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# EFFECTIVENESS OF SENSORIMOTOR TRAINING ON BALANCE AND PROPRIOCEPTION AMONG PERSONS WITH DIABETIC PERIPHERAL NEUROPATHY

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**Abstract: Background:** Diabetes mellitus is a group of metabolic disorders characterized by chronic hyperglycemia resulting from defects both in insulin secretion and insulin action. The global prevalence is 8.8% among adults with the number expected to rise to 10.4% by 2040. The main complications of diabetes are **Diabetic Peripheral Neuropathy (DPN)** which significantly deteriorates postural control, mainly due to the lack of plantar sensation, which alters both local and central postural control system. Sensory motor training comprises facilitation of sensory inputs (proprioception and somato sensory inputs), correcting muscle imbalance, and ensuring correct motor program at the level of central nervous system. This study aimed to focus on the efficacy of sensorimotor training on balance measures and proprioception in middle aged patients with severe DPN. [(5)] **Methods**: A prospective experimental study design with pre and post test measures was done on middle aged subjects with severe diabetic neuropathy .After 8 weeks of intervention with sensorimotor training post test scores for Berg Balance Scale (BBS), Timed Up and Go Test (TUG) and Kinaesthetic Sensation Grading (KSG) were calculated. **Data analysis**: Statistical analysis between pre and post-test of scores shows that BBS, which has the t-value of 3.576 and p–value as .037 denotes statistical improvement in balance; for TUG the t-value of 2.324 and p – value as .103 which is not statistically significant and for kinesthetic sensation grading the t-value of 3.000 and p–value as .06 which is also not statistically significant. **Results:** This study suggests that sensorimotor training improves balance, in patients with severe diabetic peripheral neuropathy. Among BBS, TUG and KSG, significant change in balance measures were seen in BBS scores.

## Introduction

Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects both in insulin secretion and insulin action. Metabolic abnormalities in carbohydrates, lipids and proteins result from the importance of insulin as anabolic hormone[1]. The global prevalence is 8.8% among adults with the number expected to rise to 10.4% by2040. Type 2 DM accounts for 90–95% of all diagnosed cases of diabetes with higher prevalence among older adults. It is estimated that around 360 million patients globally will have DM by 2030[2]. It is estimated that 193 million people with diabetes are undiagnosed and therefore at the risk of developing complications. The main complications of diabetes are **Diabetic peripheral neuropathy (DPN**) which affects between 30 to50% of diabetic individuals and other complications include diabetic leg and foot ulcers.[3]

Diabetic peripheral neuropathy is defined as the presence of symptoms and signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes. [4]

Prevalence of Diabetic peripheral neuropathy is the highest in the middle-aged and elderly adults with sensory loss such as vibration perception, pressure, pain, joint position thus effectively reducing control over balance and gait coordination.[5]

Diabetic peripheral neuropathy is thought to be caused by nerve dysfunction and cell death that results from oxidative stress and inflammation. Hyper glycaemia, dyslipidaemia, and insulin resistance all contribute to dysregulation of metabolic pathways that collectively cause an imbalance in the mitochondrial redoxstate, thereby leading to excess formation of mitochondrial and cytosolic reactive oxygen species.[6] This leads to a loss of axonal energy stores and axonal injury, promoting peripheral neuropathy. The earliest changes of diabetic peripheral neuropathy occur at the level of unmyelinated C fibres, resulting in pain, allodynia, and hyperesthesia. These changes lead to a progressive loss of distal sensation in a distal to proximal course along the nerve that defines diabetic peripheral neuropathy. [7]

The major dysfunction associated with diabetic peripheral neuropathy are sensory (lack of motion associated sensory), motor (impairment in movement co-ordination), autonomic (presence of postural hypotension).[8] Peripheral neuropathy causes decreased proprioception and or increased reflex reaction time. Limited joint mobility is frequently observed in Diabetic peripheral neuropathy.[9]

