Evaluate the effect the twelve weeks barefoot training along with sensory integration for improving the balance and gait in diabetic neuropathic patients

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ABSTRACT

BACKGROUND: Diabetes mellitus is emerging as a pandemic with high social and economic costs. Type 2 diabetes mellitus and its common complication, peripheral neuropathy affects a large population. The prevalence of neuropathy increased with increased in age and duration of diabetes. The two systems balance and walking are often affected in diabetic neuropathy. Individuals with diabetic neuropathy exhibit reduced physical activity, standing balance, mobility and independence. The present investigation was planned to find out to the effect of barefoot training with sensory integration on balance and gait in diabetic neuropathic patients. **AIMS AND OBJECTIVES:** To observe the effectiveness of barefoot training with sensory integration on balance and gait in diabetic neuropathic patients. **METHODOLOGY:** forty diabetic neuropathic patients were randomly selected according to inclusion and exclusion criteria and were divided into two groups – Group A and Group B. Both the groups were assessed for the balance status using berg balance scale and gait using dynamic gait index. These parameters were assessed before the start of the program as pre-test values and at the end of 12 weeks as post-test values. Group A treated with barefoot training with sensory integration and Group B conventional physiotherapy for 12 weeks. **RESULT:** The mean age of group A was 58.30 years and group B was 59.65 years. The statistical analysis correlates the study by proposing that groups taken for study either group A and B showed significant effect in improvement in balance and gait. The group B had higher significance when compared to group A. The mean improvement in balance scores of BBS was 10.77 and 17.30 in group A and B, respectively. The mean improvement in gait scores measured by DGI was 5.95 and 9.45 in group A and B, respectively. It was resulted that both techniques were effective but barefoot training with sensory integration was superior on improving balance and gait in diabetic neuropathy. **CONCLUSION:** This study concluded that bare foot training with sensory integration is useful, safe and an effective technique to treat balance and gait impairments for diabetic neuropathic patients.

KEY WORDS: Diabetes, Neuropathy, Balance, Gait, Barefoot training, Sensory integration, Conventional.

INTRODUCTION

Diabetes mellitus is emerging as a pandemic with high social and economic costs. The term Diabetes mellitus describes a metabolic disorder of multiple etiology characterized by hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both.[1] Diabetes mellitus is caused by an insufficient insulin mediated response to blood glucose, people with the disorder classified as Type 1(Beta cell destruction, usually leading to absolute insulin deficiency) or Type 2 (Predominantly insulin resistance with relative insulin deficiency or predominantly insulin secretory defect with or without insulin resistance) diabetes.[2] Type 2 diabetes mellitus and its common complication, peripheral neuropathy affects a large population. The prevalence of neuropathy increased with increased in age and duration of diabetes.[3]

The World Health Organization (WHO) estimates that nearly 200 million people all over the world suffer from diabetes and this number is likely to be doubled by 2025. India leads the world with largest number of diabetic subjects earning the dubious distinction being termed the “Diabetes capital of the world”. India has the peak number of diabetics of all the countries in the world with over 72 million people diagnosed by 2017 and the figure estimated almost double 134 million by 2025. Diabetes is a growing challenge in India with estimated 8.7 percent diabetic population in age group of 20 to 70 years. Obesity and overweight are most important risk factors responsible for diabetes.[4,5]

Diabetic neuropathy includes some degree of bilateral lower extremity loss of touch, pressure, vibratory, position, and temperature sensory perception and decreased ankle reflexes[6]

. 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[7]. 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.[10]

Balance is a complex process involving the reception and integration of sensory inputs and the planning and execution of movement to achieve a goal requiring upright posture.[11] It is ability to control the center of gravity over the base of supporting a given sensory environment. The three primary peripheral sensory inputs contributing to postural control are the bilateral receptors of the somatosensory, visual and vestibular systems. Somatosensory receptors located in the joints, ligaments muscles and skin provide information about muscle length, stretch, tension and contraction. The feet, ankles, knees, hips, back, neck and eye muscles are furnish useful information for balance maintenance. Somatosensation is the dominant sense for upright postural control and is responsible for triggering automatic postural responses. Somatosensory loss significantly impairs balance.[12]

The term Postural control and Balance refers to the ability to move efficiently and effectively in a variety of environment without falling. It involves use of many systems to obtain information about the environment and produce appropriate movement and responses. The Visual, Vestibular and Somatosensory systems relay information about the position and movement of the body, particularly the head in relation to the environment and the position and movement of environment in relation to the body.[13,14]

Postural stability relates to local proprioception or motor control losses from the lower limbs or the trunk or neck that affects balance. There are differences between static and dynamic balance. Static balance is the balance of body in standing and sitting and dynamic balance is the balance of body in walking, running and climbing stairs. Dynamic balance is more complex as it makes greater demands on motor control and cognitive-motor processes.[15]

Gait is the forward propulsion of the human skeleton through a series of movements. The prerequisites of normal gait are stability in stance; toe clearance in swing phase; swing phase pre-positioning; adequate step length; a good mechanical and metabolic efficiency.[16] Gait is a complex sequence of events that involves both somatic and autonomic functions. Locomotion involves a combination of eccentric and concentric muscular contractions in order to resist gravity and achieve forward propulsion of the body's centre of gravity.[17,18]

The two systems balance and walking are often affected in diabetic neuropathy[19]. Walking and balance are both critical for independence in activities of daily living.

Individuals with diabetic neuropathy exhibit reduced physical activity, standing balance, mobility and independence.[20,21]

Most of falls occur during locomotion in these patients may have difficulty maintaining dynamic stability while walking. Diabetic neuropathic patients showed greater deviation of their central mass from the centre of pressure during staircase and level walking.[24,25] People with diabetes took additional steps when walking in a linear path and during turns. Reduced walking speed, cadence and step length and fewer acceleration patterns have been noted in subjects with diabetic neuropathy. Individuals with diabetic polyneuropathy walk slower than age-matched healthy controls.[26] People with greater diabetic polyneuropathy related loss of plantar cutaneous sensation tended to walk with a slower preferred walking speed.[27, 28]

Allet et al. (2009)[30] also found lower limb strength, fear of falling and sensory problems to be related to spatiotemporal gait alterations. 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.[31,32] Simoneau et al. (1994)[33] reported that postural instability was further found to be significantly associated with sensory neuropathy.

