

Effects of Functional Balance Training on balance and Risk of Fall in Diabetic Neuropathy - An Interventional Study

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ABSTRACT

Background: Diabetic Peripheral Neuropathy (DPN) is defined as the presence of symptoms and/or signs of peripheral nerve dysfunction in patients with diabetes after other aetiologies have been excluded. They experience muscle weakness, decreased balance, coordination, gait control, loss of ankle reflexes, and therefore have the probable risk of falling.

Aim: To assess the effectiveness of functional balance training on balance and risk of fall in diabetic peripheral neuropathy.

Methodology: A total of 50 patients were recruited and randomly divided into two groups. Group A (Functional Balance Training + Conventional Physiotherapy) and Group B (Conventional Physiotherapy). They received treatment for 6 consecutive weeks; 4 sessions per week. Outcome measures were the Functional Reach Test (FRT) to assess balance and the Fall Efficacy Scale-International (FES-I) to assess risk of falls. Both were measured before and after 6 weeks of intervention. Data analysis was done by using SPSS version 16.

Result: Within-group analysis showed statistically significant results in Group A as well as in Group B for both FRT and FES-I scores ($p < 0.05$). Between-group analysis showed a statistically significant difference between both the groups ($p < 0.05$); as the mean difference of Group A was higher, it signified that there was a statistically significant improvement in balance and reduction in risk of fall in Group A compared to Group B.

Conclusion: Functional Balance Training along with Conventional Physiotherapy is effective in improving balance and reducing the risk of falls in Diabetic Neuropathy.

Keywords: Diabetic neuropathy, Functional balance training, Functional reach test, Fall Efficacy Scale-International.

INTRODUCTION

Diabetic Peripheral Neuropathy (DPN) is defined as the presence of symptoms and/or signs of peripheral nerve dysfunction in patients with diabetes after other etiologies have been excluded.(1)

The International Diabetes Federation estimates that 537 million adults are living with diabetes worldwide and predicted to rise to 784 million by 2045. In India, 74.2

million adults have diabetes.(2) Among the complications of diabetes, the most prevalent is Diabetic Neuropathy. In India, the prevalence of diabetic neuropathy is 10.6%.(3) It occurs in individuals with long-standing T1DM & T2DM. The incidence is higher in T2DM individuals than in those with T1DM.(4) Its development correlates with the duration of

diabetes and glycemic control. The other risk factors associated are body mass index (BMI), smoking, hypertension, elevated triglycerides, and cardiovascular diseases.(5)

The symptoms are numbness or insensitivity to pain or temperature, paraesthesia, burning or shooting pain, and extreme sensitivity to touch; starting distally at the toes and progressing proximally to the knees, and also in the upper extremities. Clinical findings are loss of sensations of pinprick, temperature, vibration, and proprioception in a 'glove and stocking' distribution; loss of ankle reflexes, weakness of foot muscles and dorsiflexors.(6)

Experimental studies suggest a multifactorial pathogenesis but the causes remain unknown. Chronic hyperglycaemia and its microvascular abnormalities play a major role in pathogenesis. Axonal thickening and decreased capillary blood flow result in poor nerve perfusion and endoneurial hypoxia.(7)

According to the Quality Standards Subcommittee of the American Academy of Neurology, people with DPN have a probable (level B evidence) risk of falling, and those with disorders of balance and gait have established (level A evidence) risk of falling.(8) According to Rinkel et al., the degree of sensory loss correlates significantly with reduced balance and increased risk of falls.(9) Ghanavati et al. found that balance and physical coordination in the elderly with DPN were lower significantly than without DPN.(10)

Balance is affected by many factors; the decline of proprioceptive, vestibular, and lower extremity muscle strength are the main reasons for impaired balance in individuals with DPN.(11) Therefore, diabetes reduces the ability to control the individual's balance during daily activities and increases the risk of falls.

Functional Balance Training includes various activities that promote static balance control and dynamic balance control. It is considered to be very important for the prevention of falls in the older population. It

has been shown to produce improvements in different aspects of postural, balance, and gait.(12)

Aim: To assess the effectiveness of functional balance training on balance and risk of falls in diabetic peripheral neuropathy.

Objectives: 1) To determine the effects of functional balance training on balance by using the functional reach test in diabetic neuropathy. 2) To determine the effect of functional balance training on the risk of falls in diabetic neuropathy.

MATERIALS & METHODS

Methodology:

Study Design: Interventional study

Study Setting: Medicine OPD &

Physiotherapy dept. of general hospital

Study duration: 1 year

Sample size: 50

Sampling technique: Consecutive sampling technique

Inclusion Criteria:

1. Patient's willingness to participate
2. Age: Above 18 years
3. Type 2 diabetes mellitus (duration > 7 years)
4. BMI: 18.5 to 29.9 kg/m²
5. Diagnosed with DPN or subclinical diabetic neuropathy
6. Michigan Neuropathy Screening Instrument (MNSI) (13)
 - Questionnaire score > 2 out of 13
 - Physical assessment score >1 out of 10
7. Ability to walk independently in the laboratory space

Exclusion criteria:

1. Partial or Total foot amputation
2. Other neurological or orthopedic impairments
3. Major vascular complications (venous or arterial ulcers)
4. Severe retinopathy or severe nephropathy

Withdrawal criteria:

If patient wants to withdraw himself/herself from the study.