Sensation from the bottom of the foot plays an important role during dynamic postural response. Also, ankle flexibility, foot sensation and strength of toe flexors are important predictors of balance and functional ability in older people.[9] Stability can be defined as a sensitivity of a dynamic system to perturbations, and local stability is the sensitivity of the system to internal perturbation such as natural fluctuations. Sources of instability of patient with type-2 diabetes include loss of peripheral sensory information in feet, the inability of CNS to appropriately integrate available postural control information. [10]

Balance is the fundamental ability for humans, and its impairment dramatically reduces an individual ability

to perform activities essential to daily living. In particular Diabetic peripheral neuropathy, which impacts 60% to70% of older people with diabetes significantly deteriorates postural control system mainly due to the lack of plantar sensation which alters both local and central postural control system. Patients with Diabetic peripheral neuropathy are unable to sense temperature.(11)

In many subjects with Diabetic peripheral neuropathy, pain develops as a symptom localized to lower extremities, primarily the soles and toes. Painful Diabetic peripheral neuropathy develops as a result of injury to Vasovasorum, axons and atrophy of axons leading to tissue damage. All nerve fibers may be injured but small myelinated and unmyelinated fibers that transmit pain and temperature are most affected.(12) About 10% diabetic patient experience persistent pain. Pain can be spontaneous or stimulus induced, severe or intractable. Chronic painful Diabetic peripheral neuropathy refers to symptoms occurring for more than six months.(13)Damage to small sensory nerve fibres is one of the earliest manifestations of Diabetic peripheral neuropathy and may be accompanied by continuous or episodic pain. Evaluation of neuropathic symptoms and signs is done by using a validated questionnaire.(6)

The three main principles of treatment for peripheral neuropathy are glycemic control, foot care, and pain management. Pharmacologic treatment is indicated for the treatment of painful diabetic peripheral neuropathy. Currently, only duloxetine and pregabalin are approved by the US Food and Drug Administration (FDA) for the treatment of diabetic peripheral neuropathic pain. Despite a large body of evidence and professional treatment guidelines on the medical management of painful diabetic peripheral neuropathy, current medication prescribing patterns are inconsistent. There is emerging evidence that lifestyle interventions including weight loss and physical activity may be helpful for managing painful peripheral neuropathy , although the data are preliminary.(4)

Sensory motor training comprises facilitation of sensory inputs (proprioception and somatosensory inputs), correcting muscle imbalance, and ensuring correct motor program at the level of central nervous system. Balance exercises are well established sensorimotor training which consists of static, dynamic, and functional approach to treating patients. Post balance training, improvement in balance measures in Diabetic peripheral neuropathy patients have been reported in older adults, middle aged adults, as well as in population comprising both these age groups. However, since these two groups could have different level of balance impairments, further study is required to provide greater insight regarding customized, structured exercise intervention for each of these two age groups with Diabetic peripheral neuropathy.(5)

Implementing balance interventions for improvement of balance characteristics have earlier shown positive outcome in Diabetic peripheral neuropathy patients and thus balance exercise has emerged as an effective physical intervention for improved balance characteristics in this population. Many studies have been done on patients with mild to moderate neuropathy. This study aimed to focus on efficacy of sensorimotor training on balance measures and proprioception in severely affected patients with diabetic neuropathy in middle aged group.(5)

## METHODOLOGY

**Study type** : Prospective study

**Study design** : Pre - Post Experimental study design

**Study population** : Middle aged subjects with Diabetic peripheral neuropathy

**Study sample** : Convenient sampling

**Study duration** : Two months

**Study set up** : Physiotherapy unit, NIEPMD

## INCLUSIONCRITERIA:

- Pre-diagnosed type II diabetes mellitus.
- Score more than 2 on Michigan Neuropathy Screening Instrument (MNSI)
- Age 45to 55years.
- Prolonged diabetes mellitus for more than 7years.
- Both male and female gender.
- Able to walk without mobility aid.

