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RESEARCH ARTICLE

EFFECTS OF SENSORY TRAINING OVER TWO DIFFERENT SURFACES ON BALANCE AND GAIT IN PERSONS WITH DIABETIC NEUROPATHY

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ABSTRACT

Alteration in the proprioceptive feedback from the support surface is thought to produce more improvement in balance and gait in patients with diabetic neuropathy. This study assessed the effects of multisensory training over two different surfaces on balance and gait in persons with diabetic neuropathies. Thirty Six persons with peripheral neuropathies were enrolled, randomized, and subdivided into 2 groups. Group A practiced a multisensory exercise programme over wobbly surface (Wobble Board) and Group B received Multisensory training on compliant surface (balance Pad) for 30 minutes, 3 times in a week over 6 weeks. Outcome measures used were 'timed up and go' test for assessing balance and '6-mintes walk test' for gait. By the end of the trial period, both groups showed a significant improvement in scores of the 'timed up and go' test, and '6-minute walk' test scores. But Group A Showed Statistically significant improvement as compare to Group B. The findings suggest that Wobbly (dynamic) surface is more effective as compare to compliant surface in improving balance and gait in persons with diabetic Neuropathy.

INTRODUCTION

Diabetes mellitus (DM) is emerging as a pandemic, with high social and economic costs. India has the highest number of diabetics of all the countries in the world, with over 30 million people now diagnosed with diabetes (Diabetes.co.uk). On average, symptoms begin 10 to 20 years after the diabetes diagnosis. Approximately 50% of people with diabetes will eventually develop nerve damage.[1] Type2 diabetes mellitus and its common complication, peripheral neuropathy, affect a large population. The prevalence of neuropathy increased with increased in age and duration of diabetes.[2]

Proprioception is the ability to perceive position and movement. This ability allows for the monitoring of the progression of any movement sequence and makes later movements possible. It is a sensory modality mediated by mechanoreceptors, which are receptors found in muscles and neuro tendinous organs. The function of mechanoreceptors is to discriminate between temporal and spatial information about pressure of contact on the feet[4,5].When the sensitivity in the sole of the foot and the information coming from mechanoreceptors is decreased, there is a decline of balance in the elderly and in individuals with diabetes.

DPN is defined as "the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes". (Boulton *et al*., 2005) Clinically, DPN presents as abnormalities in sensory and sometimes motor function in the lower Legs and the hands. Generally, sensory abnormalities in the lower leg present earlier in the Progression of DPN than motor abnormalities and the hands are usually involved only in more Severe cases of DPN. (Vinik & LeRoith, 2008) Symptoms of DPN are often stocking-like in Nature and may include burning or aching pain in about 50% of individuals with DPN; however, Others may report painless, numb feet. (Vinik & LeRoith, 2008) Clinical signs of DPN are more consistent than symptoms and usually include some degree of bilateral lower extremity loss of touch, pressure, vibratory, position, and temperature sensory perception and decreased ankle reflexes. Patient presents with depends on whether large and/or small nerve fibers are affected. Diabetes can increase accidents through poor balance issues due to numbness in the toes and feet

Sensory component of peripheral neuropathy causes gradual loss of sensitivity to pain, perception to plantar pressure temperature and Proprioception and can lead to postural instability.[3]

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Balance is common problem in diabetic neuropathy. It is seen that balance training with altered sensory input is better compared than without altered sensory Input. So this study is directed towards giving balance training with sensory re-education for improving balance and quality of life in diabetic neuropathy. Reduced balance is affected by decreased vibration sensitivity which triggers imbalance problems and cause injurious accident. Balance is controlled on the basis of afferent information from somatosensory input, visual and vestibular system. The first two systems are often affected in presence of diabetic neuropathy.