Walking barefoot is less restricting for motion control, which increases the sensitivity of the sensory mechanisms and activates the foot and lower leg muscles. Both sensory feedback sensitivity and increased foot strength improve balance in older adults and are therefore significant predictors in the prevention of falls. Barefoot training might result in beneficial effects on sensorimotor control.[35,36]

Sensory integration is the organisation of sensory input for use a perception of the body or environment, an adaptive response, a learning process and the development of some neural functions. Sensory re-training interventions are designed to retrain sensory pathways following a neurological events interfering with sensations. It includes vibrations, massage and exercises. These methods emphasize a variety of stimuli used in repetitive manner to bombard the sensory receptors.[37]

Many 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. Very few studies have been published on the role of sensory integration for improving the balance and gait in diabetic neuropathic patients and there is lack of evidence of studies on barefoot

training along with sensory integration for improving the balance and gait in diabetic neuropathic patients, hence keeping the aforesaid facts in view, the present investigation will be planned to find out the effect of barefoot training along with sensory integration for improving the balance and gait in diabetic neuropathic patients.

METHODOLOGY

Comparative study in which 40 diabetic neuropathic patients is selected randomized and study taken place in Community based diabetic neuropathy population from Udaipur, Rajasthan. Study duration was 12 weeks for 6 days per week One hour per day

Inclusion criteria:	**Exclusion criteria:**
1. Patient with diabetic neuropathy 2. Age : between 50 to 70 years 3. Both male and female 4. Patient having diabetes since 10 years. 5. Patient having balance and gait impairment.	1. Patient with foot ulcer. 2. Patient with other neurological problems which influence the gait parameters 3. Patient with orthopedic problems which influence the gait parameters. 4. Cardio- respiratory condition. 5. Non- diabetic neuropathy patients. 6. Patients with vestibular and visual impairment. 7. Psychosomatic patients.

PROCEDURE

Forty diabetic neuropathy patients with balance and gait impairment were selected by randomized sampling method according to inclusion and exclusion criteria and divide into two groups, Group A and Group B. The nature and duration of the study was explained to all participants and written consent was taken from each participant. The demographic and clinical data were collected from each participant. Pre-test level of balance impairment was assessed through Berg balance Scale (BBS) and gait impairment by the Dynamic Gait

Index (DGI) on beginning day of the study. Conventional physiotherapy techniques to group A and Barefoot training and sensory integration techniques to group B was demonstrated and the patients were practiced the same for six days per week for twelve weeks. Data was collected at the beginning of the experiment (1st day) and at the end of experiment (12th week).

INTERVENTION

GROUP A: CONVENTIONAL PHYSIOTHERAPY TECHNIQUES

Treatment parameters:

Duration of treatment: One hour per day

Frequency of treatment: Six days per week.

Treatment Protocol:

1. Balance exercises on physio ball:

Position of patient: Patient sit on a physio ball with feet on floor.

Procedure: The hands are joined and elbow straight. Move the upper limb towards right and left side while rotating spine.

Progression: Decrease base of support while sitting on physio ball and perform the same exercise by increasing range of rotation.

Plate 2: Balance exercises on physio ball

2. Static Balance training:

Position of patient: Standing with feet apart.

Procedure: The hands are joined and elbow straight. Move the upper limb towards right and left side while rotating spine.

Progression: Decrease base of support while standing.

Plate 3: Static Balance training

3. **Standing Reachouts:**

   Position of patient: Standing with feet apart.

   Procedure: Try to reach to an object by moving upper limb.

   Progression: Decrease base of support and perform reachouts.

   Plate 4: Standing Reachouts

4. **Dynamic balance training:**

   Position of patient: Standing with feet apart.

   Procedure: Move right lower limb in front, back and sideways and perform by left.

   Progression: Dynamic balance with reachouts.

Plate 5: Dynamic balance training

5. **Unsupported gait training:**

   Position of patient: Standing without support.

   Procedure: walking without support with wide base of support.

   Progression: walking without support with narrow base of support also increase speed and distance of walking.

Plate 6: Unsupported gait training

6. **Semi tendom walking:**

   Position of patient: Standing without support.

   Procedure: Draw a line on floor. Try to walk by placing feet near to line.

   Progression: Try for tendom walking.

Plate 7: Semitendom walking

7. **Tendom walking:**

Position of patient: Standing without support.

Procedure: Draw a line on floor. Try to walk by placing feet on line.

Progression: Tendom walking with increasing speed and distance of walking.

Plate 8: Tendom walking

8. **Obstacle crossing:**

Position of patient: Standing without support.

Procedure: Place obstacles and try to walking by crossing them.

Progression: Increase height and length of obstacles.

Plate 9: Obstacles crossing

Progression:

Dual task Balance and Gait training exercises[74]:

Position of patient: Standing without support.

Procedure: Catch a ball, talking to others or counting and perform other activities during standing and walking.

Plate 10: Dual task training by catching ball while walking

GROUP B: BAREFOOT TRAINING[75] AND SENSORY INTEGRATION[76]

Treatment parameters:

Duration of treatment: One hour per day

Frequency of treatment: Six days per week.

Treatment Protocol:

1. **Vibration:** High frequency vibrating tool is used. Apply on affected feet and legs

Plate 11: Vibration

2. **Mini-trampoline:**

   1. Standing with wide base of support:

Plate 12: Standing on trampoline with wide base of support

2. Standing on trampoline with narrow base of support:

Plate 13: Standing on trampoline with narrow base of support

3. Foot stamping:

Plate 14: Foot stamping on trampoline

Progression: Progress to one leg standing and hopping.

Plate 15: One leg standing and hopping on trampoline

3. **Barefoot training**:

1. Barefoot sitting:

Plate 16: Barefoot sitting

2. Barefoot standing:

Plate 17: Barefoot standing

3. Barefoot walking

Plate 18: Barefoot walking

Plate 19: Barefoot stepping

Progression: Barefoot physio ball exercises with feet touch to ground:

Plate 20: Barefoot physio ball exercise with feet touch to ground

Progression: Barefoot lunges

10. OUTCOME MEASURES

The outcome measures of pre and post treatment will be subject to statistical analysis for significance.

