International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

# Effect of Rhythmic Auditory Stimulation on Balance in Subjects with Diabetic Peripheral Neuropathy Associated with Type 2 Diabetes Mellitus – A Quasi-Experimental Study

**Dr. Kashish Mahna[1], Dr. Jaspinder Kaur[2], Dr. Swati Nagpal[3]**

[1]Masters of Physiotherapy, Neurology Department, DAVIPTR, Jalandhar, Punjab, India
[2]Associate Professor (MPT, Neurology), Neurology Department, DAVIPTR, Jalandhar, Punjab, India
[3]Associate Professor (MPT Musculoskeletal), Orthopedics Department, DAVIPTR, Jalandhar, Punjab, India

**Abstract**

**Background**: Diabetes Mellitus can cause Diabetic Peripheral Neuropathy (DPN), a serious condition that can negatively impact a person's walking. It disrupts the body's sensorimotor system. Walking stability is decreased and muscle coordination is altered by diabetic peripheral neuropathy (DPN).

**Objective:** This study aims at finding whether rhythmic auditory stimulation has an impact on patients with diabetic peripheral neuropathy having type 2 diabetes mellitus.

**Methodology:** The patients having diabetic peripheral neuropathy and who were eligible for inclusion were recruited for the study. A minimum of 20 patients, divided into 2 groups, both male and female, aged between 40 to 60 years were selected for the trial by non-convenient sampling. Group A was experimental group, receiving Rhythmic Auditory Stimulation and group B was conventional group, receiving conventional balance training. The treatment was given for 6 weeks, 3 times a week for 45 minutes. The patients were assessed using berg balance scale. The data was collected at baseline and at 3rd week and 6th week post intervention.

**Results:** The results of study showed statistically significant difference between the berg balance score of Group A and Group B.

**Conclusion:** From the results of present study, it is depicted that when compared with conventional physiotherapy management techniques, rhythmic auditory stimulation proved to be better approach in improving berg balance scores.

**Keywords:** Diabetic Peripheral Neuropathy, Rhythmic Auditory Stimulation, Balance

## 1. Introduction

Diabetes mellitus includes a group of disorders expressed by abnormal glucose metabolism. Numerous pancreatic, hormonal, pharmacological and genetic diseases can also lead to impaired glucose tolerance. (1)

Diabetic neuropathy (DN) is referred to a common condition characterized by manifestations of peripheral

nerve impairment in individuals with DM, after excluding other possible causes of nerve dysfunction. It is estimated that clinical or subclinical neuropathy affects two-thirds of subject. [2]

**1.1 Types of Diabetic Peripheral Neuropathy**

**(a) DISTAL SYMMETRICAL POLYNEUROPATHY (DSPN)-** DSPN is the most prevalent type of DN and likely makes up 75% of all DNs. It could involve small, large, or both types of fibres and be either sensory or motor. There is sensory impairment in the distribution of gloves and stockings, and motor indications are not noticeable. [2]

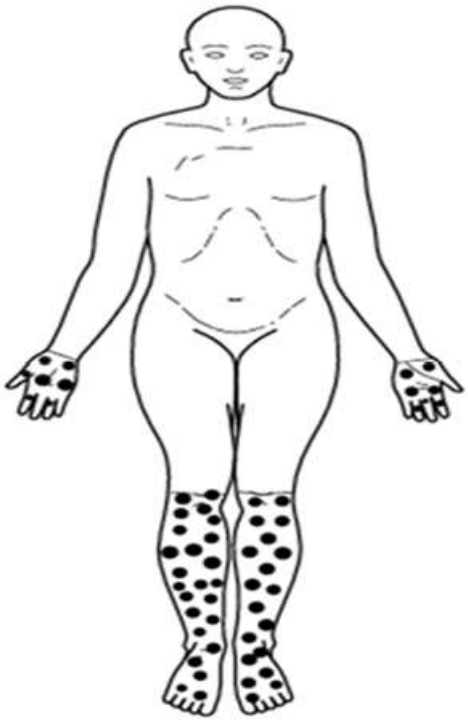


**Figure 1.1. Distal symmetrical polyneuropathy [2]**

**(b) ASYMMETRICAL PROXIMAL DIABETIC NEUROPATHY-** Patients often report unilateral, but sometimes bilateral, discomfort in the low back, hip, and anterior thigh. The withering and atrophy of the leg and thigh muscles within a few days or weeks comes after. Knee reflex is either absent or diminished. The symptoms of paraesthesia or numbness are mild. [2]