## EXCLUSIONCRITERIA:

- Foot ulcers.
- Inability to walk independently.
- Retinopathy.
- Other neurological impairment.
- Musculoskeletal problems.
- Recent surgery.
- Score less than 2 on MNSI questionnaire.
- Vestibular insufficiency.

## OUTCOME MEASURES:

- BERG BALANCE SCALE (BBS)
- TIMED UP AND GO TEST (TUG)
- KINESTHETIC SENSATION GRADING (KSG)

**DURATION OF TREATMENT:**

All intervention was performed for thrice a week for eight weeks.

**PROCEDURE:**

The study is an experimental study. Patients were received in National Institute for Empowerment of Persons with Multiple Disabilities, Physiotherapy unit. The consent form was taken from the patients. Patient history and demographic data were collected. Patients were checked for inclusion criteria, exclusion criteria and were checked for vitals and basic assessment of function was done. This study involves pre-evaluation, intervention, post evaluation.Participants were randomized to two groups.

**GROUP A-** Intervention group.

**GROUP B-** Control group.

The intervention group received sensorimotor training and the control group received diabetes and foot care education.

The sensorimotor training consists of exercise which was conducted thrice a week for eight weeks (total 24session). Each session comprised of 10 minutes warm up followed by 50 to 60 minutes exercise, followed by 5 to 10 minutes of cool down exercise.

Warm up exercises were done with cycle ergometer or treadmill at intensity of 50% to 60% HR max (10minutes).

**SENSORI MOTOR TRAINING COMPRISES OF:**

**WALL SLIDES** – It is the beginner exercise for improving strength in quads, gluteus, calf. This closed chain exercise can also help improve balance and posture.

**Figure:1 client performing wall slides**

Stand facing a wall in a split stance (one foot in front of the other), and bring the elbow up to 90 degrees–pressing them (and forearm) into the wall. Keep the core engaged, slowly lift your arms up over head sliding them along the wall. This is done for 10-12 repetitions and four sets.

**CORE EXERCISE:**

- Bilateral leg raise

**Figure:2 client performing bilateral leg raise**

Crunches- This exercise is done for10-12 repetition and 4 sets.

**BALANCE EXERCISE ON UNSTABLE SURFACE:**

- Wobble board (for 7 minutes)

**Figure:3 client performing wobble board exercise**

- Ramp walk

**Figure: 4 client performing ramp walk**

**GAIT TRAINING:** Static cycling (for10 minutes)


**Figure: 5 client performing static cycling**

**COOL DOWN EXERCISE:**

- Deep breathing (10 times 3 sets)

**Figure: 6 client performing deep breathing exercise**

- Mild stretching (10 minutes)

**Figure:7 represents mild stretching for lower limb**

**DIABETIC FOOT CARE EDUCATION:**

Diabetes and footcare education comprises of dispensing information about understanding the complications of diabetes, diabetic management and foot care guidelines, along with dietary counseling. The instruction was provided by professional physiotherapist specialized in diabetes care. Subjects were allowed to continue with their daily activities.

**DAILY FOOT CARE CHECKLIST:**

- Thoroughly inspect your feet daily, and keep them clean and dry.
- Never walk barefoot, as it increases your chance of injuring them. Wear comfortable shoes that fit well and protect your feet
- Keep the blood flowing to your feet. Put your feet up while sitting.
- Wiggle your toes and move your ankles up and down for 5 minutes two or three times a day. Don't cross your leg for longer period.

CHARACTERSTICS OF FOOT WEAR:

- Avoid shoes that are too tight or high heeled shoes
- Avoid thong sandals, narrow toe box and slippers as it may cause injury to the feet if not well fitted.
- The characteristics of good footwear such as wide toe box, suitable shoe material made of letter or micro fiber and special foot bed made with shock absorbing materials.

**THERAPEUTIC FOOT WEAR:**

- These are special shoes fitted by professional. An extra deep shoe cradles your foot.
- Support around ankle gives you more stability.

