

# Effectiveness of Home-Based Activities on Functional Balance and Mobility of Indian Older Adults with Diabetic Neuropathy

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DOI: <https://doi.org/10.52403/ijhsr.20230917>

## ABSTRACT

Diabetic Peripheral Neuropathy (DPN) is the most prevalent and chronic complication of elderly diabetics, occurring in up to 65% of elders with diabetes. Falls in this vulnerable population pose a significant burden to the healthcare system. An association between increased fall risk and DPN has been established. Postural instability, gait and balance problems provide the ground for falling and increased risk. There is a need to develop strategies to improve balance and efficiently train older adults with DPN to reduce falls and control factors leading to risk of falling. Various balance training interventions have been applied and studied. It has been found that a simple, specific, integrated, and convenient training program to improve balance and mobility within the home setup provides better opportunity to achieve this goal for DPN. For this purpose, a home activities-based training program was designed and studied. Pre and post evaluation of functional balance and mobility was done using Berg Balance Scale, Timed Up and Go test and Functional Reach Test. Forty Indian community dwelling older adults aged 60 years and above with a diagnosis of DPN were included with exclusion of those having any other conditions causing balance impairments. The paired t-test was used to compare the effects of training ( $p \leq 0.05$ ). The trial showed improvements in functional balance and mobility of elderly with DPN. Thus, a home activities-based program amalgamating proprioceptive, mobility and biomechanical strategies can be applied to improve functional balance in Indian community dwelling older adults with DPN.

**Keywords:** Diabetic Peripheral Neuropathy (DPN), Falls, Elderly, Balance, Home based activities program

## INTRODUCTION

The One of the most frequent chronic diseases which have increased globally is diabetes mellitus as mentioned by Javadzadeh et al. 2013.[1] Diabetic Peripheral Neuropathy (DPN) is the most common complication of elderly diabetics, occurring in up to 65% of elders with diabetes.[2] DPN is longstanding and deteriorates with passage of time.[1] In developing countries, DPN has been associated with complications of type 2 diabetes mellitus on a rapidly increasing rate

and the prevalence has ranged from 13% to 68% in the diabetic population in 2009.[3] A strong association has been established between increasing age and poor balance. Also, an association between increased fall risk and DPN has been established.[4] A high incidence of falls in the elderly with DPN of up to 65% had been cited by Pan and Bai in 2014. Similarly, an occurrence of falls was found to be 79% in elderly with DPN in the same study.[2] Further, poor balance has been associated with having diabetes. Postural instability, gait and

balance problems provide the ground for falling and increased risk. In their study, Stevens et al. found that 16% diabetics had affected balance.[5]

Falls in the older adults with DPN pose a significant burden to the healthcare system [6] identified as the most common cause of death in people aged 65 years and above. DPN is defined as a complex and progressive disorder with symmetrical distal degeneration of peripheral nerves leading to symptoms of pain and sensory loss as characteristic features.[1] It is the damage to the sensory and motor nerves of the feet, legs, hands, and arms in response to long term elevation of blood glucose levels and is associated with pain, paraesthesia, sensory loss, muscle atrophy with fat infiltration, and muscular dysfunction in the limbs.[7] These symptoms lead to falls and have an impact on both physical and mental quality of life. Several factors predispose older adults with diabetes mellitus to a higher risk of falls. DPN is one of three major risk factors identified for falling in patients with diabetes along with retinopathy and vestibular dysfunction. Patients with DPN are two to three times more likely to fall than those with diabetes and no neuropathy.[8]

