

# The Effectiveness of Toe Flexor Strengthening on Balance and Risk of Fall in Patients with Diabetic Polyneuropathy- A Pilot Study

Saifuddin Khand<sup>1\*</sup>, Pragna Landge<sup>2</sup>

<sup>1</sup>PG Scholar (Neurology & Psychosomatic Disorders) KSPR, KPGU, Vadodara, Gujarat, India,

<sup>2</sup>Associate Professor (Neurology & Psychosomatic Disorders) KSPR, KPGU, Vadodara, Gujarat, India

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## ABSTRACT

**Background:** Diabetic polyneuropathy (DPN) is relatively common complication of long-term diabetes and is thought to be progressive and irreversible. The loss of sensations associated with Diabetic polyneuropathy is thought to contribute to impaired balance and increased risk of falling. Reduced toe flexor strength is an independent predictor of falls. However, it is unknown whether strengthening programs can restore toe flexor strength in patients with DPN. The aim of this study was to investigate whether a progressive resistance training program, focused specifically on the foot & toe flexor muscles, could improve toe flexor strength in patients with DPN.

**Methods:** A total of 20 patients were allocated into two groups of 10 each. Group A receive 12 sessions of (Conventional physiotherapy & Modified toe training programme) and Group B (Conventional physiotherapy & General toe exercise). Berg balance score (BBS), Fall efficacy scale international (FES-I) & Time up and go test (TUG) were measured on first day (Week 1) and last day (Week 4) of intervention. Pre-test and post-test scores were compared and results were tabulated.

**Result:** Both groups showed significant improvement in balance performance. The Group A showed statistically significant improvement in static & functional balance when compared to Group B.

**Conclusion:** The study demonstrated a significant improvement in balance and functional mobility was seen among Group A.

Keywords: Diabetic polyneuropathy, Toe flexor strengthening, BBS, FES-I, TUG.

## INTRODUCTION

Diabetes mellitus (DM) is a fast growing chronic metabolic disorder resulting from a defect in insulin secretion, insulin action or both. According to predictions from 2019, 77 million people in India had diabetes, and by 2045, that number is predicted to reach over 134 million. DM is the most common endocrinal disorder in which insulin deficiency results to persistent hyperglycemia with disturbance of carbohydrate, fat, and protein metabolism. As

the condition worsens, tissue or vascular damage occurs, which can cause serious diabetic side effects such as impairment of immune system, retinopathy, neuropathy, nephropathy, cardiovascular problems, somatic and autonomic neuropathy, diabetic foot and ulceration.<sup>1-3</sup> Diabetes has an impact on the peripheral nervous system, and the most frequent complication of diabetes is diabetic polyneuropathy (DPN).

The prevalence of DPN ranges from 2.4% to 78.8% worldwide and the risk factors

**Corresponding author:** Saifuddin Khand, PG Scholar (Neurology & Psychosomatic Disorders) Kspr, Kpgu, Vadodara, Gujarat, India

Email: Saifuddinkhand40@gmail.com

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include age, male gender, chronicity of diabetes, uncontrolled glycaemia, overweight and obesity, insulin treatment, smoking and hypertension.<sup>4,5</sup>

The most frequent symptoms therefore seen are sensory and motor in character; as a result, patients frequently complain of pain, signs of discomfort such as burning pain, sharp shooting pain, feeling of numbness, extreme sensitivity to touch and the glove and stocking distribution in the distal part of hand and feet.<sup>6</sup> When the condition worsens, patients may experience motor [system] involvement, like wasting of interossei in hands, weakness and atrophy within feet and lower extremity, slower movement of feet, unstable gait, diminished reflexes, postural instability, anxiety, depression and frequent fall.<sup>7</sup>