Materials:

1. Consent form
2. Assessment form
3. Michigan Neuropathy Screening Instrument (MNSI)
4. Touch Test Sensory Evaluator (Semmes Weinstein Monofilament)
5. Pen & paper
6. Plinth, chair or stool
7. Stepper
8. Measuring tape
9. Tuning fork & Reflex hammer

Procedure:

All the patients were screened first from Medicine OPD. Information taken included demographic data, chief complaints of the patient, duration of diabetes mellitus, drug history, and any history of falls. Michigan Neuropathy Screening Instrument was also used for screening. Only the patients who fulfill all the mentioned above inclusion criteria were included. A consent form was signed by patients prior to participation in which the purpose and nature of treatment were explained. A total of 50 patients were recruited and randomly allotted to their respective groups. Group A (n=25) and Group B (n=25). Baseline data were taken before starting their respective interventions. Outcome measures were the Functional Reach Test (FRT) and the Fall Efficacy Scale-International (FES-I). Both

Outcome Measures:

1. Functional Reach Test (FRT): A test that assesses the furthest distance one can reach forward beyond arm's length while standing with a fixed base of support. It measures the margin of stability; a test of anterior and posterior dynamic stability.
2. Fall Efficacy Scale-International (FES-I): A measure of fear of falling or concerns about falling. It consists of 16-item scale of perceived confidence to

the groups received the interventions for 6 weeks. All the patients were advised to continue the treatment for the recommended duration. After 6 weeks of interventions, the outcomes were measured again.

Intervention:

Group A: Functional Balance Training + Conventional Physiotherapy

Group B: Conventional Physiotherapy

Functional Balance Training (14,15)

1. Sit to stand (5 times)
2. Standing with shifting weight anteriorly, posteriorly, and sideway (5 times for each direction)
3. Functional reach sideway and anterior (5 times for each direction)
4. Standing on toes (5-20 seconds, 5 times)
5. Standing on heels (5-20 seconds, 5 times)
6. Step up & step down (10-15 times)
7. One leg stance (5-20 seconds, 5 times)
8. Tandem stance (5-20 seconds, 5 times)

Conventional Physiotherapy

1. Active ROM exercise for lower limb
2. Gait training on stable surface

➤ Duration of intervention:

Group A: 60 minutes (30 minutes of conventional physiotherapy + 30 minutes of functional balance training)

Group B: 30 minutes of conventional Physiotherapy

- #### ➤ Frequency: 4 sessions per week, for 6 consecutive weeks.

complete physical daily activities and used to measure the level of concern about falling during social and physical activities inside and outside the home.

RESULT

A total of 48 patients completed the study and 2 patients discontinued the treatment. Group A (n=23) received Functional Balance Training + Conventional Physiotherapy and Group B (n=25) received Conventional Physiotherapy. Statistical Analysis was done using software the SPSS version 16. Before analysis, normal

distribution and baseline characteristics were screened. Shapiro-Wilk test was applied to check whether the data followed normal

distribution or not and it showed that only Age and Duration of diabetes followed normal distribution ($p > 0.05$).

Table 1: Statistical analysis for normal distribution of the variables

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value (Group A)	p-value (Group B)
Age	56.04 ± 9.82	50.88 ± 9.54	0.069	0.148
BMI	22.84 ± 2.45	23.51 ± 2.23	0.172	0.029
Duration of diabetes	10.91 ± 3.16	9.68 ± 2.23	0.056	0.064
FRT pre	26.77 ± 3.97	29.80 ± 5.79	0.296	0.040
FES-I pre	31.52 ± 6.56	28.52 ± 6.78	0.157	0.001

Baseline characteristics were analyzed, where the result showed that $p\text{-value} > 0.05$, hence null hypothesis could be accepted which signifies that there was no statistically significant difference among the variables between the two groups at the baseline. This suggests that the two groups were similar at baseline. The statistical analysis of both the variables (FRT & FES-I) was done using non-parametric tests where the level of

significance was kept at 5% and a confidence interval of 95%.

Within-group analysis

To analyze the difference in FRT and FES-I after 6 weeks of intervention in both groups, the Wilcoxon test was used. Analysis showed a statistically significant difference in FRT and FES-I within the groups ($p < 0.05$).