1. BERG BALANCE SCALE

Description: 14-item scale designed to measure balance of the older adult in a clinical setting.

Equipment needed: Yardstick, 2 standard chairs (one with arm rests, one without), Footstool or step, Stopwatch or wristwatch, 15 feet walkway.

Scoring: A five-point ordinal scale, ranging from 0-4.

"0" indicates the lowest level of function and "4" the highest level of function.

Total Score = 56

Interpretation:

41-56 = independent

21-40 = walking with assistance

0 –20 = wheelchair bound

ITEM DESCRIPTION:

1. SITTING TO STANDING:

INSTRUCTIONS: Please stand up. Try not to use your hand for support.

(4) Able to stand without using hands and stabilize independently

(3) Able to stand independently using hands

(2) Able to stand using hands after several tries

(1) Needs minimal aid to stand or stabilize

(0) Needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED:

INSTRUCTIONS: Please stand for two minutes without holding on.

(4) Able to stand safely for 2 minutes

(3) Able to stand 2 minutes with supervision

(2) Able to stand 30 seconds unsupported

(1) Need several tries to stand 30 seconds unsupported

(0) Unable to stand 30 seconds unsupported

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL:

INSTRUCTIONS: Please sit with arms folded for 2 minutes.

(4) Able to sit safely and securely for 2 minutes

(3) Able to sit 2 minutes under supervision

(2) Able to able to sit 30 seconds

(1) Able to sit 10 seconds

(0) Unable to sit without support 10 seconds

4. STANDING TO SITTING:

INSTRUCTIONS: Please sit down.

(4) Sits safely with minimal use of hands

(3) Controls descent by using hands

(2) Uses back of legs against chair to control descent

(1) Sits independently but has uncontrolled descent

(0) Need assistance to sit

5. TRANSFERS:

INSTRUCTIONS: Use chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.

(4) Able to transfer safely with minor use of hands

(3) Able to transfer safely definite need of hands

(2) Able to transfer with verbal cuing and/or supervision

(1) Needs one person to assist

(0) Need two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED:

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.

(4) Able to stand 10 seconds safely

(3) Able to stand 10 seconds with supervision

(2) Able to stand 3 seconds

(1) Unable to keep eyes closed 3 seconds but stays safely

(0) Need help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER:

INSTRUCTIONS: Place your feet together and stand without holding on.

(4) Able to place feet together independently and stand 1 minute safely

(3) Able to place feet together independently and stand 1 minute with supervision

(2) Able to place feet together independently but unable to hold for 30 seconds

(1) Needs help to attain position but able to stand 15 seconds feet together

(0) Needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING:

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

(4) Can reach forward confidently 25 cm (10 inches)

(3) Can reach forward 12 cm (5 inches)

(2) Can reach forward 5 cm (2 inches)

(1) Reaches forward but needs supervision

(0) Loses balance while trying/requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION:

INSTRUCTIONS: Pick up the shoe/slipper, which is place in front of your feet.

(4) Able to pick up slipper safely and easily

(3) Able to pick up slipper but needs supervision

(2) Unable to pick up but reaches 2-5 cm (1-2 inches) from slipper and keeps balance independently

(1) Unable to pick up and needs supervision while trying

(0) Unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING:

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

(4) Looks behind from both sides and weight shifts well

(3) Looks behind one side only other side shows less weight shift

(2) Turn sideways only but maintains balance

(1) Needs supervision when turning

(0) Need assistance to keep from losing balance or falling

11. TURN 360 DEGREES:

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

(4) Able to turn 360 degrees safely in 4 seconds or less

(3) Able to turn 360 degrees safely one side only 4 seconds or less

(2) Able to turn 360 degrees safely but slowly

(1) Needs close supervision or verbal cuing

(0) Needs assistance while turning

12. PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED:

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touch the step/stool four times.

(4) Able to stand independently and safely and complete 8 steps in 20 seconds

(3) Able to stand independently and complete 8 steps in > 20 seconds

(2) Able to complete 4 steps without aid with supervision

(1) Able to complete > 2 steps needs minimal assist

(0) Needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT:

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width.)

(4) Able to place foot tandem independently and hold 30 seconds

(3) Able to place foot ahead independently and hold 30 seconds

(2) Able to take small step independently and hold 30 seconds

(1) Needs help to step but can hold 15 seconds

(0) Loses balance while stepping or standing

14. STANDING ON ONE LEG:

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

(4) Able to lift leg independently and hold > 10 seconds

(3) Able to lift leg independently and hold 5-10 seconds

(2) Able to lift leg independently and hold ≥ 3 seconds

(1) Tries to lift leg unable to hold 3 seconds but remains standing independently

(0) Unable to try of needs assist to prevent fall

TOTAL SCORE (Maximum = 56)

2. DYNAMIC GAIT INDEX

Description: Used to assess the likelihood of falling in older adults.

Equipment needed: Box (Shoebox), Cones (2), Stairs, 20' walkway, 15" wide

Completion: Time: 15 minutes Scoring: A four-point ordinal scale, ranging from 0-3. "0" indicates the lowest level of function and "3" the highest level of function.

Total Score = 24

Interpretation:

< 19/24 = predictive of falls in the elderly

> 22/24 = safe ambulators

ITEM DESCRIPTION:

1. GAIT LEVEL SURFACE:

Instructions: Walk at your normal speed from here to the next mark (20')

(3) Normal: Walks 20', no assistive devices, good sped, no evidence for imbalance, normal gait pattern: 3

(2) Mild Impairment: Walks 20', uses assistive devices, slower speed, mild gait deviations: 2

(1) Moderate Impairment: Walks 20', slow speed, abnormal gait pattern, evidence for imbalance: 1

(0) Severe Impairment: Cannot walk 20' without assistance, severe gait deviations or imbalance: 1

2. CHANGE IN GAIT SPEED:

Instructions: Begin walking at your normal pace (for 5'), when I tell you "go," walk as fast as you can (for 5'). When I tell you "slow," walk as slowly as you can (for 5').