Currently, diabetic peripheral neuropathy is most frequently blamed for older persons with type 2 diabetes' with decreased balance and accompanying higher risk of falling (DPN)<sup>[8]</sup>. The incidence rate of falls in elderly individuals with diabetes is 78% as compared to 30% in healthy elderly individuals; further, the fall risk rate 11.5 times higher in elderly patients with DPN than in normal people.<sup>9</sup> Maintaining balance is a difficult skill that requires the combination of numerous sensorimotor and cognitive processes, and age-related decline in both the sensorimotor and cognitive systems can impair the balance ability, hence for older persons with type 2 diabetes fall must be reduced to maintain independency, quality of life, and physical function<sup>[8]</sup>. The abundance of literature proposed that physical therapy [aerobic exercise, resistance exercise or both] play a major role in controlling blood glucose level, decreasing body weight, improving muscle quality, gait, balance and QOL in patient suffering from DPN.<sup>9</sup>

The primary role in balance is recognized by large muscle groups, such as the trunk, hips, knees and ankles, but the contribution of the toe flexor muscles to the integrated physiological balance systems throughout the body is less understood. Each of the ten toe flexor muscles contributes to motion of the foot when leg is free in space and when in contact with the supporting surface. Each muscle is classified as extrinsic - with muscle bellies in the posterior lower leg, or as intrinsic -

with muscle bellies within the plantar aspect of the foot.

In the upright position, there is an adequate generation of a plantar flexor torque by the toe flexors which prevents the anterior displacement of the center of mass beyond the base of support. The toe flexor Group actively contracts to stabilize the foot in response to constricting Muscle strength becomes more active with increased postural control demands while standing on one leg and while walking<sup>[10]</sup>. The current study will be designed with the goal of comparing the effectiveness of general toe exercises or modified toe training programme along with conventional therapy in addition to diabetic polyneuropathy patients to improve balance and reduce the risk of fall.

## METHODOLOGY

20 patients were recruited from shivay hospi care and Vallabh hospital Vadodara based on inclusion criteria. Patients were without severe cognitive or physical impairment (i.e., they were able to walk and transfer independently). Written informed consent was taken from all the patients who actively agreed to participate in the study. Patients were allocated randomly in 1:1 ratio either of modified toe training programme or general toe exercise in DPN patient.

Conventional therapy was remaining same in both the groups and baseline data were obtained. Before intervention Berg balance score [BBS], fall efficacy scale international [FES-I] & Time up and go [TUG] test were noted. Both the groups were given intervention of 12 sessions in 4 weeks. (3days/week). Post intervention again data were obtained for BBS, FES-I & TUG.

Inclusion criteria<sup>11</sup> for the study were Age 55 to 75 year old Patients diagnosed with DPN and referred by diabetologist, ability to understand instruction, Patient who actively participate in the study

Exclusion criteria<sup>11</sup> - Patient who experienced pain or having symptoms of rheumatoid arthritis, Impairment of central and peripheral nervous system, Taking medication that could impact stability of patient during Treatment,

Lower extremity complications such as fracture , experienced dislocation in lower limb at least six months prior to the study , having history of surgical operation in muscles, bones, and joints of lower extremities, THR, AVN, TKR, and knee joint flexion contracture, interruption of the intervention for more than two sessions.

### **INTERVENTION<sup>12, 13</sup>**

**Group A:** Patients received conventional physiotherapy + modified toe training exercise programme.

**Group B:** Patients received conventional physiotherapy + general toe exercise.

### **CONVENTIONAL THERAPY: -**

- Relaxed deep breathing exercise.
- Range of motion exercises for ankle joint.

### **Static Balance training exercise**

- Standing and hip flexion along with knee flexion for 10 seconds hold in each leg [5 times].
- Standing and hip extension for 10 seconds hold in each leg [5 times].
- Standing and side leg raise for 10 seconds hold in each leg [5 times].

### **Functional balance training:**

- Sit to stand [5 times].
- Standing weight shift [5 times].
- Functional reach sideward and forward for touching targets set by the therapist [5 times].
- Bilateral heel rise for 20 seconds [5times].
- Unilateral standing 15 seconds [5 times].

### **Gait Training:**

- Tandem walking.
- Spot marching.

### **GENERAL TOE EXERCISES: -**

It consisted of eight general foot exercise that have no resistance which include general toe exercises that is toe squeezes, toe pulls, marble pickup and towel pulls and the short foot exercise and at last cool down phase consisted of rolling a ball underneath each foot for 2 minutes.