**DIABETIC FOOT CARE EXERCISE:**

- Passive dorsi flexion and plantar flexion
- Toe curls
- Marble pickup
- Tennis ball roll
- Toe spread exercises.

## DATA ANALYSIS

### STATISTICALTOOLS:

Data's were collected and descriptive analysis was done using SPSS software and paired t – test was used to find within the group. Independent t test was used to compare the changes in all mean values of all parameters between group A and group B.

**TABLE 1**

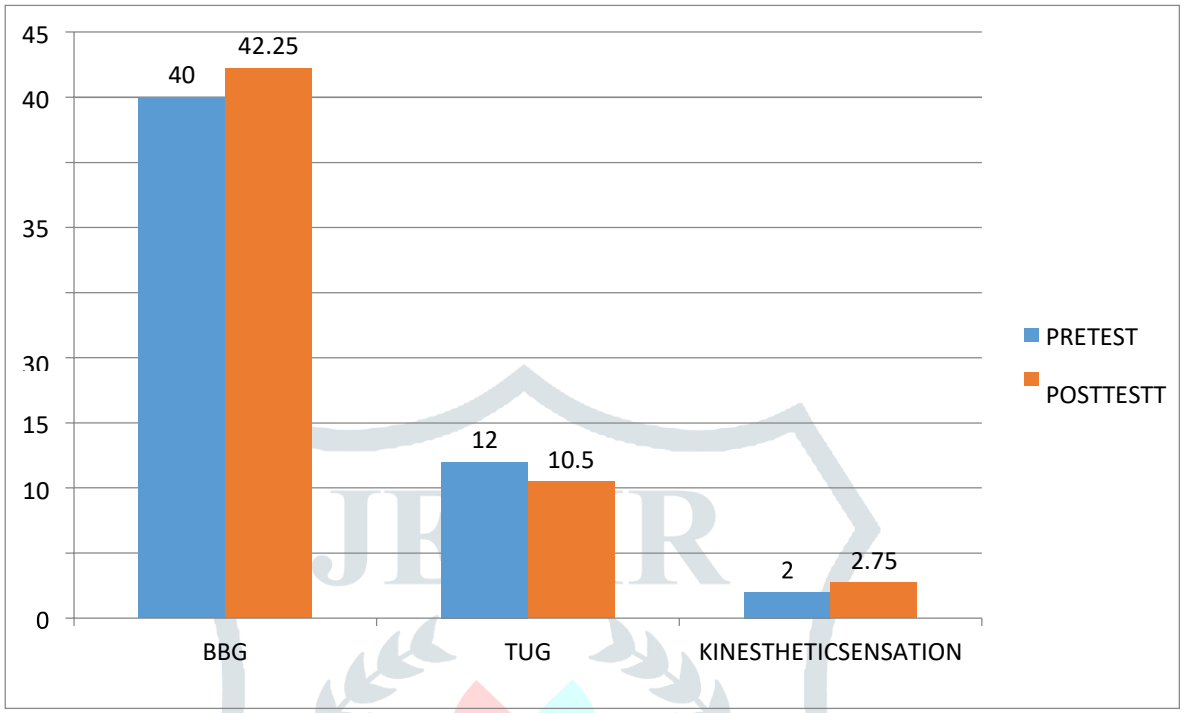
**COMPARISON OF PRE AND POST TREATMENT MEASURES OF BBS, TUG, KSG VALUE WITHIN GROUP A.**

| Outcome Tools | | No. of Samples | Mean | S.D | t-value | p-value | Level of Significance |
|---|---|---|---|---|---|---|---|
| BBS | Pre-Test | 4 | 40.000 | 0.81650 | 3.576 | 0.037 | <0.05 |
| | Post-Test | 4 | 42.250 | 0.95743 | | | |
| TUG | Pre-Test | 4 | 12.000 | 0.81650 | 2.324 | 0.103 | >0.05 |
| | Post-Test | 4 | 10.500 | 1.29099 | | | |
| KSG | Pre-Test | 4 | 2.000 | 0.81650 | 3.000 | 0.06 | >0.05 |
| | Post-Test | 4 | 2.750 | 0.50000 | | | |