Diabetic persons with peripheral neuropathy have lower gait velocity, decreased cadence; shorter stride length, increased stance time and higher step to step variability compared with healthy Individuals. These gait alterations increase on irregular surfaces. Allet *et al* (2009) also found lower limb strength, fear of falling and sensory problems to be related to spatiotemporal gait alterations.[6]Additionally, persons with peripheral neuropathy show postural instability with

a larger centre of pressure displacement, higher sway area and greater instability when standing still with eyes closed (Lafond *et al,* 2004). Simoneau *et al* (1994) reported that postural instability was further found to be significantly associated with sensory neuropathy.

Walking and balance are both critical for independence in activities of daily living (Prasansuk *et al,* 2004). Recent studies show that people with diabetes are 15 times more likely to fall when walking than those in the same age-matched population of people without diabetes (Dingwell& Cavanagh, 2001). Individuals with PN exhibit reduced physical activity, standing balance, mobility and independence. They walk 20-30% slower than age-matched healthy controls. It has been demonstrated that those with greater PN-related loss of plantar cutaneous sensation tend to move with slower preferred walking speed (PWS). It has therefore been argued that this "cautious" gait strategy is the primary compensatory mechanism employed to maintain safe walking patterns under conditions of reduced sensation (Menz *et al*, 2004).

PN can interrupt the afferent and efferent functions of the lower extremities that are responsible for maintaining normal posture and normal walking. In consequence, Proprioception is lost. When there is a decrease in sensitivity of the sole of the foot and in the information coming from mechanoreceptors, balance declines in the elderly and in persons with diabetes. Separate somatosensory, visual and vestibular inputs comprise the primary sources of information that contribute to postural orientation. The process of melding these three distinct senses into a single unified perception of body-in-space is "sensory integration". Multisensory intervention emphasizes the stimuli to sensory systems. Postural sway in these patients is increased, especially with the eyes closed [6]. Peripheral neuropathy caused by diabetes causes significantly impaired sensation in the feet, reducing patients' ability to control their balance properly during daily activities [7]. Poor balance can be due to proprioception impairment [8]. Balance problems are also caused by movement-strategy impairment, biomechanical structural disorders, and disorientation [9]. People with diabetic neuropathy have balance disorders even with open eyes, making them vulnerable to falls [12].

A better understanding of gait and balance may represent an important aspect of diabetes management for safety. Shorter stride length, increased stance time and higher step to step variability compared with healthy controls. These gait alterations increase on irregular surfaces. Allet *et al* (2009) also found lower limb strength, fear of falling and sensory problems to be related to spatiotemporal gait alterations.

Balance training is utilization and integration of appropriate sensory systems. Normally three sensory source of inputs are utilized to maintain balance: somatosensory inputs ,visual inputs and vestibular inputs.5The background of the dynamics of balance and the deficits in these areas among ambulatory diabetic, it is postulated that the balance training in ambulatory diabetic may be a useful exercise and may result in better out comes and improved function.14Within this context, physical activities directed at improving proprioception and balance can reduce morbidities related to ageing and diabetes, with significant effects observed after 12 weeks of training9,10

No definitive treatment for diabetic neuropathies has been reported, and very few studies have been published on the role of exercise in reducing either the symptoms or incidence of diabetic neuropathies. Only a few studies have evaluated treatments that aim to improve gait and balance, and decrease fall risk (Petrofsky, 2006).

This study aimed to evaluate the effect of multisensory exercise training on the gait and balance of persons with diabetes.

Balance Exercise with Wobble Board: Subjects performed balance training exercises on wobble boards with open and closed eyes. It can be use to improve range of motion in ankle joint complex; strengthen musculature of foot ankle and lower leg. It will improve static balance.

Balance Exercise with Balance Pad: It is compliant surface. It will improve postural orientation by forcing faster modification of sensory and motor system**.**

Aim and Objectives of Study

1. To study the effectiveness of sensory training on wobble board to improve balance and gait in diabetic neuropathy.
2. To study the effectiveness of sensory training on Balance Pad to improve balance and gait in diabetic neuropathy.
3. To compare effectiveness of both surfaces to improve balance and gait in diabetic neuropathy.