Akbari et al. precisely presented the eloquent role of DPN in falls among older adults. They explained that peripheral neuropathy caused by diabetes leads to balance disorders with increased postural sway specially with eyes closed. DPN causes significant impairment in sensation in the feet that reduces balance ability during activities of daily living. This deficient balance can be due to proprioceptive impairment, movement strategy impairment, biomechanical structural disorders, and disorientation. People with diabetic neuropathy face balance problems even with open eyes which make them vulnerable to falls.[9] Individuals with diabetic neuropathy suffer from postural instability, impaired gait, and report an increased incidence of falling. An association between increased risk of fall

and DPN has been established in a review by Khan et al. as well [4]. Pan and Bai et al. have further cited that elderly with DPN were 23 times more likely to fall and are 15 times more likely to report an injury compared with matched non neuropathic subjects from previous studies by Cavanagh et al. [2] They emphasised on the importance of active interventions to reduce risk of falls prevent falls in elderly with DPN [2]. As cited by Hassani et al, the complications of DPN include loss of vibration sense, reduce tactile sensitivity, proprioception deficiency, decreased muscle strength, and changes in balance and gait patterns.[3] This, further results in reduced performance and the vicious circle goes on. The complications of DPN lead to decrease in balance& equilibrium, which is an integral part for doing activities of daily living. This leads to doing of lesser activity resulting in reduced range of motion, decreased strength, and deterioration of gait biomechanics and balance. Further, the subject adopts the strategy of slowness in a gradual manner, and thus completes a cycle of vicious circle.[10]

Literature provides support with studies concluding that rehabilitation interventions can improve gait parameters, balance, and function in people with DPN.[11] A combination of various training methods including lower limb muscle strength, proprioceptive training, balance and walking tasks, have been found to have better effects on improving balance and reducing falls in DPN in older adults.[2,12,13] In a scoping review Hassani et al. suggested the duration of interventions to be ranging from 2 to 12 weeks, however the studies significantly differ in terms of intervention components. It was concluded that rehabilitation interventions are effective in improving balance, proprioception, coordination of lower limb muscles, and muscle strength.[3]

In a nutshell, there is a tangible need to develop strategies to improve balance and mobility. As well as it is also needed to efficiently train older adults with DPN to

reduce falls and control factors leading to risk of falling.[14] Therefore, the need to design and apply an active rehabilitation program to improve the functional balance and mobility to reduce the risk of falls in elderly with DPN is of utmost importance. This would consequently reduce morbidity and improve their quality of life.

## **MATERIALS & METHODS**

### ***Development of the Home-Based Program (HBP)***

Various factors affecting balance and mobility and methods to improve them were examined and feasible solutions drawn on basis of which the Home-Based Program (HBP) has been designed.

#### **A) Components of balance and mobility**

1. Firstly, the major building block of balance and mobility i.e., proprioception and impact of its alteration was considered. Somatosensory inputs from the legs and feet contribute to postural stability during normal standing.[15] The presence of neuropathy is associated with an increased body sway, faster sway speed and greater sway dispersion during bilateral stance with eyes open while the values exceed with eyes closed when compared to controls. Maximum step length having poor relation with balance and mobility is found to be reduced in patients with DPN.[16] Decreased proprioception and increased reaction time lead to postural instability and balance disorders associated with DPN.[10] Patients with DPN walk slower with shorter stride length and lower cadence as compared to healthy controls.[16] Patients with DPN are at an increased risk of falls due to decreased accuracy of progress safety feedbacks.[17] Thus, any changes in shear stress and pressure on the soles of the feet during standing tasks can stimulate mechanoreceptors to the higher nervous centres which leads to increased balance ability in patients with diabetic neuropathy [9]. Further, in a

randomised control trial done in India in 2019 by Ahmed et al. found improvements through sensory motor and gait training in patients with DPN.[16]

2. The next stimulus impacting balance and mobility under consideration was vestibular input. Kim et al. found nearly 60% incidence of vestibular dysfunction in elderly patients with DPN. They suggested that this could lead to decline in capabilities of brain to integrate information and decline balance function and increase the risk of falls. Moreover, training of vestibular function in this population could make correct understanding of sensory signals into the brain faster and promote correct judgement of motion response by sensory reorganization and enhance balance further leading to reduced risk of falls.[13] Vestibular training exercises have shown improvements in the ability to stabilize, as well as significantly positive changes in dynamic and static balance in elderly with DPN [9,18]