**Table 1** reveals mean, standard deviation, t-value, p-value of BBS, TUG and kinesthetic sensation grading between pre-test and post-test within group A. This table shows statistically significant difference between Pre and post-test of BBS which has the t-value of 3.576 and p–value as .037 which denotes statistical improvement in balance; for TUG the t-value of 2.324 and p – value as .103 which is not statistically significant; for kinesthetic sensation grading the t-value of 3.000and p–value as .06 which is not statistically significant.

GRAPH1

**COMPARISON OF PRE AND POST TREATMENT MEASURES OF BBS, TUG,KSG WITHINGROUP A.**




This graph compares the pre and post-test values of BBS, TUG, kinesthetic sensation grading in group A.

**TABLE 2**

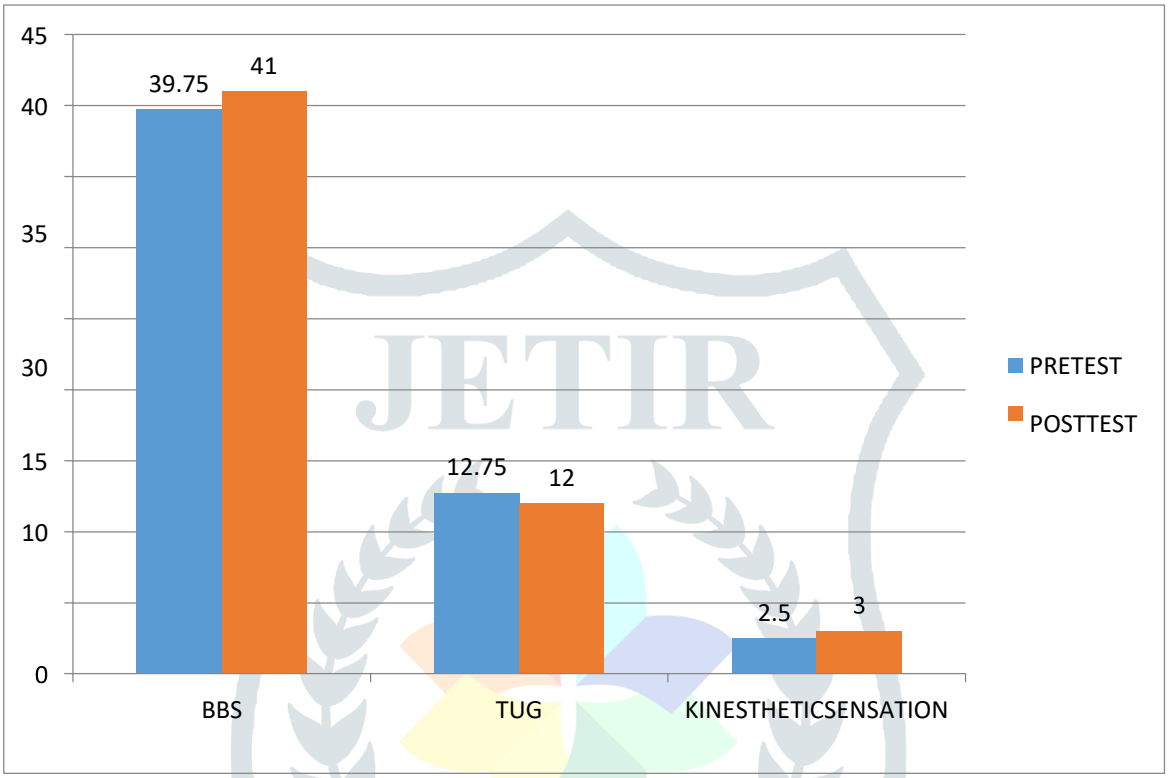
**COMPARISON OF PRE AND POST TREATMENT MEASURES OF BBS, TUG, KSG VALUE WITHIN GROUP B.**

