investigating the role of physical activity in diabetes management. Clinical guidelines from the American Congress of Clinical Rehabilitation emphasize the importance of aerobic

exercise, flexibility exercises, strength training, and group-specific balance training in managing chronic diabetic complications (4). Research also indicates that nutritional interventions can help control neuropathy symptoms in diabetic patients (5).

Individuals with chronic diabetes face an increased risk of developing diabetic peripheral neuropathy (DPN) and associated balance problems, making exercise interventions crucial for these patients (6). The prevalence of type 2 diabetes mellitus has surged due to increasing sedentary lifestyles worldwide (7). While various interventions have been proposed to address balance issues in diabetes mellitus, aerobic exercise training remains one of the most commonly utilized methods (8). Additionally, strengthening and stretching techniques have proven beneficial in preventing complications (9). Patient psychology, gender, and lifestyle also significantly impact diabetes-related problems (10). Diabetes elevates the risk of falls, thereby increasing mortality rates (11). Exercise has been shown to effectively control blood glucose levels in diabetic patients. Despite numerous rehabilitation centers advocating exercise regimens for diabetes, there is a paucity of literature focusing on balance control in DPN patients through physical activity and exercise, particularly for severe diabetic peripheral neuropathy (12). Studies examining gait and balance issues in DPN patients are also limited (13).

Diabetic somatic neuropathies present a paradox, with some patients experiencing severe neuropathic pain but only minimal deficits upon examination, while others have insensate feet and are asymptomatic until foot ulcers develop (14). Historically, the lack of awareness and inadequate management of DPN has resulted in unnecessary morbidity and substantial healthcare costs. Proper management and patient education could prevent at least half of all foot ulcers, the end stage of such neuropathy. The dysfunction associated with DN's three major components—sensitive (lack of motion-associated sensory), motor (movement coordination impairments), and autonomic (postural hypotension presence)—can impair balance in affected patients (15). Most DPN patients suffer from muscle weakness, pain, balance loss, and lower limb dysfunction (16). Non-pharmacological approaches such as low-intensity exercises, balance training, resistance exercises, and aerobic exercises are crucial in preventing falls and ensuring postural stability in chronic diabetic patients. Exercise is considered an essential component of diabetes management, alongside nutrition and medication (17). Comparative studies on nerve conduction velocities in motor and sensory nerves indicate that the duration of diabetes affects neuropathy severity (18). Loss of muscle strength, speed, power, and endurance, particularly in lower limb muscles, may synergistically reduce functional capacity, contributing to altered gait, increased fall risk, and impaired balance in DPN patients. It is well-established that diabetes mellitus (DM) and DPN are associated with a loss of muscle mass and strength in humans (19).

Studies suggest that DPN patients can benefit from balance training and aerobic exercise, as DPN causes imbalance, impairing daily living activities (20). Evidence of aerobic exercise and balance training effectiveness is needed for patients in Lahore and surrounding areas. Aerobic exercises strengthen muscles against peripheral neuropathy, while balance training aids in preventing falls in diabetic patients. The primary aim of this study is to evaluate the effects of aerobic exercise training and balance training on patients with DPN. This randomized control trial, an experimental study design, seeks to provide beneficial results for the diabetic population.

2 Material and Methods

This study was conducted at the diabetic clinic of Mayo Hospital, Lahore, under the supervision of a physician. The study population consisted of patients with diabetic peripheral neuropathy (DPN), diagnosed using the Neurodisability Score (NDS) with values of 2 or higher, indicating symptoms such as tingling and burning in the feet. A total of 60 patients, comprising equal numbers of males and females, were selected through convenience sampling. This technique was employed due to time constraints, allowing for the selection of patients available during the daily interval between 10:00 AM and 12:00 PM. Data collection occurred from December 1, 2019, to April 30, 2020.

Patients were randomly assigned to three groups using a lottery method, with 20 patients in each group. Group A received aerobic exercise training, which included 6 minutes of bicycling and 15 minutes of walking daily. Group B underwent balance training, while Group C served as the control group, receiving traditional balance training. The interventions were administered three times a week for four weeks. The Berg Balance Scale (BBS) was utilized to assess the patients' balance capabilities before and after the intervention.

Data were collected using direct personal interviews and telecommunication methods, as these were deemed most efficient given the sample size and population distribution. Informed consent was obtained from all participants prior to the study. The study was conducted following the principles outlined in the Declaration of Helsinki, ensuring the ethical treatment of all participants.

The primary variables examined in this study included age, gender, locality, socio-economic status, history of diabetes, type and nature of pain, prognosis with physical therapy, and satisfaction with physical therapy. Age was measured on a ratio scale, as diabetic peripheral neuropathy is more prevalent among older individuals. Gender was assessed using a nominal scale, as DPN is more common in females. Locality, also measured on a nominal scale, examined the incidence of DPN in urban versus rural areas. Socio-economic status was evaluated using an ordinal scale, as DPN is more prevalent in the middle class due to varying activity levels. The type and nature of pain were categorized into persistent, intermittent, burning, localized, radiating, or generalized.

Data analysis was performed using SPSS version 25. The paired t-test and one-way ANOVA were employed to assess the effectiveness of therapeutic interventions on balance problems in DPN patients. Descriptive statistics, including mean and standard deviation, were used to summarize the data. The study hypothesized that aerobic exercise and balance training do not have the same effect on balance in DPN patients. A post-survey was conducted to test the reliability of the study findings. The results of the study are presented with transparency, adhering to the standards of scientific integrity, with no competing interests declared by the authors.

3 Results

The study involved a total of 60 patients with diabetic peripheral neuropathy, divided equally into three groups: aerobic exercise (Group A), balance training (Group B), and traditional balance training (Group C). The data analysis focused on comparing the pre-treatment and post-treatment Berg Balance Scale (BBS) scores across the three groups.