(3) Normal: Able to smoothly change walking speed without loss of balance or gait deviation. Shows a significant difference in walking speeds between normal, fast and slow speeds: 3

(2) Mild Impairment: Is able to change speed but demonstrates mild gait deviations, or not gait deviations but unable to achieve a significant change in velocity, or uses an assistive device: 2

(1) Moderate Impairment: Makes only minor adjustments to walking speed, or accomplishes a change in speed with significant gait deviations, or changes speed but has significant gait deviations, or changes speed but loses balance but is able to recover and continue walking.

(0) Severe Impairment: Cannot change speeds, or loses balance and has to reach for wall or be caught.

3. GAIT WITH HORIZONTAL HEAD TURNS:

Instructions: Begin walking at your normal pace. When I tell you to "look right," keep walking straight, but turn your head to the right. Keep looking to the right until I tell you, "look left," then keep walking straight and turn your head to the left. Keep your head to the left until I tell you "look straight, "then keep walking straight, but return your head to the center.

(3) Normal: Performs head turns smoothly with no change in gait.

(2) Mild Impairment: Performs head turns smoothly with slight change in gait velocity, i.e., minor disruption to smooth gait path or uses walking aid.

(1) Moderate Impairment: Performs head turns with moderate change in gait velocity, slows down, staggers but recovers, can continue to walk.

(0) Severe Impairment: Performs task with severe disruption of gait, i.e., staggers outside 15" path, loses balance, stops, reaches for wall.

4. GAIT WITH VERTICAL HEAD TURNS:

Instructions: Begin walking at your normal pace. When I tell you to "look up," keep walking straight, but tip your head up. Keep looking up until I tell you, "look down," then keep walking straight and tip your head down. Keep your head down until I tell you "look straight," then keep walking straight, but return your head to the center.

(3) Normal: Performs head turns smoothly with no change in gait.

(2) Mild Impairment: Performs head turns smoothly with slight change in gait velocity, i.e., minor disruption to smooth gait path or uses walking aid.

(1) Moderate Impairment: Performs head turns with moderate change in gait velocity, slows down, staggers but recovers, can continue to walk.

(0) Severe Impairment: Performs task with severe disruption of gait, i.e., staggers outside 15" path, loses balance, stops, reaches for wall.

5. GAIT AND PIVOT TURN:

Instructions: Begin walking at your normal pace. When I tell you, "turn and stop," turn as quickly as you can to face the opposite direction and stop.

(3) Normal: Pivot turns safely within 3 seconds and stops quickly with no loss of balance.

(2) Mild Impairment: Pivot turns safely in > 3 seconds and stops with no loss of balance.

(1) Moderate Impairment: Turns slowly, requires verbal cueing, requires several small steps to catch balance following turn and stop.

(0) Severe Impairment: Cannot turn safely, requires assistance to turn and stop.

6. STEP OVER OBSTACLE:

Instructions: Begin walking at your normal speed. When you come to the shoebox, step over it, not around it, and keep walking.

(3) Normal: Is able to step over the box without changing gait speed, no evidence of imbalance.

(2) Mild Impairment: Is able to step over box, but must slow down and adjust steps to clear box safely.

(1) Moderate Impairment: Is able to step over box but must stop, then step over. May require verbal cueing.

(0) Severe Impairment: Cannot perform without assistance.

8. STEP AROUND OBSTACLES: Instructions: Begin walking at normal speed. When you come to the first cone (about 6' away), walk around the right

side of it. When you come to the second cone (6' past first cone), walk around it to the left.

(3) Normal: Is able to walk around cones safely without changing gait speed; no evidence of imbalance.

(2) Mild Impairment: Is able to step around both cones, but must slow down and adjust steps to clear cones.

(1) Moderate Impairment: Is able to clear cones but must significantly slow, speed to accomplish task, or requires verbal cueing.

(0) Severe Impairment: Unable to clear cones, walks into one or both cones, or requires physical assistance.

8. STEPS STAIRS:

Instructions: Walk up these stairs as you would at home, i.e., using the railing if necessary. At the top, turn around and walk down.

(3) Normal: Alternating feet, no rail.

(2) Mild Impairment: Alternating feet, must use rail.

(1) Moderate Impairment: Two feet to a stair, must use rail.

(0) Severe Impairment: Cannot do safely.

TOTAL SCORE: ___ / 24

11. DATA COLLECTION AND ANALYSIS

The pre and Post test data was collected and tabulated. All data were statistically analyzed using paired and unpaired 't' test for interpretation of the results. The differences in the means was compared by Least Significant Differences (LSD) at 5 per cent level ($P<0.05$).

DATA ANALYSIS

Pre-test and Post-test data within the group and between groups will be analysed by using Paired and unpaired 't' test. [33,3] The differences between pre - test and post – test values were found. It was done for the values taken before and at the end of sixth week respectively. The mean difference of BBS and Ankle DGI of group A were compared with group B and the actual pattern of variation were observed. With the 't' value from the pre-test and post-test, the accurate level of significance was analyzed and interpreted. An alpha level of $p<0.05$ was the level of significance for the test. Paired 't' test was performed to analyze the efficacy of treatment within the groups

and unpaired ‘t’ test was performed to analyze the efficacy of treatment between both groups.

PAIRED ‘t’ TEST WITHIN GROUP:

The paired ‘t’ test was used to find out the significance within the same group with the values of parameters considered for the study

UNPAIRED ‘t’ TEST BETWEEN GROUP:

The ‘t’ test was used to find out the significance between the groups and it gives the valuable information regarding this study.

RESULT AND DATA INTERPRETATION

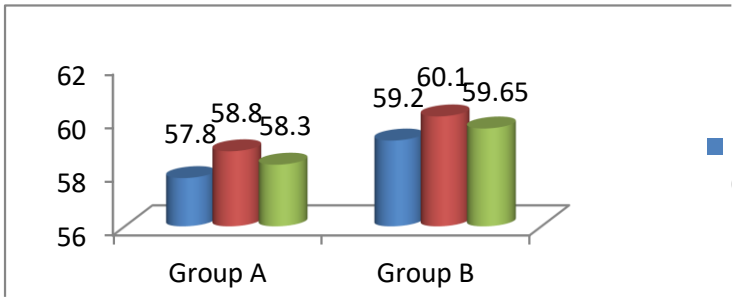
The present study was carried out to observe the effects of barefoot training with sensory integration to improve balance and gait in diabetic neuropathic patients. The improvement in balance was assessed by Balance Berg Scale and gait by Dynamic Gait Index.