3. Multiple studies have indicated that the combined impact of aging and DPN may cause muscle degeneration leading to weakness and loss of lower limb muscle strength and increased risk of falls.[2] Adequate muscle strength is essential for performance of appropriate functional balance and mobility. Thus, strengthening of lower extremity muscles in patients with DPN can enhance the elderly balance and reduce occurrence of falls. Previous studies related to balance training as a function was then investigated. It has been recommended to develop balance training programs for reducing fall risk in elderly with DPN.[2] Balance training on stability trainer proved beneficial in improving functional balance in diabetic patients with distal sensory neuropathy.[19] It was hence decided to combine lower limb strength training in the exercise program.

Hence, it was inferred that a combination of proprioceptive training, vestibular training, and lower limb strength training, could enhance balance and reduce its risk of falling in elderly with DPN from different aspects [2]. Likewise, it is mentioned that training of muscles around the ankle when combined with balance training interventions could enhance balance in elderly with DPN.[2] Including specific foot related exercises have additional effects on foot strength functionality and mobility in people with DPN.[20] Additionally, it was found that the effect of ankle proprioceptive training was more effective in improving gait and reduction of risk of falls in the patients with diabetic neuropathy.[21] Therefore, a combined training of more than one of these constituents of balance and mobility provides better ground for improved functionality of balance and gait, ultimately reducing the chances of falling in elderly.

Considering such multifactorial composition of balance and mobility, approach towards managing diverse components leading to falling in elderly with DPN have been referred to and investigated time and again. Bored et al. examined the long-term effects of multicomponent exercise program on balance mobility and exercise behaviour in healthy older adults. Significant improvements from baseline standing, TUG and sway was found in participants who continued exercising.[22] Efficacy of exercise rehabilitation program was evaluated on the gait of DPN patients in Egypt in 2014[23]. Studies have shown that collective form of movements and home exercise training could improve the exercise motivation and maybe effective to improve compliance or adherence to the program in elderly with DPN.[2]

## **B) Duration of Program**

The next step was to decide the duration of the program. Various public health guidelines have been recommended for the management of diabetes which includes many exercise programs. Most of these

programs involve a minimum of 30 minutes per day to maintain gait security and balance. The duration of interventions was found to be ranging from 2 to 12 weeks in a scoping review.[3] In addition, recommendations were considered for older adults with diabetes mellitus to choose a lower resistance, low intensity, usage of major muscle groups of movements during exercises. [24,25] Review of literature supports that exercise-based interventions of more than equal to 4 weeks are beneficial for patients with DPN.[7]

Based on existing literature, evidence, ideas and experiences in the clinical practice in consultation with experts, the components/home-based activities were finalised and woven into a training program to improve functional balance and mobility of elderly with DPN. After contemplating the above, a simple, specific, integrated, and convenient training program within the home setup was formulated, targeting functional balance and mobility that would ultimately prevent and reduce falling for this population. Thus, the Home-Based Program (HBP) was formulated as described under.

### ***Home-Based Program (HBP)***

This is a simple, specific, integrated, and convenient training program to improve balance within the home setting for training Indian community dwelling older adults designed for training older adults with DPN. The comfort of home and utilisation of activities easily available at convenient time provide better opportunity to achieve this goal for this population. These activities encompass proprioceptive, movement and biomechanical strategies to improve balance. This is a six week home based training program (3 times a week), with maximum of 30 minutes duration at a stretch and 1 minute break in between the activities.

The six activities composing HBP, and their dosage are as below:

- Weight bearing on each leg (10 seconds each x 5 times per leg)

- Standing on a medium height pillow (approximately 2 inches) with arm raises in front (10 movements)
- Ankle movements on the rolling pin medium size (approximately 2 inches diameter) (10 repetitions)
- Straight line walking to 3 metres with or without assistive device (3 repetitions)
- Side walking to 1 meter each on both sides with or without assistive device (2 repetitions)
- Figure of eight walk with or without assistive device (1 round clockwise and anticlockwise each).