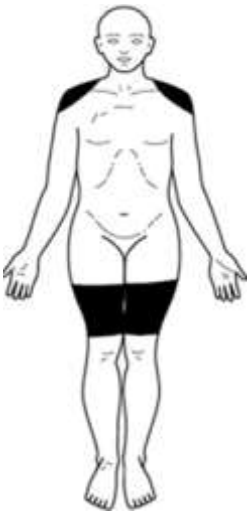


**Figure 1.2. Asymmetrical proximal diabetic neuropathy [2]**

**(c) CRANIAL NEUROPATHY-** The oculomotor nerve, trochlear nerve, and cranial nerve VII are the most frequently affected in diabetes patients with cranial neuropathy. [2]

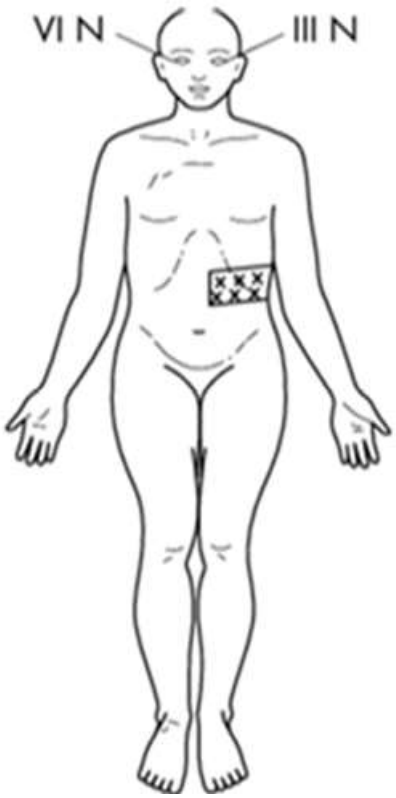



**Figure 1.3. Cranial neuropathy [2]**

**(d) MONONEUROPATHY-** The peroneal, medial nerves are among the various entrapment neuropathies that affect diabetes individuals. [2]

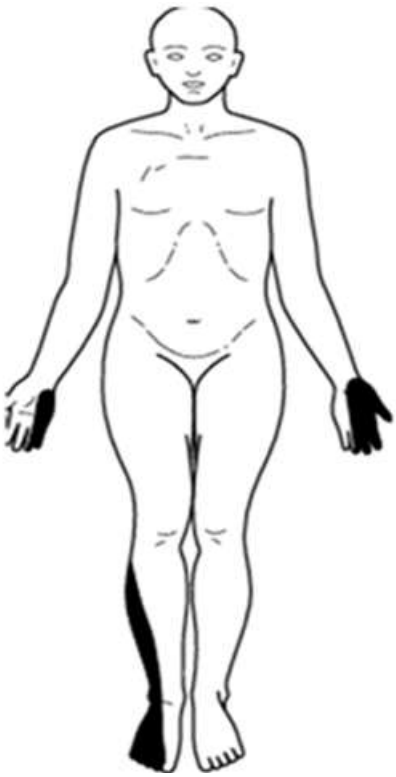


**Figure 1.5. Mononeuropathy [2]**

### 1.2 Causes of Diabetic Peripheral Neuropathy

The primary causes of peripheral neuropathy are oxidative stress, metabolic disorders, microangiopathy, and other diabetes-related conditions that disrupt the normal structure and function of nerve cells through unique signal transduction pathways, resulting in neuronal demyelination and damage. This is brought on by damage to unmyelinated nerves, axonal atrophy, and myelin loss in myelinated neurons. These effects show up as altered nerve conduction velocity and abnormal sensory function. [3]

According to recent research, Schwann Cells have a role in several stages of DPN formation. Certain important signalling pathways in Schwann Cells are triggered by DPN. These changes ultimately cause demyelination, myelin destruction, abnormalities in axonal conduction, and impaired neuronal regeneration. [4]

### 1.3 Pathophysiology of Diabetic Peripheral Neuropathy

High blood sugar is a major contributing cause to diabetic neuropathy. It is believed that dyslipidaemia has a significant role in T2DM. Insulin signalling alterations are also important; people with T1DM have lower levels of both insulin and C-peptide, whereas those with T2DM are believed to have lower neuronal insulin sensitivity. [5]

### 1.4 Risk factors [6]

a. Advanced age
b. Hypertension
c. Peripheral vascular disease
d. Smoking
e. Dyslipidaemia
f. Poor glucose control
g. Long-standing diabetes
h. Obesity
i. Excessive alcohol consumption
j. Positive HLA-DR3/4 genotype