Table 2: Statistical analysis of within groups

Variables	Pre-treatment (Mean ± SD)	Post-treatment (Mean ± SD)	z-value	p-value
Group A				
FRT	26.77 ± 3.97	31.99 ± 4.36	- 4.198	0.000
FES-I	31.52 ± 6.56	23.65 ± 5.95	- 4.222	0.000
Group B				
FRT	29.80 ± 5.79	33.20 ± 5.26	- 4.373	0.000
FES-I	28.52 ± 6.78	25.20 ± 6.23	- 4.406	0.000

Between-group analysis

To analysis of the difference in FRT and FES-I after 6 weeks of intervention between both groups, the Mann-Witney U-test was

used. Analysis showed a statistically significant difference between both the groups for both the outcome measures FRT and FES-I ($p < 0.05$).

Table 3: Statistical analysis of between groups

Outcome Measure	Group A (Mean ± SD)	Group B (Mean ± SD)	U value	z-value	p-value (<0.05)
FRT	5.22 ± 1.93	3.4 ± 1.33	134	-3.169	0.002
FES-I	7.86 ± 2.47	3.32 ± 1.70	37	-5.222	0.000

So, from these results of the present study, Null Hypothesis H_{01} & H_{02} are rejected and Alternative Hypothesis H_1 & H_2 are accepted. Thus, there is a significant improvement in the Functional Reach Test and Fall Efficacy Scale-International score for balance and risk of fall due to additional functional balance training along with conventional physiotherapy in diabetic neuropathy.

As the mean difference of Group, A is higher than Group B, Functional Balance Training has a more significant effect on balance and risk of falls as compared to Conventional Physiotherapy alone. Between-group analysis of FES-I showed a more statistically significant difference between both groups.

DISCUSSION

The major finding of the present study is that the individuals who received Functional Balance Training along with Conventional Physiotherapy showed significant improvement in balance and a significant reduction in the risk of falls.

The possible underlying mechanisms behind the effectiveness of Functional Balance Training in individuals with diabetic neuropathy could be: Functional Balance Training includes various activities that promote static balance control and dynamic balance control. In my study, the training includes Weight Shifts and Functional Reach in standing which moves the COG through space. Narrowing the BOS as in Tandem stance and One Leg stance, makes control of the COG demanding. Transitional movements such as sit-to-stand involve large COG excursions over a stable BOS. A lateral weight shift is required in addition to the partial stand. This training could especially enhance their balance and reduce the risk of falls by challenging the individual's limits of stability. Ankle Strategy is found to be the most effective way for controlling COG through the limits of stability on a stable surface.

Therefore, it can be said that by improving the strength of ankle and foot muscles, the improvement in balance can be achieved, and eventually the risk of falls can be minimized. A strong association between falls/loss of balance and decreased ankle strength was found by Wolfson et al. in their study. An improvement in ankle muscle strength and muscle tension may also improve ankle proprioceptive thresholds.(16)

The findings support the idea that balance training can improve the balance ability of neuropathic diabetic patients as Akbari et al. believed that both vibration and exercise can activate the afferent sensory input, but that exercise additionally can make the patient actively exert the motor response and necessary movement in reaction to sensory demand. In this way, the afferent motor

system also could be trained and improved.(17)

This is also supported by Allet et al. and by Richardson et al. that increased hip and ankle strength as well as ankle mobility improves gait velocity and both static and dynamic balance.(14,15)

Balance exercises can activate the afferent sensory input, and can actively exert the motor response and necessary movement in reaction to sensory demand placed upon the patient through these functional balance exercises. In this way, the afferent motor system also could be trained and improved.

In addition, the most recent literature by Tinetti et al. suggests that specific balance and strength exercise programs are effective in reducing the risk of falling. However, their optimal intensity and frequency remain to be determined.(18)

Active ROM exercises which were part of conventional physiotherapy; may be beneficial for these patients as it was also found by Turner et al. that hyperglycaemia leads to the glycation of collagen which may lead to periarticular structures thickening and may confound differences in ankle motion. (19) This can further reduce mobility at the ankle joint which could further reduce the ability to balance for an individual.

Gait training should also be given along with Functional Balance Training as gait training might improve hallux and toe mobility and function. This mechanism is also supported by Sartor et al. that the stretching exercises and gait training were efficient in improving hallux and toe mobility and function, reflected in the redistribution of plantar pressure. They also showed an improvement in intrinsic and extrinsic muscle function, especially in ankle dorsiflexion (tibialis anterior), toe flexion (flexor digitorum brevis), and of interosseous muscles.(20)

So, the whole of the study concluded that Functional Balance Training along with conventional physiotherapy is proved to be more beneficial compared to conventional physiotherapy alone.

CONCLUSION

According to the present study findings, Functional Balance Training along with Conventional Physiotherapy is found to be effective in improving balance and reducing the risk of falls in individuals with Diabetic Neuropathy.

Clinical Implications

Individuals with diabetic neuropathy who experience balance problems and have a higher risk of falls or have a history of falls can achieve better balance and can reduce the risk of falls through functional balance training which emphasizes challenging the person's limits of stability. Therefore, Functional Balance Training should be given along with Conventional Physiotherapy.

Declaration by Authors

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