1. DEMOGRAPHIC PRESENTATION OF DATA IN GROUPS:

TABLE: 1

GROUP	NUMBER	AGE IN YEARS					
		MEAN			SD		
		Male	Female	Both	Male	Female	Both
Group A	20	57.80	58.80	58.30	5.88	5.12	5.39
Group B	20	59.20	60.10	59.65	6.13	4.84	5.39
Total	40	58.50	59.45	58.98	5.89	4.89	5.37

GRAPH: 1



INTERPRETATION:

Table 1 show that the average age of all the participants was 58.98 years. Group A had a mean age of 58.30 years and Group B had a mean age of 59.65 years. The mean age of male participants was 57.80 years in group A and 59.20 years in group B and average age of male participants was 58.50 years. The mean age of female

participants was 58.80 years in group A and 60.10 years in group B and average age of female participants was 59.45 years.

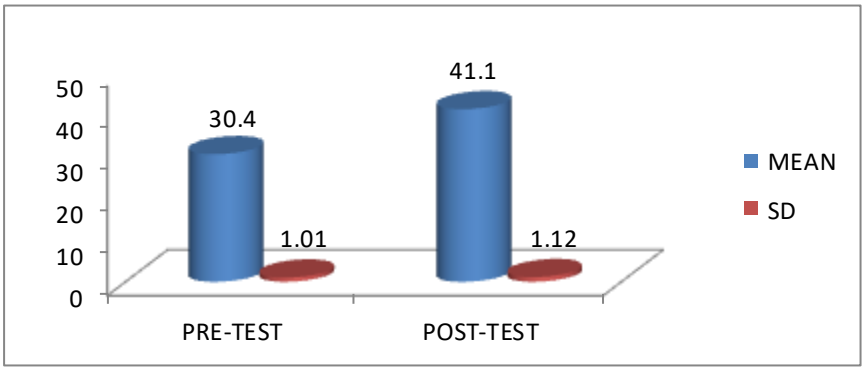
2. ANALYSIS OF PRE-TEST AND POST-TEST VALUES OF BERG BALANCE SCALE (BBS) WITHIN GROUP A:

TABLE: 2

	Mean	N	SD	Std. Error Mean	R	Mean Diff	T	P
Pre-test	30.40	20	4.52	1.01	0.7600	10.70	14.387	0.0001*
Post-test	41.10	20	4.99	1.12				

***** Significant difference (P<0.05)

GRAPH: 2



INTERPRETATION:

The above table shows the mean of pre-test and post – test values of BBS were 30.40 and 41.10, respectively. The mean improvement in balance score of Group A was 10.70. The 't' value 14.387 and 'P' value 0.0001 for balance scores using BBS within Group A analysis. When compared to table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that Group A treated with conventional physiotherapy had significant improvement in balance of diabetic neuropathic patients within Group A.

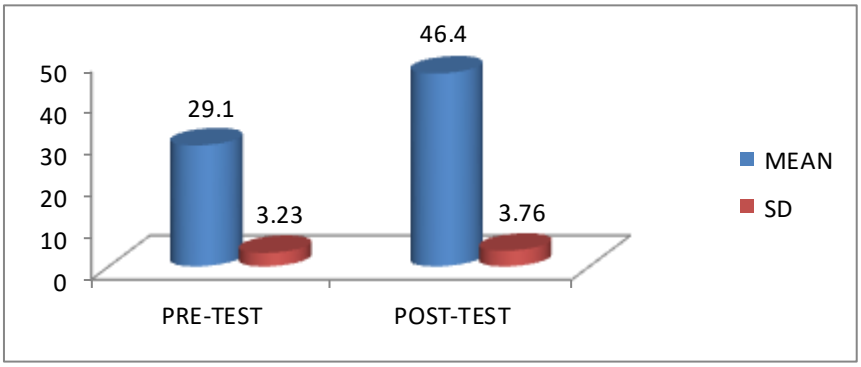
3. ANALYSIS OF PRE-TEST AND POST-TEST VALUES OF BERG BALANCE SCALE (BBS) WITHIN GROUP B:

TABLE: 3

	Mean	N	SD	Std. Error Mean	R	Mean Diff	T	P
Pre-test	29.10	20	3.23	0.72	0.9420	17.30	59.431	<0.0001*
Post-test	46.40	20	3.76	0.84				

***** Significant difference (P<0.05)

GRAPH: 3



INTERPRETATION:

The above table shows the mean of pre-test and post – test values of BBS were 29.10 and 46.40, respectively. The mean improvement in balance score of Group B was 17.30. The 't' value 59.431 and 'P' value <0.0001 for balance scores using BBS within Group B analysis. When compared to table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that Group B treated with barefoot training with sensory integration had significant improvement in balance of diabetic neuropathic patients within Group B.

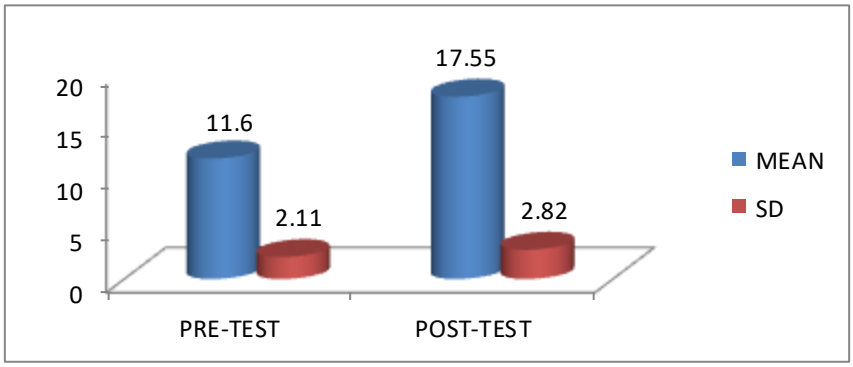
4. ANALYSIS OF PRE-TEST AND POST-TEST VALUES OF DYNAMIC GAIT INDEX (DGI) FOR SIGNIFICANCE WITHIN GROUP A:

TABLE: 4

	Mean	N	SD	Std. Error Mean	R	Mean Diff	T	P
Pre-test	11.60	20	2.11	0.47	0.8609	5.95	18.125	0.0010*
Post-test	17.55	20	2.82	0.63				

***** Significant difference (P<0.05)

GRAPH: 4



INTERPRETATION:

The above table shows the mean of pre-test and post – test values of DGI were 11.60 and 17.55, respectively. The mean improvement in gait score of Group A was 5.95. The 't' value 18.125 and 'P' value 0.0010 for gait scores using DGI within Group A analysis. When compared to table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that Group A treated with conventional physiotherapy had significant improvement in gait of diabetic neuropathic patients within Group A.