### 1.5 Clinical features

DPN begins in the toes and progresses proximally over time. After becoming well established in the lower limbs, it spreads to the upper limbs, causing sensory loss that typically follows the "glove and stocking" pattern. About one-third of patients with DPN and 20% of all diabetes patients experience painful sensations as burning, tingling. [7]

Pain, weakness, unsteadiness, ataxia, and falls are among the symptoms. At night, painful symptoms are usually prominent. Unsteadiness is becoming more often acknowledged as a sign of DPN since it can be caused by abnormal muscle sensory function and impaired proprioception. Patients may have a positive Romberg's sign in more extreme situations where they have lost proprioception. [8]

Both the somatosensory and the motor control systems are compromised by DPN, which has an impact on the magnitude and calibre of sensory data acquired. This leads to increased instability in static posture. [9]

Since the brain instructs the limb muscles to stabilize the body, cognitive and attention deficits play a significant role in maintaining balance and postural control. Patients with diabetes who have cognitive and attentional problems will therefore have trouble walking with balance. [10]

### 1.6 Management of Diabetic Peripheral Neuropathy [11]

**(a) Pharmacological treatment-**

1. First-line agents- Gabapentinoids (eg, pregabalin and gabapentin), Duloxetine
2. Second-line agents- Serotonin and norepinephrine reuptake inhibitors, Tricyclic antidepressants, Tapentadol, Capsaicin patch 8%, Lidocaine patch 5%
3. Third- and Fourth-line agents- Tramadol, Opioid

**(b) Stimulation and drug Therapy**

1. Dorsal column spinal cord stimulation
2. Intrathecal drug delivery system

### 1.7 Rhythmic auditory stimulation

Rhythmic stimulation is a motivating, accessible, and reasonably priced gait rehabilitation technique. Rhythmic stimulation, especially rhythmic auditory stimulation (RAS), is used in certain clinical populations to improve motor unit activation patterns in certain gait-related muscles and gait kinematic measurements. [12]

RAS is defined as a therapeutic application of pulsed rhythmic or musical stimulation to improve balance. [13]

Little is known about how RAS affects DPN patients' balance. This study will ascertain whether RAS intervention has an impact on the lower limb muscle coordination in DPN patients.

### 1.8 Need of Study

As per the previous studies, general activities that enhance gait and balance have been shown to be beneficial in those diagnosed with diabetic peripheral neuropathy. However, a notable rate of therapy dropouts exists during conventional training due to lack of engagement. Enhancing functional gait and maintaining functional balance are two benefits of RAS training. The majority of research supports the effectiveness of RAS-assisted rehabilitation. This study will be crucial for better understanding of how auditory cues impact the functional gait and balance in these patients.

## 2. Methodology

### 2.1 Study Design

The study design is Quasi Experimental in nature. The convenient sampling technique was used.

### 2.2 Protocol

All the subjects meeting the inclusion criteria were enrolled in the study. A written informed consent was undertaken from each participant. The required screening and assessment of the subjects was done. A total of 20 subjects were selected for the study divided into 2 groups that is group A and group B, each group containing 10 subjects. The subjects were assessed using berg balance score. The total duration of this study was 6 weeks, 3 sessions per week with a minimum duration of 45 minutes per day for all the groups. The subjects were assessed at baseline, 3$^{rd}$ week and 6$^{th}$ week.

### 2.3 Procedure

The eligible patients were recruited for the study. After obtaining the consent, two groups were formed-

(a) Experimental group (Group A) - receiving rhythmic auditory stimulation.

(b) Conventional group (Group B) - receiving conventional gait and balance training.

**(A)Experimental Group – Rhythmic auditory Stimulation**

After assessing the patient, the protocol of rhythmic auditory stimulation (RAS) was explained to the patient. The treatment was given for 6 weeks, 3 times a week for a duration of 45-60 minutes a day. At the

beginning of the study, gait of the patient was assessed so as to set an average speed for the patient. For this, patient was made to walk continuously for about 20 minutes while they were listening to auditory cues, i.e., RAS. After that, the patients' walk was assessed prior to the treatment session. They were asked to move at their chosen pace along a 6-meter corridor. To get the footprints, boric powder was applied to the middle two meters of the walkway's floor. Following the first walk trial, the following walk was used to measure step length (the distance between one foot's heel and the other foot's heel) and stride length (the distance between same foot's floor contact points throughout a single gait cycle) using an inch tape. Gait speed (the amount of time needed to cover a 6-meter distance), and cadence (the number of steps per minute) were also assessed.