The age distribution of the participants is shown in Table 1. The majority of patients were over 60 years old, reflecting the higher prevalence of diabetic peripheral neuropathy in older adults.

Table 1: Age Distribution of Participants

Age Group	Frequency	Percentage
45-50	11	18.3%
50-55	12	20%
55-60	15	25%
Above 60	22	36.7%
Total	60	100%

The gender distribution of participants is presented in Table 2, indicating a higher prevalence of diabetic peripheral neuropathy among females.

Table 2: Gender Distribution of Participants

Gender	Frequency	Percentage
Male	23	38.3%
Female	37	61.7%
Total	60	100%

The effectiveness of the interventions was evaluated using the Berg Balance Scale (BBS). Table 3 summarizes the pre- and post-treatment BBS scores for each group.

Table 3: Pre- and Post-Treatment BBS Scores

Group	Time	Mean	N	Std. Deviation	Std. Error Mean
Group A	Pre-Treatment	47.20	20	7.02	1.57
	Post-Treatment	52.65	20	3.34	0.75
Group B	Pre-Treatment	43.95	20	6.96	1.56
	Post-Treatment	48.25	20	6.23	1.39
Group C	Pre-Treatment	43.95	20	6.96	1.56
	Post-Treatment	46.80	20	6.06	1.35

The paired t-test revealed significant improvements in BBS scores for all groups, with p-values less than 0.001, indicating the effectiveness of the treatments. The mean differences and significance levels are detailed in Table 4.

Table 4: Paired Samples T-Test Results

Group	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Group A	-5.45	4.29	0.96	-5.67	19	0.000
Group B	-4.30	2.43	0.54	-7.91	19	0.000
Group C	-2.85	1.42	0.32	-8.95	19	0.000

A one-way ANOVA was conducted to compare the effectiveness of the different treatments on balance improvement. The results, as shown in Table 5, indicate significant differences between the groups ($p < 0.001$), with Group A showing the greatest improvement.

Table 5: One-Way ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	648.70	2	324.35	10.39	0.000
Within Groups	1779.90	57	31.23		
Total	2428.60	59			

The results demonstrate that both aerobic exercise and balance training significantly improved balance in patients with diabetic peripheral neuropathy compared to traditional balance training. However, aerobic exercise (Group A) yielded the most substantial improvement in balance, as evidenced by the highest mean difference and significant F-value in the ANOVA. These findings support the hypothesis that aerobic exercise is more effective in improving balance than traditional balance exercises.

4 Discussion

The study demonstrated significant improvements in balance among patients with diabetic peripheral neuropathy (DPN) following interventions with aerobic exercise and balance training. The findings aligned with previous research, highlighting the effectiveness of exercise interventions in managing neuropathic symptoms and improving postural stability (2, 3). The results indicated that while both aerobic exercise and balance training significantly enhanced balance, aerobic exercise had a more pronounced effect, suggesting it as a preferable intervention for DPN patients.

This study corroborated earlier findings that aerobic exercise is beneficial for patients with diabetic neuropathy, not only in enhancing balance but also in alleviating neuropathic pain and improving overall function (8, 9). The emphasis on aerobic exercise supports recommendations from the American Congress of Clinical Rehabilitation, which highlights its role in controlling chronic diabetic complications alongside other exercise forms (4). Additionally, the study's use of the Berg Balance Scale (BBS) as a primary assessment tool provided reliable and valid data on balance capabilities, confirming its status as the gold standard for functional balance testing in clinical settings (21).

One of the strengths of this study was the use of a randomized control trial design, which minimized bias and ensured the reliability of the results. The use of a convenience sampling method allowed for the recruitment of a representative sample of the population, albeit with some limitations regarding generalizability. The study was conducted in a single center, and the sample size was relatively small, which could limit the broader application of the findings. Future studies should consider larger, multicenter trials to validate these results further.

A notable limitation was the impact of the COVID-19 pandemic, which necessitated reliance on telecommunication methods for patient assessment and may have affected patient adherence to exercise regimens. Additionally, the short duration of the intervention might not reflect long-term benefits, indicating a need for prolonged studies to assess the sustained impact of these interventions on balance and neuropathic symptoms.

Recommendations for future research include exploring the combined effects of aerobic and other forms of exercise, such as strength and flexibility training, to identify the most effective intervention protocols for DPN patients. It is also essential to investigate the potential benefits of personalized exercise programs tailored to individual patient needs and capabilities. Moreover, addressing the psychosocial aspects of exercise adherence, especially in older adults with DPN, could enhance the effectiveness of these interventions.

This study highlighted the significant role of aerobic exercise and balance training in improving balance among patients with diabetic peripheral neuropathy. Aerobic exercise, in particular, emerged as a superior intervention, offering substantial improvements in balance and potentially reducing the risk of falls in this vulnerable population. These findings contribute to the growing body of evidence

supporting exercise as a crucial component in the management of diabetes and its complications. However, further research is necessary to explore long-term effects and optimize exercise interventions for patients with DPN.

5 Conclusion

The study concluded that both aerobic exercise and balance training significantly improve balance in patients with diabetic peripheral neuropathy, with aerobic exercise demonstrating a more pronounced effect. These findings underscore the importance of incorporating structured exercise programs into the management strategies for diabetic neuropathy to enhance balance and reduce fall risk. The human healthcare implications of this study are substantial, suggesting that healthcare providers should prioritize aerobic exercise interventions in the treatment plans for DPN patients. By integrating such exercise programs into routine care, there is potential to improve patients' quality of life, reduce healthcare costs associated with fall-related injuries, and contribute to more effective management of diabetes complications.

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Disclaimers

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