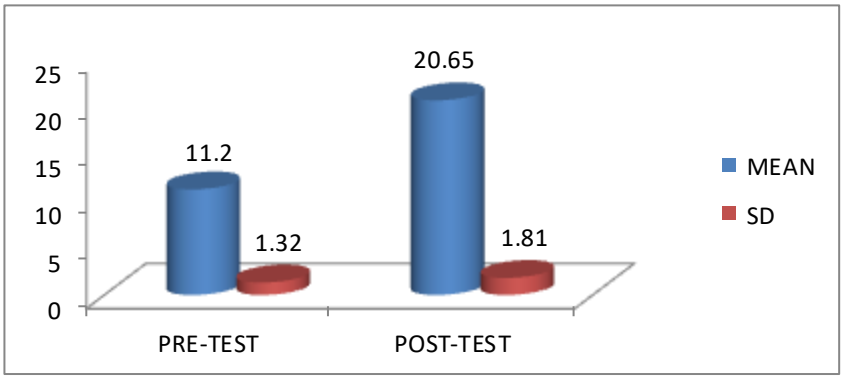
5. ANALYSIS OF PRE-TEST AND POST-TEST VALUES OF DYNAMIC GAIT INDEX (DGI) FOR SIGNIFICANCE WITHIN GROUP B:

TABLE: 5

	Mean	N	SD	Std. Error Mean	R	Mean Diff	T	P
Pre-test	11.20	20	1.32	0.30	0.9085	9.45	51.190	<0.0001*
Post-test	20.65	20	1.81	0.41				

***** Significant difference (P<0.05)

GRAPH: 5



INTERPRETATION:

The above table shows the mean of pre-test and post – test values of DGI were 11.20 and 20.65, respectively. The mean improvement in gait score of Group B was 9.45. The 't' value 51.190 and 'P' value <0.0001 for gait scores using DGI within Group B analysis. When compared to table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that Group B treated with barefoot training with sensory integration had significant improvement in gait of diabetic neuropathic patients within Group B.

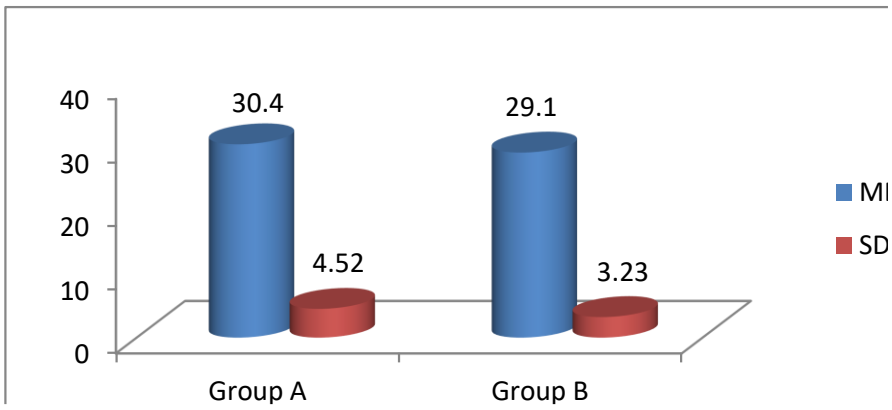
6. ANALYSIS OF PRE-TEST VALUES OF BERG BALANCE SCALE (BBS) BETWEEN GROUPS:

TABLE: 6

Group	Mean	N	SD	Std. Error Mean	Mean Diff	T	P
A	30.40	20	4.52	0.01	1.30	1.046	0.3020[NS]
B	29.10	20	3.23	0.72			

[NS] Non-significant difference (P<0.05)

GRAPH: 6



INTERPRETATION:

The above table shows the mean of pre-test values of BBS were 30.40 and 29.10 in Group A and Group B, respectively. The mean difference in balance scores between groups were 1.30. The 't' value 1.046 and 'P' value 0.3020 for balance scores using BBS between Group A and Group B analysis. When compared the table value, the above 'P' value is greater at P<0.05, which is non-significant. It indicates the homogeneity in pre test values of both the groups.

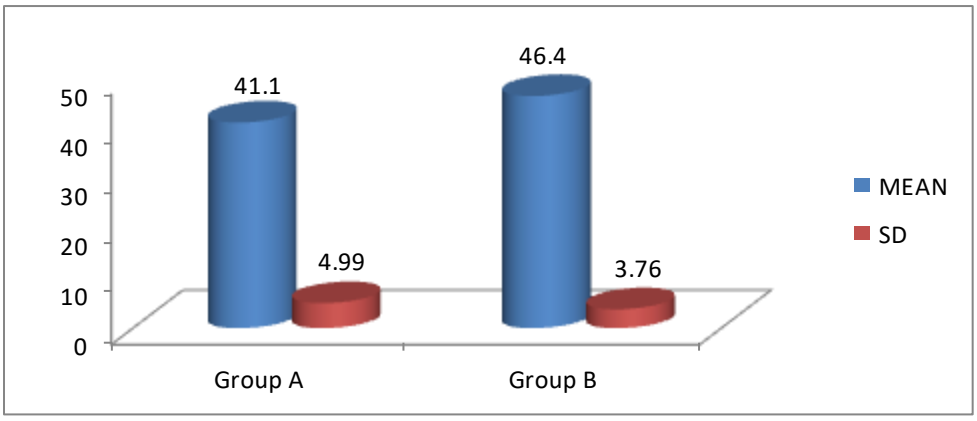
7. ANALYSIS OF POST-TEST VALUES OF BERG BALANCE SCALE (BBS) BETWEEN GROUPS:

TABLE: 7

Group	Mean	N	SD	Std. Error Mean	Mean Diff	T	P
A	41.10	20	4.99	1.12	5.30	3.791	0.005*
B	46.40	20	3.76	0.84			

***** Significant difference (P<0.05)

GRAPH: 7



INTERPRETATION:

The above table shows the mean of post-test values of BBS were 41.10 and 46.40 in Group A and Group B, respectively. The mean difference in balance scores between groups were 5.30. The 't' value 3.791 and 'P' value 0.005 for balance scores using BBS between Group A and Group B analysis. When compared the table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that both the techniques were effective on improvement in balance but Group B treated with bare foot training with sensory integration was more effective than group A treated with conventional physiotherapy.