### ***Sample Size and Participants***

Forty Indian community dwelling older adults aged sixty years and above with a diagnosis of DPN were recruited from Jaipur and Delhi via convenient sampling. Assessment of eligibility and recruitment of participants will be based on the inclusion and exclusion criteria. Inclusion criteria are of subjects of age 60 years and above, diagnosis of DPN from a medical expert, Indian community dwelling. Exclusion criteria are those having any other medical and surgical conditions causing balance impairments, hospitalised, institutionalised, and wheelchair bound. The participants had to follow the six-week HBP at their convenience in their home setting as instructed and demonstrated.

### ***Assessments and Measurements***

The demographic information, history taking and confirmed diagnosis of DPN was done in the first meeting with the participant and baseline assessment was done. This was followed by pre intervention recording on the three outcome measures: Berg Balance Scale, Timed Up and Go Test, and Functional Reach Test. This was followed by a re-evaluation at the end of completion of six weeks home activities-based program training and post intervention data recorded. Berg Balance Scale (BBS) is the gold standard test for static and dynamic balance abilities. The BBS is used to measure ability to maintain balance while doing functional

task search as reach, standing position and transferences. It is a valid instrument used for the evaluation of effectiveness of interventions with quantitative description of function in clinical practice as well as research. It consists of 14 items including simple balance tasks from everyday life. The ability of performing each task is rated on a 5-point scale and given a score from zero meaning unable to 4 meaning independent. [10,26] The BBS was found to have good predictive validity for the identification of future fall risk and discriminative ability to predict multiple falls.[27]

The functional mobility was measured using Timed Up and Go (TUG) test which is a reliable and valid test and is useful to measure clinical change over time. It is quick to administer and does not require any training or special equipment. The patient is observed, and time is noted using a stopwatch to rise from an armchair, walk 3 metres, turn, walk back, and sit down again. Static and dynamic balance impairment is demonstrated by a longer duration needed to perform the test. [10,26] The time required to perform the TUG is strongly related to the risk of falls. [16] Lin et al. demonstrated the inverse relationship between the severity of DPN and functional reach.[28] thus with increase in severity of DPN there is a corresponding increase in the risk of falls while performing reaching task in standing position. [6,29]

Functional Reach Test: As the severity DPN increases the performance on functional reach test declines.[6] FRT is a single item test for dynamic balance and acts as a quick screen for balance problems in older adults. The distance between the length of an outstretched arm in a maximal forward reach, while maintaining a fixed base of support is measured. A score of 6 inches or less indicates a significant increased risk for falls. A score between 6-10 inches indicates a moderate risk for falls.[30]

**Procedure:**

The study began with a baseline assessment. Pre intervention assessment on TUG, BBS, and FRT were recorded. Clear instructions and demonstrations of activities of the HBP were given individually in presence of a caretaker. The participants underwent the HBP for 6 weeks (3 times a week, maximum of 30 minutes) at a suitable time in the comfort of their home. The activities utilised simple articles available in the household and needed a break of at least 1 minute between them. The program required the presence of a caretaker or a family member while performance. After completion of the program for 6 weeks, a reassessment on the outcome measures was done and recorded after 6 weeks of HBP.

**STATISTICAL ANALYSIS**

The baseline scores of the variables were compared with the post-training scores of

the variables after completion of 6 weeks of the HBP using the paired t-test. The analysis was done using SPSS 21 software at a significance level of 0.05.

**RESULT**

A total of 48 older adults with DPN diagnosed by the medical expert and fulfilling the inclusion criteria were enrolled in the study. Eight participants dropped out because of associated health issues and inability to come for post intervention assessment. Therefore, 40 participants successfully completed the HBP and reported for reassessment after 6 weeks. These included 19 males (mean age 67.9yrs) and 21 females (mean age 65.6yrs). The participants following HBP reported improved functional balance and mobility than before beginning the program.