MATERIALS AND METHODS

Study design*:* Experimental comparative study.

Source of data: Physiotherapy OPD, Parul Sevashram Hospital, Limda, Waghodia.

Sample size*:* 36

Sampling technique: Simple random sampling

Inclusion Criteria

1. Patient with diabetic neuropathy.
2. Patient with age group of 45-65 will be included in this study.
3. Both male and female included.
4. Patient having diabetes since 10 years.
5. Patient having both sensory and balance impairment.

Exclusion Criteria

1. Patient with foot ulcer at the moment of intake.
2. Patient with orthopedic problems influencing gait.
3. Patient with neurological problems influencing gait parameters.
4. Non diabetic neuropathy, and other neurological pathologies (other than PN) that Could influence gait variables.
5. Impairment without correction, recent complaints of dizziness or falls were also excluded from the study.

Test Description and Measures

The participants were tested before and after 6 weeks of the study. Both groups

Underwent the following tests

'Timed Up and Go' Test

The 'Timed Up and Go' test (TUG-test) is an effective method for assessing Mobility and quantifying loco motor performance, including a sequence of Functional maneuvers used in everyday life. Basic mobility skills are tested, Such as rising from a chair, walking 3 meters, turning and sitting down on the same chair. A stopwatch is used to time the test (in seconds). The test is convenient in clinical settings as it is quick, requires no special equipment or training, and is easily included as part of the routine medical examination. TUG was proven to have good inter-rater reliability (ICC = 0.99) (Steffen et al, 2002).Good test-retest reliability (ICC = 0.97–0.99 and Spearman's = 0.93) have been demonstrated in many studies.

'Six-Minute Walk' Test

The 'Six-Minute Walk' Test (6MWT), a measure of the distance a person walks in 6 minutes, was used to assess overall physical performance. Subjects were asked to cover as much distance as possible within 6 minutes, without running. The 6MWT has been shown to be reliable and valid in detecting differences in mobility performance and has high test-retest reliability (Steffen *et al*, 2002).

Treatment Description

The experimental group was submitted to multisensory exercise training thrice a week for 30 minutes, over 6 weeks. The intervention group and control group were allowed to continue their usual leisure activities. Participants were instructed to report any symptom or feeling of falling during the exercise session.

The therapist stood beside the participant to guarantee physical safety in case of loss of balance. A 5- minute warm-up before the activity included short walks and games with balls, using hands or feet. As part of the multisensory training, they performed exercises under the following conditions: (1) eyes open, (2) eyes close. This final session lasted for 10 minutes.

Patients were randomly allocated to two groups by table of random numbers in to group A and group B

Group A: Balance exercise over balance Pad.

A high-density closed cell foam pad was used in this study to alter the proprioceptive feedback from the support surface and create a more dynamic task.

Group B: Balance exercise over wobble board.

Both groups were submitted to multisensory exercise training thrice a week for 30 minutes, over 6 weeks. Exercise interventions, in the form of multisensory exercise programs, are now recognized as a new strategy to improve physical function. A 5- minute warm-up before the activity included short walks and games with balls, using hands or feet. Participants were asked to walk forwards, backwards, and sideways, with eyes both open and closed, at different speeds and for various distances.

The exercises included

Exercise-1: performing double-legged stance for 10 seconds,

Exercise-2: performing tandem stance for10 seconds,

Exercise-3: performing single legged stance for 10 seconds.

Exercise-4: Raising heels in the standing Position.

Exercise-5: Raising toes in the standing position. Exercise-6: weight shifting Exercise.