| Outcome Tools | | No. of Samples | Mean | S.D | t-value | p value | Level of Significance |
|---|---|---|---|---|---|---|---|
| **BBS** | Pre-Test | 4 | 39.750 | 1.70783 | 5.000 | 0.015 | <0.05 |
| | Post-Test | 4 | 41.00 | 1.41421 | | | |
| **TUG** | Pre-Test | 4 | 12.75 | 0.96 | 3.00 | 0.103 | >0.05 |
| | Post-Test | 4 | 12.00 | 0.82 | | | |
| **KSG** | Pre-Test | 4 | 2.500 | 0.577 | 1.732 | 0.06 | >0.05 |
| | Post-Test | 4 | 3.00 | 0.0 | | | |

**Table 2** reveals mean, standard deviation, t-value, p-value of BBS TUG and kinesthetic sensation grading between pre-test and post-test within group B. This table shows statistically significant difference between Pre and post-test values of BBS which has the t-value of 5.000 and p – value as .015 which is statistically significant; for TUG the t-value of 3.000 and p –value as .103 which is not statistically significant; for kinesthetic sensation grading the t-value of 1.732 and p– value as .06which is not statistically significant.

**GRAPH 2**

**COMPARISON OF PRE AND POST TREATMENT MEASURES OF BBS, TUG, KSG WITHIN GROUP B.**




This graph compares the pre and post-test values of BBS, TUG, kinesthetic sensation grading in group B.

**TABLE 3**

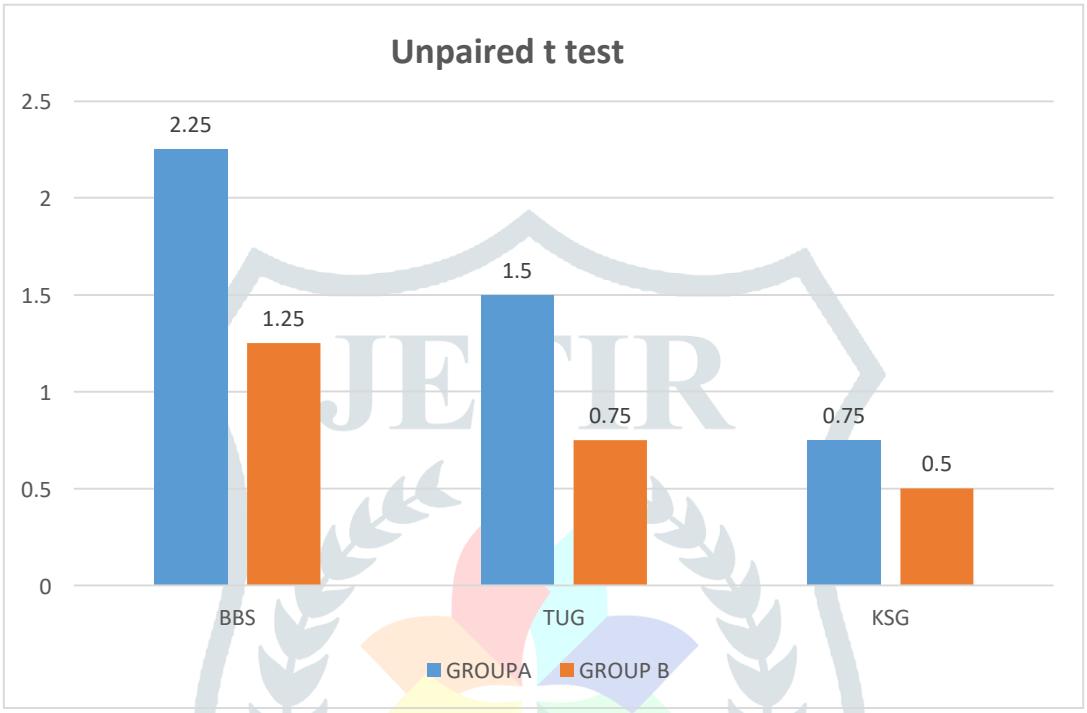
**COMPARISON OF MEAN VALUES OF BBS, TUG AND KINESTHETIC SENSATION GRADING BETWEEN THE GROUP A AND B**