Table 1 Pre and Post Training comparison of TUG, FRT & BBS

	Pre-training	Post-training	Mean difference	P value
TUG	19.71±6.26	16.91±5.48	2.79	0.00**
FRT	19.77±5.67	22.59±6.05	-2.82	0.00**
BBS	35.27±9.72	43.80±6.67	-8.52	0.00**

The results of paired t –test for pre-post comparison is presented in Table 1 & Figure 1. It shows that at post-training session the

performance of TUG test significantly was faster (19.71 versus 16.91 second, mean difference=2.79, t=7.27, p=0.00\*\*).

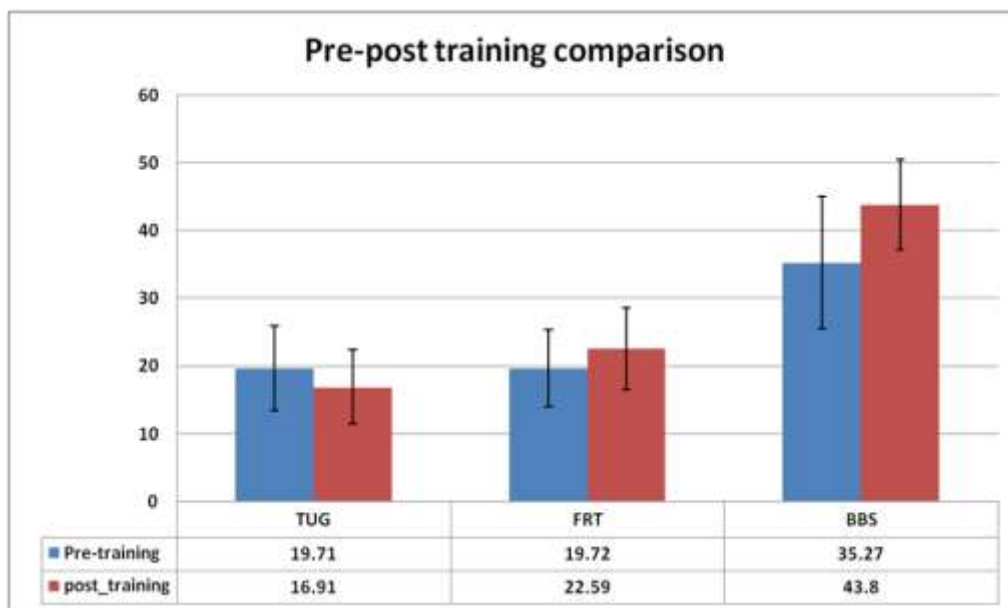


Figure 1. Pre-post training comparison of TUG, FRT & BBS

Similarly at post-training session the performance of FRT test (19.72 versus 22.59, mean difference=-2.89, t=7.53, p=0.00\*\*) & BBS (35.27 versus 43.80, mean difference=-8.52, t=6.54, p=0.00\*\*) was statistically significant. That indicates that the values were better than that at the pre-training session.

**Table 2 Gender comparison of TUG, FRT & BBS (n=19 male, n=21 females)**

Outcome Measure	Gender	Mean ± SD	Mean difference	P value
TUG score pre intervention	Males	21.56±8.22	3.53	0.74 <sup>NS</sup>
	Females	18.03±3.04		
TUG score post intervention	Males	18.68± 6.97	3.37	0.51 <sup>NS</sup>
	Females	15.31±3.04		
FRT score pre intervention	Males	23.99±4.43	8.03	0.00**
	Females	15.95±3.57		
FRT score post intervention	Males	27.16±4.85	8.71	0.00**
	Females	18.45±3.52		
BBS core pre intervention	Males	37.79±7.34	4.79	0.121 <sup>NS</sup>
	Females	33.00±11.22		
BBS score post intervention	Males	44.68±6.18	1.68	0.432 <sup>NS</sup>
	Females	43.00±7.13		

Furthermore, the gender wise comparison using unpaired t test revealed that there was no statistically significant difference between scores of TUGS, BBS & FRT. (Table 2)

Observations/Results of your study should be written in this section along with tables/charts/figures etc. write serial numbers and appropriate heading/title of tables and legend/caption of figures.