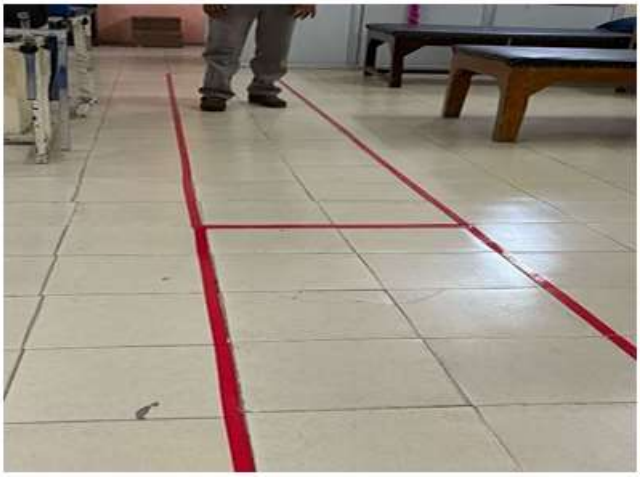


**Figure 2.1- Patient walking at his own pace prior to treatment**

**Figure 4.12- Patient's Footprint using boric powder**

The pace was determined by comparing cadence of each patient to that of healthy individuals of the same age, i.e., if the cadence of patient at the beginning of study was –

1. Below normal individual's cadence- RAS pace was set at a value of 10% higher than the patient's own cadence
2. Below but close to the normal cadence- the RAS pace was set at normal individuals' cadence values.

The patients were made to walk six meters, turn 180 degrees, and return to the starting point while matching their steps to the metronome output beat. Each session of the training lasted 30 minutes. The metronome output beat for each patient was adjusted each week to match the desired cadence plus 10%.

**Figure 2.2 – Patient walking while listening to auditory cues, i.e., Rhythmic Auditory Stimulation**

**(B)Conventional training Group –**

Patients' walk was assessed prior to the treatment session. Their footprints were taken by making them walk over boric powder and their step length, stride length was measured using an inch tape. Their cadence and gait speed were also assessed. The conventional training consisted of Balance Training –

1. Each session comprised of 10 minutes of warm up, followed by 45-50 minutes of exercise and ended with 5-10 minutes of cool down.
2. Warm up also included gentle stretching, forward, backward and sideways step ups.
3. Balance training consisted of-

- Static balance exercises (including- heel and toe raise, one legged stance for each limb, weight shifting forward, backward and sideways and turning head to left and then to right keeping the feet together)
- dynamic balance exercises (involving- narrow walking / tandem walking, stepping over obstacles and throwing and catching ball).

## 3. Results

The data was evaluated in line with the study objectives using statistical tools. The selected level of significance was at $p \leq 0.05$. The aim of the analysis was to transform the collected data into a meaningful and interpretable form, enabling comparison of results and identification of statistical significance.