| OutcomeTools | | No.of Samples | Mean Differance | S.D | t-value | p-value | Level of Significance |
|---|---|---|---|---|---|---|---|
| **BBS** | GROUP A | 4 | 2.25 | 1.26 | 1.4771 | 0.1901 | >0.05 |
| | GROUP B | 4 | 1.25 | 0.50 | | | |
| **TUG** | GROUP A | 4 | 1.50 | 1.29 | 1.0835 | 0.3202 | >0.05 |
| | GROUP B | 4 | 0.75 | 0.50 | | | |
| **KSG** | GROUP A | 4 | .75 | .50 | 0.6547 | 0.5370 | >0.05 |
| | GROUP B | 4 | .50 | .58 | | | |

**Table 3** reveals the mean difference, SD, t-value, p-value of BBS TUG and kinesthetic sensation grading between the group A and B. This table shows that there was no significant difference between pre and post values of BBS which has the t-value of 1.4771 and p – value as 0.1901 which is not statistically significant; for TUG the t-value of 1.0835 and p – value as 0.3202 which is not statistically significant; for kinesthetic sensation grading the t-value of 0.6547 and p – value as 0.5370 which is not statistically significant.

**GRAPH 3**

**COMPARISON OF MEAN VALUES OF BBS, TUG AND KINESTHETIC SENSATION GRADING BETWEEN GROUP A AND GROUP B.**




This graph compares the pre and post-test mean values of BBS, TUG, kinesthetic sensation grading between group A and B.

## RESULT

Out of 15 participants screened, 8 were selected based on MNSI questionnaire. Assessment is done and divided into intervention (n=4) and control group (n=4).

According to table 1, there is a statistically significant difference between Pre and post-test of BBS which has the t-value of 3.576 and p–value as .037 which denotes statistical improvement in balance; for TUG, the t-value of 2.324 and p – value as .103 which is not statistically significant; for kinesthetic sensation grading, the t-value of 3.000 and p – value as .06 which is not statistically significant.

According to table 2, there is statistically significant difference between Pre and post-test values of BBS which has the t-value of 5.000 and p–value as .015 which is statistically significant; for TUG, the t-value of 3.000 and p – value as .057 which is not statistically significant; for kinesthetic sensation grading, the t-value of 1.732 and p–value as .182 which is not statistically significant.

According to table 3, there was no significant difference between pre and post values of BBS which has the t-value of 1.4771 and p–value as 0.1901 which is not statistically significant; for TUG the t-value of 1.0835 and p – value as 0.3202 which is not statistically significant; for kinesthetic sensation grading the t-value of 0.6547 and p – value as 0.5370 which is not statistically significant.

In graph 1, pre and post treatment measures BBS, TUG, kinesthetic sensation grading within group A individuals were compared. ;BBS shows significant difference within a group and TUG and kinesthetic sensation grading shows statistically no significance

In graph 2, pre and post treatment measures BBS, TUG, kinesthetic sensation grading within group B individuals were compared ;BBS shows significant difference within a group and TUG and kinesthetic sensation grading shows statistically no significance

In graph3, pre and post-test mean values of BBS, TUG, kinesthetic sensation grading between group A and B were compared which showed no significant difference between the groups.

## DISCUSSION

The present study was conducted to find the effectiveness of sensorimotor training on balance and proprioception measures on patients with diabetic peripheral neuropathy.

Sensory motor training (SMT) comprises of facilitation of sensory inputs (proprioception and somatosensory inputs), correcting muscle imbalances, and ensuring correct motor program at the level of central nervous system. Exercises to improve balance are well-known for sensory treatment of patients using a static, dynamic, and functional training [(5)].