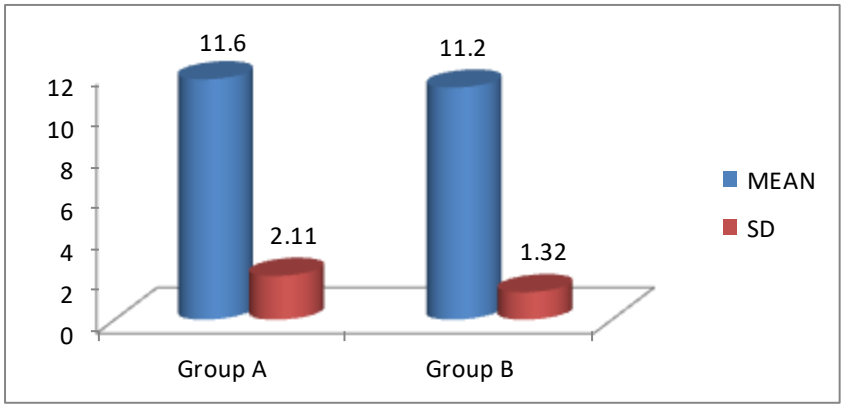
8. ANALYSIS OF PRE TEST VALUES OF DYNAMIC GAIT INDEX (DGI) BETWEEN GROUPS:

TABLE: 8

Group	Mean	N	SD	Std. Error Mean	Mean Diff	T	P
A	11.60	20	2.11	0.47	0.40	0.7178	0.4773^{NS}
B	11.20	20	1.32	0.30			

^{NS}Non-significant difference (P<0.05)

GRAPH: 8



INTERPRETATION:

The above table shows the mean of pre-test values of DGI were 11.60 and 11.20 in Group A and Group B, respectively. The mean differences in gait scores between groups were 0.40. The 't' value 0.7178 and 'P' value 0.4773 for gait scores using DGI between Group A and Group B analysis. When compared the table value, the above 'P' value is greater at P<0.05, which is non-significant. It indicates the homogeneity in pre test values of both the groups.

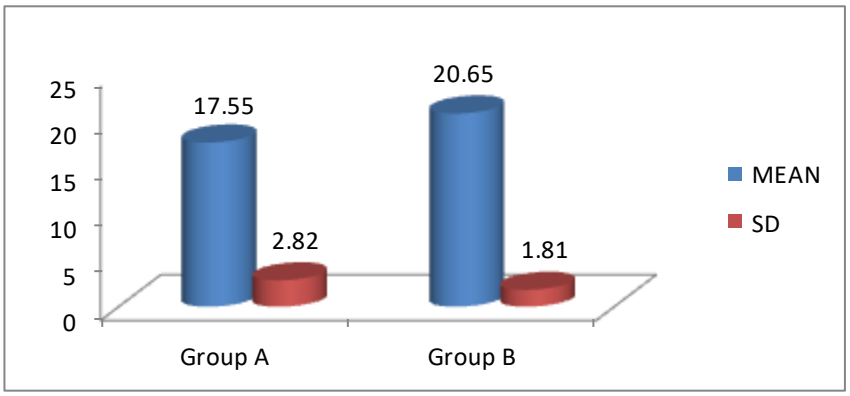
9. ANALYSIS OF POST - TEST VALUES OF DYNAMIC GAIT INDEX (DGI) BETWEEN GROUPS:

TABLE: 9

Group	Mean	N	SD	Std. Error Mean	Mean Diff	T	P
A	17.55	20	2.82	0.63	3.10	4.136	0.0012*
B	20.65	20	1.81	0.41			

***** Significant difference (P<0.05)

GRAPH: 9



INTERPRETATION:

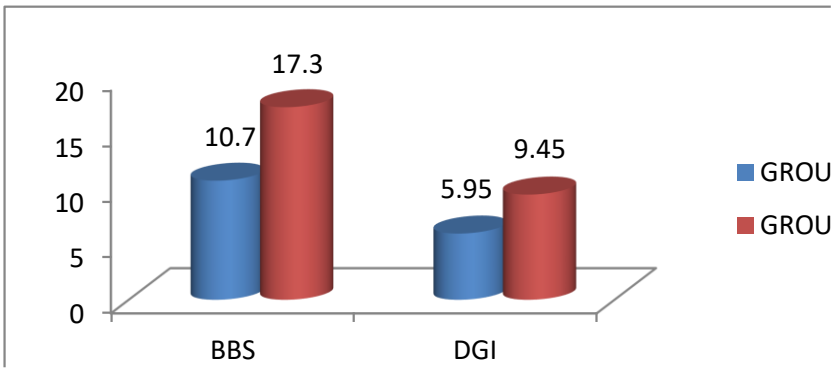
The above table shows the mean of post-test values of DGI scores were 17.55 and 20.65 in Group A and Group B, respectively. The mean difference in gait scores between groups was 3.10. The 't' value 4.136 and 'P' value 0.0012 for gait scores using DGI between Group A and Group B analysis. When compared the table value, the above 'P' value is lesser at P<0.05, which is significant. It indicates that both the techniques were effective in improving gait but Group B treated with bare foot training with sensory integration was more effective than group A treated with conventional physiotherapy.