### **TOE TRAINING EXERCISE PROGRAMME:**

**Short foot exercise:** - Patient will be asked to raise his arch of foot by sliding his big toe toward his heel without curling his toes or lifting his heel [3 x 5 reps on each foot, holding position for 5 sec. And later progression to 5x5 reps on each foot, hold for 10 sec.]

**Toe flexion:** - Theraband was placed over the sole of patient foot with one end under the heel and the alternative was over the toes and, patient was asked to keep foot in neutral position and flexed his toes downward into the band. Hold and slowly return back to normal position [2 x 10] yellow band, later progresses to [2 x 10 blue band].

**Hallux flexion:** -Same as above but the theraband was wrap solely around patient's big toe. [2 x 10 yellow band later progressed to 2 x 10 blue band].

**Big toe pull:-** Band was placed around patients big toes and hold the end of bands in opposite hands. Patient's heel will remain on ground only and patient was asked to pull his big toes away from each other or towards the little toes. [1 x 10 yellow band, hold for 5 seconds, later progressed to 1 x 10 blue band].

**1 COOL DOWN PHASE [3 - 5 MIN]:-** plantar fascia stretch.

### **OUTCOME MEASURES<sup>14,15</sup>**

#### **BBS [BERG BALANCE SCORE]**

Berg Balance Score is used to test static and dynamic balance. Patient were asked to fill 14 item scale which were containing simple task, after each task scoring were done from 0 [unable to perform task] to 4 [Independent performing task]. At last summing of all score was performed. Lower score indicate severe balance impairment.

#### **FES -I [FALL EFFICACY SCALE – INTERNATIONAL]**

It is used to measure falling likeliness. Patients were asked to fill self 16 item questionnaire related to routine work. Score range from minimum 1 [means not concerned] to maximum 4 [very concerned]. Higher the score of FES-I indicate more chances of fall.

**TUG [TIME UP AND GO TEST]-**

It is used to screen for balance problems in older people. The TUG test consist of the participant getting up from a chair, walk 3m, turning at a designed spot, returning to the seat and sitting down. The time taken to perform the test was measured using stopwatch.

**STATICALLY ANALYSIS**

Descriptive statically analyses obtain use in zrequency, percentage, mean, SD, CI, median & IQR. Paired t-test use for the comparison of pre and post data within group. Unpaired t-test was used for the comparison of data between Group-A & Group-B. All the statically analysis wasperformed by using IBM SPSS version 29.0.0.

**RESULT**

Table 1 depicts pre & post comparison of mean SD of BBS , FES-I & TUG score between Group A & Group B

0A significant improvement was found in the group A of age (68.73±4.42) in which total number of (male-2 & female-8) who received conventional physiotherapy & Modified toe training programme (42.8±4.70 in BBS) compared to Group B of age (69.5±3.43) in which total number of male-4 & female-6) who received conventional physiotherapy & general toe exercise (37.2±3.79 in BBS) (p<0.0089) considering significance level at p<0.0 Followed by 4 week period for both the group.

Significant effects were found for single leg standing balance with eyes open & reach out activities in modified toe training programme group whereby there was less effect was seen in the Control group.

A positive significant improvement was found post intervention in item 11(walking on a slippery

surface), followed by items 14 and 15 in FES-I in group A [33.4±5.58], when data were combined from both the groups, FES-I were not significantly improved in the group B (40±6.46) (P<0.025) considering significance level at p<0.05.

In TUG both the groups showed a significant improvement, indicating a better improvement in dynamic balance ability. however, there was a greater improvement seen in TUG performance in GROUP A (17±2.49) who received modified toe training programme compared to group B (19.4±5.03) who received general toe exercise (P<0.19) considering significance level at p<0.05.

**DISCUSSION**

The aim of the study was to investigate the effects of conventional balance training along with toe training programme and conventional balance training along with general toe exercise on static and dynamic balance and fall efficacy in patients with diabetic neuropathy.

The result of the present study findings showed that both the treatment protocol shows improvement in dynamic and static balance abilities (BBS, FES-I and TUG), but toe training programme is more effective protocol to improve static and dynamic balance significantly and reduce risk of falling after toe flexor strengthening.