Exercise-7: The subjects maintaining balance on both feet will perform small knee bends to change balance

Wobble board Balance Pad **Figure-2** Exercise-1: double-legged stance

Figure-3 Exercise-2: tandem stance **Figure-4** Exercise-3: single legged stance

Figure-6 Exercise-5 Raising toes **Figure-7** Exercise-6: Raising heels

Figure-5 Exercise-4: Weight shifting **Figure-8** Exercise-7: Small knee bends

Data Analysis

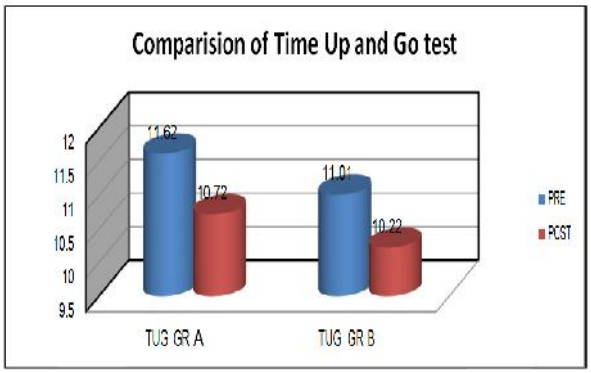
Using Microsoft Excel, data was converted into SPSS (Statistical Package for Social Sciences) format for analysis. SPSS version 19 was used. The descriptive statistics were first calculated and the distribution of data was checked.

Table-1 Base line Data

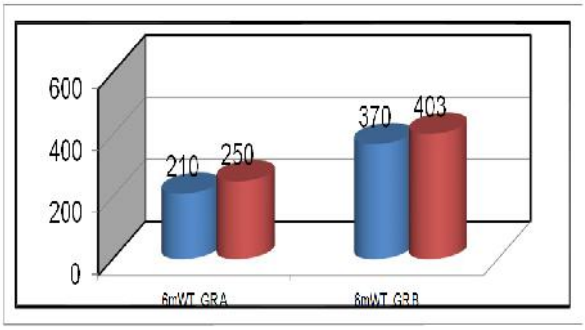
	Group A (n=18)	Group B (n=18)	
Age (years)	58.82 (53.00–61.50)	59.05 (52.50–64.50)	0.68
Gender, male (n)	7 (41.2%)	5 (29.4%)	0.47
Weight (kg)	77.94 (69.00–85.00)	71.64 (63.00–80.00)	0.09
Height (m)	166.11 (161.50–172.50)	163.23 ± 5.75	0.30
BMI (kg/m2)	27.76 (25.25–30.00)	26.67 (24.25–28.75)	0.23
Duration of diabetes(years)	10.00 (5.00–14.50)	11.82 (7.50–16.00)	0.47

Table-2 Intra Group Comparison

	Pre Mean±SD	Post Mean±SD	t Value	p value 95% CI
Group A (wobble board)				
TUG	11.62±0.87	10.76±2.73	14.234	<0.0001
6min WT	210±98.04	252±97.03	20.570	<0.0001
Group B (balance pad)				
TUG	11.01±0.97	10.22±1.002	13.549	<0.0001
6min WT	370±104.97	403±102.45	17.569	<0.0001



Graph 1 Comparison of time for TUG Test.

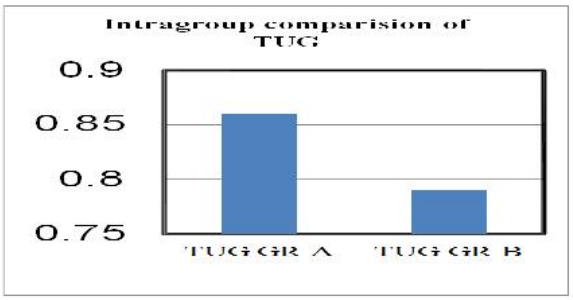


Graph 2 Comparison of distance covered in 6 min walk test

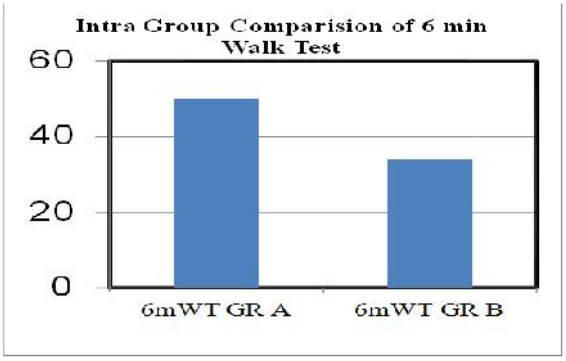
Intergroup Comparison

Table-3 Intra Group Comparison of TUG and 6 min walk test.