Patients progress through three stages of SMT: static, dynamic, and functional. Within each stage, patients progress through exercises in different postures, bases of support, and challenges to their center of gravity. Each exercise should elicit automatic and reflexive muscular stabilization, challenging the patient to

maintain postural control under a variety of situations.

Static phase: In the static phase, emphasis is placed on developing a stable pelvis (‘‘core’’) from which to build movement in subsequent phases. The pelvis is stabilized by a ‘‘pelvic chain’’ of muscles Lewit (2016): the multifidus, transverse abdominus, pelvic floor, and diaphragm [(67)]. Janda (2006) noted that many movement impairments are caused by, or reflected in the pelvis and hip musculature [(68)]. Without a stable base at the pelvis, extremity movement will be compensated elsewhere in the kinematic chain. This is the principle of ‘‘proximal stability for distal mobility’’.

Dynamic phase: Once the patient exhibits the ability to maintain pelvic stability in the half-step position under a variety of conditions, progress the challenges of their centre of gravity in the dynamic phase. The patient begins‘‘building’’on the stable pelvis by performing movements of the upper and lower extremity, gradually adding resistance to the movements.

Functional phase: The final stage of SMT is functional progression of postures with extremity movement with a stable pelvis. These include walking, squats, lunges, steps, jumps, and running and balance boards.

SMT exercises are typically performed to fatigue or for a certain amount of time. Rather than prescribe a specified number of repetitions, have the patient perform the exercise under direct supervision to the point of fatigue. Remember that the goal of SMT is to increase muscle reaction and tissue endurance rather than joint strength. At the first sign of fatigue (The initial burning sensation or any compensated movement) the exercise is stopped to avoid further compensatory movements that may promote dysfunction. SMT improves proprioception, strength, and postural stability in lower extremity rehabilitation (Beard et al., 1994; Ihara and Nakayama, 1986; Pavlu and Novosadova, 2001).

The reduced balance control in adults with DPN could be a result of decrease in general physical functions, reduced position sense / peripheral sensation, neurological control and fear of falls. Hence in the absence of cues, subjects held their position by increasing the co-contraction of ankle and sole muscles, thus increasing joint stiffness, and which leads to decrease in postural motion. Since lack of proprioception is responsible for postural instability in DPN, improved proprioceptive feedback enhances postural/ balance control in DPN patients.

The findings from the studies we reviewed provide substantial evidence to support the use of strength and balance training for older adults at risk for falls and beginning evidence to support strength and balance training for individuals with peripheral neuropathy. The studies were viewed of strength and balance training programs for diabetics with peripheral neuropathy indicate that persons with neuropathy can safely participate in and may receive benefit from strength and balance training.

We hypothesized that structured exercise programs for DPN patients would promote balance improvement, which would lead to a lower risk of falls and a decrease in the fear of falling.

## CONCLUSION

From this study, it was concluded that the sensorimotor training for subjects with severe diabetic peripheral neuropathy in middle age group individuals, significantly improves their balance as measured by their BBS scores post the intervention. Among BBS, TUG, KSG, Berg balance scale shows a beneficial change in balance measures, which may in turn help to prevent falls. Hence further study can be combined with centre of pressure (COP) and sway to have a precise measurement and to detect variation in balance outcome measures.

## STUDY LIMITATIONS AND RECOMMENDATIONS

### LIMITATIONS

- The sample size of this study is small.
- The samples drawn for this study was by convenient sampling.
- Results are subjective due to possibility of the subjective error.

### RECOMMENDATIONS

- The study can be further progressed by undertaking a large sample of subjects with different age groups in persons with diabetic peripheral neuropathy
- Progression of sensorimotor training from moderate to strenuous exercise
- More Experimental research allows cause and effect to be determined which helps in future studies on sensorimotor training.
- This study can also be combined with centre of pressure (COP) sway to have a precise measurement and to detect variations in balance outcome measures.

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