Individual’s balance is a complex multidimensional concept related to postural control, which essentially refers to the ability to maintain posture (e.g. sitting or standing), to move between postures, and to not fall when responding to external disturbances, balance and strength training can help prevent two-thirds of falls and even fatalities.<sup>16</sup>.

The toe flexor muscles perform a crucial function to control foot movementand assist with the propulsive force when walking. This is

**Table 1: Comparison of pre and post mean SD of BBS, FES-I and TUG of both the groups**

	BBS		FES-I		TUG	
	Pre	Post	Pre	Post	Pre	Post
Group-A	31±5.73	42.8±4.70	39.6±6.83	33.4±5.58	20.9±2.72	17±2.49
Group-B	30.4±4.83	37.2±3.79	42.9±5.91	40±6.46	21.5±4.03	19.4±5.03
p-value	0.80	0.0089	0.26	0.025	0.70	0.19

achieved by the contraction of the muscles at the late stance phase in the gait cycle, it was estimated that the muscles of the flexor hallucis longus, brevis, flexor digitorum longus and brevis exert forces of approximately 52%, 36%, 9% and 13% of body weight during propulsion, respectively.<sup>17</sup>

According to Shogo Misuit et al it was demonstrated that aging is associated with reduced toe flexion strength, and that toe deformities were associated with weak toe flexor strength. In addition, older people with reduced toe flexor strength had impaired balance function and a higher risk of fall.<sup>17</sup>

Our study also supports Koutatsu Nagai, RPT, MS et al whose purpose of this study was to investigate the effects of toe and ankle training for the elderly to improve Muscle strength, physical function and fear of falling. A significant improvement was found in quadriceps strength, functional reach and possible improvement in toe flexor force. This approach may help elderly individuals to maintain their activity level without increasing risks.<sup>18</sup>

These results indicate an important contribution of toe function to dynamic balance. The functional reach test includes a forward shift of the center of pressure. Improvement in toe function could be one of the factors involved in the increase in reach distance in the present study.<sup>18</sup>

Our study also support Hiroaki Kataoka et al whose purpose of study was to investigate the effect of short-term toe resistance training on Toe Pinch Force in patients with T2DM, and demonstrated significantly increased the TPF in the T2DM patients. Toe resistance training is thus recommended in clinical practice for patients<sup>[19]</sup>

Our study also supports Allet et al. This showed that functional balance and walking ability are significantly increased by a combination of resistance training, balance training, and walking for 12 weeks.<sup>20</sup>

Our study also support Richardson et al who reported that the results of single-leg standing and functional reach test were

Significantly improved for 3 weeks by resistance training and balance training in

patients with T2DM with diabetic neuropathy. These results suggest that physical therapy could improve motor function in patients with T2DM.<sup>21</sup>

## CONCLUSION

In conclusion, the study demonstrated a significant improvement in balance and functional mobility among participants who received the toe training program alongside conventional physiotherapy (Group A) compared to those who received general toe exercises with conventional physiotherapy (Group B). Group A showed significant enhancements in Berg Balance Scale (BBS) scores, particularly in single leg standing balance with eyes open and reach out activities. Moreover, Group A exhibited positive significant improvements in specific activities related to fear of falling (FES-I items 11, 14, and 15) and performed better in the Timed Up and Go (TUG) test, indicating superior dynamic balance abilities. These findings emphasize the effectiveness of modified toe training program in enhancing balance, functional mobility, and reducing the fear of falling in the studied population.

## CLINICAL IMPLICATION

Including modified toe training exercises in conventional treatment programme can substantially benefit patients by improving their balance and reducing risk of fall among diabetic polyneuropathy patients.