10. MEAN IMPROVEMENT IN ALL THE PARAMETERS BETWEEN GROUP A AND GROUP B

TABLE: 10

	Group	N	Mean		Group	N	Mean
BBS	A	20	10.70	DGI	A	20	5.95
	B	20	17.30		B	20	9.45

GRAPH: 10



INTERPRETATION:

The above table shows the mean improvement in balance scores of BBS was 10.70 in Group A and 17.30 in Group B. The difference between mean improvement in balance scores of Group B was 6.60 higher than Group A. So, It was resulted that Group B treated with bare foot training with sensory integration was more effective on balance impairments in diabetic neuropathic patients than Group A treated with conventional physiotherapy.

The above table shows the mean improvement in gait scores of DGI was 5.95 in Group A and 9.45 in Group B. The difference between mean improvement in gait scores of Group B was 3.50 higher than Group A. So, It was resulted that Group B treated with bare foot training with sensory integration was more effective on gait impairments in diabetic neuropathic patients than Group A treated with conventional physiotherapy.

Thus, the above study resulted that both the techniques were effective but bare foot training with sensory integration had superior effect over conventional physiotherapy on balance and gait in diabetic neuropathic patients.

DISCUSSION

A complex set of balance, posture and gait alterations can be present in diabetic patients due to polyneuropathy. Impairment of postural control and weakness together with limited joint mobility foot deformities leads to posture and gait alterations. It is well known that postural control while standing is reduced since early stages of neuropathy and that the balance deficit increases the frequency of injuries and falls.[83] The quality of balance is linked to vestibular, somatosensory, visual sensitivity and motor outputs. Each of these afferent and efferent systems can be compromised in diabetic patients but somatosensory sensitivity and motor outputs are more susceptible to damage by DPN. Diminished somatosensory information and the delay in motor outputs in feet, ankles and legs can result in the lack of feedback, higher reaction time and deficits such as a decrease in rapidly available ankle strength. Diabetic neuropathy patients show a significantly wider distance between center of pressure and center of mass in anterior-posterior and medial-lateral positions in comparison to healthy age-matched subjects.[84]

Diabetic neuropathy may induce a diminished perception of leg or foot position, ankle movement, and the type of foot contact with the ground. As consequence, during gait, these patients may have difficulty understanding when they can safely transfer their body weight from limb to limb. These deficits, together with the presence of a steady rigid foot, lead to a gait similar to flat-footed walking, in which the foot arrives on the ground almost flat due to lower ankle dorsiflexion. The gait is characterized by a minimal heel strike phase due to the difficulty in controlling the legs' deceleration and in braking the forward momentum of the body. The presence of a steady rigid foot involves lower foot pronation at initial contact and lack of physiological helical movements of the foot during the stance phase. All this during mid-stance is associated with less ankle movement (flexion–extension) and difficulty in the foot's inversion/eversion. This does not allow the physiological passage of the foot from a flexible to a rigid condition, necessary to adequately perform the foot's push-off. Moreover, the stance phase is characterized by abnormal foot rolling and a difficult

forward progression of the body weight. Subjects with impaired glucose tolerance and peripheral neuropathy have less trunk control and elderly people with diabetes exhibit forward trunk lean during walking. This may contribute to flat-footed gait.[85]

In present study, forty diabetic neuropathic patients with balance and gait impairment were selected randomly and divided into two groups - Group A and Group B (20 participants in each group). Group A received conventional physiotherapy and group B received barefoot training along with sensory integration for next 12 weeks. The improvement in balance was assessed by using BBS and gait by DGI. Pre-test data were collected at the beginning of the study and post-test data were collected at the end of 12th week. The data were statistically analysed and comparing Group A and Group B.

The study also compared the conventional physiotherapy and barefoot training along with sensory integration on improving balance of diabetic neuropathic patients. The balance score of each patient was assessed by using BBS before the start of the treatment as pre-test values and at the end of 12th week as post-test values. The mean of pre-test and post - test values were 30.40 and 41.10, respectively in group A and 29.10 and 46.40, respectively in group B. The mean improvement in BBS score of group A and group B was 10.70 and 17.30, respectively. The statistical analysis correlates the study by proposing that groups taken for study either Group A treated by conventional physiotherapy or Group B treated by barefoot training along with sensory integration showed significant effect in improvement on balance of diabetic neuropathic patients. The Group B treated with barefoot training along with sensory integration had superior effect in improvement on balance in diabetic neuropathic patients when compared to Group A treated with conventional physiotherapy.

Maurer C et al. (2001)[92] and Sowjanya Maruboyina et al. (2019).[93] Their research suggesting that sensory specific intervention is helpful in improve balance and gait when compared to conventional exercises alone in diabetic neuropathic patients. By giving barefoot training and sensory integration exercises the proprioceptive information from the joint receptors pass through the Spinocerebellar tracts and reach cerebellum which is a chief controlling organ for balance. The somatosensory input given will increase the sensitivity of the receptors there by balance is improved. Adding the visual and vestibular inputs alteration will make the individual to depend

on the somatosensory inputs to control balance. Therefore, combining all these will certainly help the individual.

Thus, the above study resulted that barefoot training along with sensory integration had a superior effect over conventional physiotherapy on balance and gait of diabetic neuropathic patients.

LIMITATIONS

1. The study was limited to diabetic neuropathic patients.
2. The study was limited due to shorter duration of treatment.
3. The study was limited due to less number of participants.
4. The study was limited age group between 50 – 70 years.
5. The study was limited to balance and gait impairments.

RECOMMENDATIONS .

1. It may be recommended that treatment duration could be more than 12 weeks, so that more results could be evaluated.
2. It may be recommended that study could be done on more than 40 diabetic neuropathic patients.
3. It may be recommended that study could be done on different age groups.
4. It may be recommended that more studies are needed to be done in various techniques to improve balance and gait in diabetic neuropathic patients.

CONCLUSION

Based on the results, the present study states that both bare foot training with sensory integration and conventional physiotherapy are effective to improve balance and gait but both bare foot training with sensory integration has better results than conventional physiotherapy on improvement in balance and gait of diabetic neuropathic patients.

Thus, it can be concluded that bare foot training with sensory integration is useful and an effective technique to treat balance and gait impairments of diabetic neuropathic patients. Bare foot training with sensory integration is safe and easily applied to treat balance and gait impairments of diabetic neuropathic patients.

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