## DISCUSSION

The study showed that the HBP is a simple, specific, integrated, and convenient training program to improve functional balance and mobility for community dwelling older adults with DPN. The HBP may prove to be beneficial to this population at large and reduce falls and their complications in older adults with DPN. Understanding the high prevalence of Diabetes with around 1/3 of the diabetic population affected with neuropathy draws attention of all professionals. The associated balance and gait problems are exhibited by around one third of individuals with DPN. [16] It has been reported in the literature that presence of diabetic neuropathy in patients with diabetes mellitus is associated with compromised balance during daily activities and lead to decline in mobility, activity avoidance, institutionalization, and mortality with 5-fold increased risk of falling.[26]

This chain of subsequent reactions was identified and the work on application of

training a combination of various strategies of balance training in elderly with DPN was revisited. It was concluded that Balance training could improve balance in elderly with DPN and reduce their risk of falling. The major reasons for impaired balance in elderly with DPN were identified in relation to existing literature including deterioration of proprioceptive, vestibular, and lower extremity muscle strength.[31] It was concluded that mixed training relatively has better impact on improvement of balance and reduction of falls in elderly with DPN.[2] The opportunity for such training could be derived from the context of maximum interface and maximum comfort with the elderly. Nothing else could have replaced the home setting for this purpose. Hence, the need of a home-based rehabilitation program which is simple yet specific and convenient to reduce the risk of falls in elderly with DPN, to achieve better balance and mobility in elderly with DPN and lead to prevention and reduction of risk of falling and ultimately improve their quality of life.

Participants reported the program to be convenient as the materials required were found in almost every Indian household that improved the feasibility of the program. Another feature was the flexibility component that reportedly allowed compliance of this group of participants and was appreciated by the participants. The findings of this study are consistent with the previously reviewed rehabilitation

interventions that demonstrated effectiveness of rehabilitation interventions in gait and balance improvement. [3] Balance training is an important way towards prevention of falls in older population. [16]

Multiple reviews have been done supporting the efficacy of exercises to improve balance characteristics in older adults and elderly with DPN.[5,16,28] Thus, the increase in the mean BBS scores of participants demonstrated the efficacy of HBP in improving static as well as dynamic balance performance. An increase in the severity of DPN has been associated with a higher risk of falling during performance of functional reach.[6,29]The participants could reach farther as indicated by the significant difference in the functional reach test values with training on HBP. This is again an indication of improved dynamic component of functional balance, on completion of the program. On analysis it was found that the time taken in TUG test for participants decreased significantly with the 6-weeks HBP training indicating better functional mobility. The improvements are indicative of better functional balance and mobility of the Indian community dwelling older adults with DPN with the program followed by the older adults with DPN living in the community at the comfort of their homes at their convenience. The program may hence prove to be a feasible and crucial answer for preventive, remedial as well as maintenance of direct and indirect impact of DPN in elderly. Small sample size and lack of control group are limitations of the study. Multiple other components like follow up, impact on other components like muscle strength and cognitive capabilities were not studied and the program was based only on performance basis to allow inclusion of older adults with varied activity levels and age variations. Future studies on larger population and control studies may be taken up to generalize the results to this vulnerable population at large.

## CONCLUSION

The HBP designed and applied to Indian community dwelling older adults could achieve the desired improvements in balance and functional mobility. The study provides a simple, feasible, cost effective, home activities based, convenient yet specific regime of combined interventions to improve functional balance and mobility in Indian community dwelling older adults with diagnosis of DPN.

### *Declaration by Authors*

**Ethical Approval:** Approved

**Acknowledgement:** None

**Source of Funding:** None

**Conflict of Interest:** The authors declare no conflict of interest.

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- How to cite this article: Archna Kaushik, Akhilesh Shukla, Madhuchhanda Mohanty. Effectiveness of home-based activities on functional balance and mobility of Indian older adults with diabetic neuropathy. *Int J Health Sci Res.* 2023; 13(9):101-110.  
DOI: <https://doi.org/10.52403/ijhsr.20230917>

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