	Group A	Group B	t	p value 95% CI
TUG	0.86	0.79	0.806	<0.0001
6 min WT	50	34	5.255	<0.0001



Graph 3 Intra Group Comparison of TUG



Graph 4 Intra Group Comparison of 6 min Walk test

RESULTS

Results of inter group comparison shows that both group shows improvement in scores of TUG and 6 min walk test after intervention over different surfaces however intergroup comparison, suggest that Group A (i.e. wobble board group) showed greater improvements in scores of TUG and 6min walk test ($p<0.0001$) than Group B (i.e. balance pad group).

Thus, null hypothesis is rejected and the alternative hypothesis is accepted.

DISCUSSION

- The study compared the effect of balance training over two different surfaces i.e. wobbly and compliant surface on balance and gait in patients with diabetic neuropathy.
- There was significant improvement in scores of TUG and 6min walk test in patients in group A who received balance training over wobble board. Onigbinde AT *et. al*. concluded that wobble board exercise improved both static and dynamic balance The reason for that is due improvement in range of motion in ankle joint complex; strengthen musculature of foot ankle and lower leg.
- There was significant improvement in scores of TUG and 6min walk test in patients in group B who received balance training over balance pad due improvement in postural orientation by forcing faster modification of sensory and motor system.
- This improvement was due to the improved proprioception and muscle strength. Salsabili and colleagues observed better balance performance after balance training in patients with DN which was independent of the severity of the neuropathy [Salsabili *et al*. 2011].
- Jiyeun *et al*. demonstrated that the patients exercising on balance pad showed a significant improvement in Berg balance scale (BBS) and parameters of sway of the center of pressure (COP) suggesting a significant improvement of balance as compared to those exercising on a stable surface. This finding is in agreement with a study which reported that balancing exercises on an unstable surface had a greater effect on sensory motor function than exercises on a stable surface, and a report that postural reactions were faster on a moving surface.
- The statistical analysis carried out using paired t test for inter group comparison demonstrated that the balance and gait improvement is significantly higher in group A (Wobble board) as compared to group B (BALANCE PAD) .Thus shows that the wobble board is the more effective for balance and gait training.
- A balance pad increases the external swing which more effectively encourages postural orientation by forcing faster modifications of the sensory system and motor system. Furthermore, it assists in the postural strategy of self-postural control. Adedoyin *et al* reported that wobble board exercise can be used to improve the symmetry of weight distribution of lower extremity in sedentary subjects. Some study also focused that it improves static balance. Balancing exercises on an unstable surface sensitize the muscle spindle through gamma motor neurons, thereby improving motor output, which influences the stability of joint.

So based on the results obtained we reject null hypothesis that 'There will be no significant difference of sensory training over two different (wobbly & compliant) surface on balance and gait in persons with diabetic neuropathies' And we accept the alternative hypothesis that 'There will be significant difference of sensory training over two different (wobbly surface & compliant) surface on balance and gait in persons with diabetic neuropathies'. And say that balance training is effective on both surfaces but wobbly surface proves to be the most efficient one for balance training in ambulant stroke patients.

CONCLUSION

The findings suggest that wobbly (dynamic) surface is more effective as compared to compliant surface in improving balance and gait in persons with diabetic neuropathy.

Limitation

1. Small sample size.
2. Although the result of 6 min walk test is statistically significant for clinical significance the difference should be 54 meters.

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