## Limitation of the study

Small sample size and short period of intervention

**Future scope:** Future research with more sample size and long period of intervention.

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**Conflicts of interest:** None

**Source of funding:** Self

**Ethical approval:** Approval was taken from ethical committee.

## ABBREVIATIONS

**DM:** Diabetes Mellitus

**DPN:** Diabetic Polyneuropathy

**BBS:**Berg Balance Score

**FES-I:**Fall Efficacy scale International

**TUG:**Time Up & Go Test

## REFERENCES

1. Bastaki S. Diabetes mellitus and its treatment. *Dubai Diabetes and Endocrinology Journal*. 2005 Mar 1;13(3):111-34.
2. Kaul K, Tarr JM, Ahmad SI, Kohner EM, Chibber R. Introduction to diabetes mellitus. *Diabetes: an old disease, a new insight*. 2013:1-1.
3. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. *Indian journal of ophthalmology*. 2021 Nov;69(11):2932.
4. Román-Pintos LM, Villegas-Rivera G, Rodríguez-Carrizalez AD, Miranda-Díaz AG, Cardona-Muñoz EG. Diabetic polyneuropathy in type 2 diabetes mellitus: inflammation, oxidative stress, and mitochondrial function. *Journal of diabetes research*. 2016;2016.
5. Papanas N, Ziegler D. Risk factors and comorbidities in diabetic neuropathy: an update 2015. *The review of diabetic studies: RDS*. 2015;12(1-2):48.
6. Alam U. Diabetic neuropathy collection: Introduction to diabetic neuropathy. *Diabetes Therapy*. 2020 Apr;11:755-60.
7. Andersen H. Motor neuropathy. *Handbook of clinical neurology*. 2014 Jan 1;126:81-95.
8. Hewston P, Deshpande N. Falls and balance impairments in older adults with type 2 diabetes: thinking beyond diabetic peripheral neuropathy. *Canadian journal of diabetes*. 2016 Feb 1;40(1):6-9.
9. Kaur J, Singh SK, Singhvij J. Physiotherapy and rehabilitation in the management of diabetes mellitus: a review. *Indian Journal of Scientific Research*. 2015;6(2):171-81.
10. Quinlan S, Yan AF, Sinclair P, Hunt A. The evidence for improving balance by strengthening the toe flexor muscles: A systematic review. *Gait & Posture*. 2020 Sep 1;81:56-66.
11. Stolarczyk A, Jarzemeski I, Maciąg BM, Radzimowski K, Świercz M, Stolarczyk M. Balance and motion coordination parameters can be improved in patients with type 2 diabetes with physical balance training: non-randomized controlled trial. *BMC Endocrine Disorders*. 2021 Dec;21(1):1-9.
12. Mickle KJ, Caputi P, Potter JM, Steele JR. Efficacy of a progressive resistance exercise program to increase toe flexor strength in older people. *Clinical Biomechanics*. 2016 Dec 1;40:14-9.
13. Ajitha M. Effectiveness of stability trainer exercises over conventional physiotherapy on balance re-education in patients with type 2 diabetic peripheral neuropathy.
14. Timar B, Timar R, Gaiță L, Oancea C, Levai C, Lungeanu D. The impact of diabetic neuropathy on balance and on the risk of falls in patients with type 2 diabetes mellitus: a cross-sectional study. *PloS one*. 2016 Apr 27;11(4):e0154654.
15. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Physical therapy*. 2000 Sep 1;80(9):896-903.
16. Fangxin WE, Ziqi HU, Ruiyao HE, Yu WA. Effects of balance training on balance and fall efficacy in patients with osteoporosis: A systematic review and meta analysis with trial sequential analysis. *Journal of rehabilitation medicine*. 2023:55
17. Misu S, Doi T, Asai T, Sawa R, Tsutsumimoto K, Nakakubo S, Yamada M, Ono R. Association between toe flexor strength and spatiotemporal gait parameters in community-dwelling older people. *journal of neuroengineering and rehabilitation* 2014 dec;11:1-7
18. Nagai K, Inoue T, Yamada Y, Tateuchi H, Ikezoe T, Ichihashi N, Tsuboyama T. Effects of toe and ankle training in older people: a cross-over study. *Geriatrics & gerontology international*. 2011 Jul;11(3):246-55.
19. Kataoka H, Miyatake N, Muraio S, Tanaka S. A randomized controlled trial of short-term toe resistance training to improve toe pinch force in patients with type 2 diabetes. *Acta Medica Okayama*. 2018;72(1):9-15.
20. Allet L, Armand S, De Bie RA, Golay A, Monnin D, Aminian K, Staal JB, de Bruin ED. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. *Diabetologia*. 2010 Mar;53:458-66.