### 3.1 Within the Group Analysis of Berg Balance Score

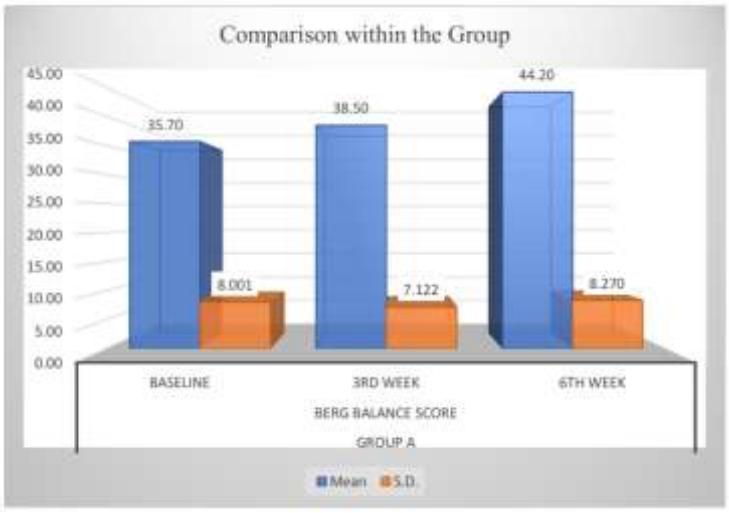
(a) for group A

**Table 3.1: Within-Group Analysis of Berg Balance Score in Group A (Repeated ANOVA)**

| . | Group A | | |
|---|---|---|---|
| Repeated ANOVA | BERG BALANCE SCORE | | |
| | BASELINE | 3rd WEEK | 6th WEEK |
| Mean | 35.70 | 38.50 | 44.20 |
| S.D. | 8.001 | 7.122 | 8.270 |
| Median | 38.5 | 41 | 48 |
| Number | 10 | 10 | 10 |
| Maximum | 44 | 46 | 50 |
| Minimum | 18 | 23 | 26 |
| DF1 | 2 | | |
| DF2 | 18 | | |
| F Test | 101.12 | | |
| P value | 3.555 | | |
| Table Value | <0.001 | | |
| Result | Significant | | |
| Tukey's method for Pairwise comparison | BASELINE | | |
| Mean Difference & Result> | 3rd WEEK | 2.8Sig | 3rd WEEK |
| | 6th WEEK | 8.5Sig | 5.7Sig |

The above table presents the intra-group analysis of Berg Balance Score in Group A measured at start, 3rd week, and 6th week using repeated ANOVA. The mean balance score increased from 35.70 at starting to

38.50 at the 3rd week and later improved to 44.20 at the 6th week. The corresponding standard deviations were 8.001, 7.122, and 8.270 respectively. Median values also demonstrated a consistent upward trend across the assessment periods. The number of participants remained constant at 10. The calculated F value was 101.12 with a significance level of $p<0.001$ indicating a statistically substantial improvement over time. Tukey's post-hoc analysis showed appreciable differences between baseline and 3rd week, baseline and 6th week, and between 3rd week and 6th week. These findings indicate significant improvement in balance performance within Group A following the intervention.




**Graph 3.1- Comparison of berg balance score within the group A**

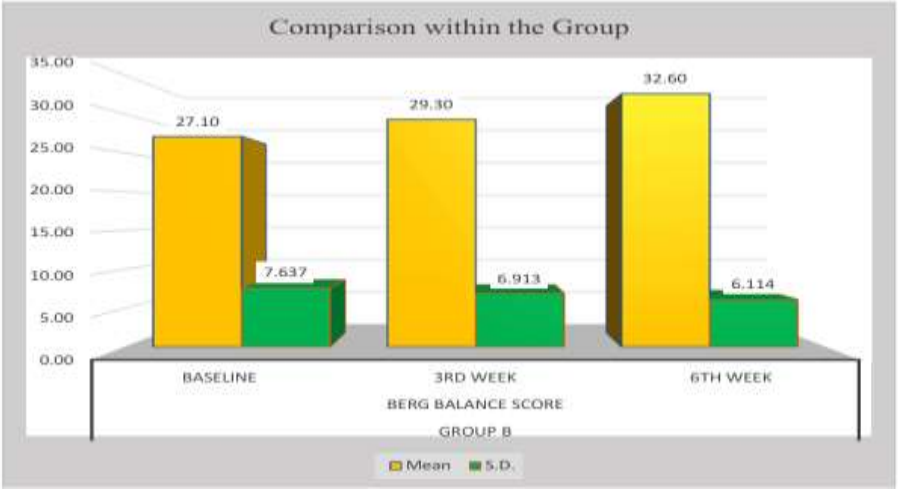
**(b) For group B**

**Table 3.2: Within-Group Analysis of Berg Balance Score in Group B (Repeated ANOVA)**

| . | Group B | | |
|---|---|---|---|
| Repeated ANOVA | BERG BALANCE SCORE | | |
| | BASELINE | 3rd WEEK | 6th WEEK |
| Mean | 27.10 | 29.30 | 32.60 |
| S.D. | 7.637 | 6.913 | 6.114 |
| Median | 29 | 31.5 | 34 |
| Number | 10 | 10 | 10 |
| Maximum | 39 | 40 | 42 |
| Minimum | 15 | 19 | 24 |
| DF1 | 2 | | |
| DF2 | 18 | | |
| F Test | 42.14 | | |
| P value | 3.555 | | |
| Table Value | <0.001 | | |
| Result | Significant | | |
| Tukey's method for Pairwise comparison | BASELINE | | |
| Mean Difference & Result> | 3rd WEEK | 2.2Sig | 3rd WEEK |
| | 6th WEEK | 5.5Sig | 3.3Sig |

The fourteenth table presents the within-group analysis of Berg Balance Score in Group B assessed at baseline, 3rd week, and 6th week using repeated ANOVA. The mean balance score increased from 27.10

at baseline to 29.30 at the 3rd week and further to 32.60 at the 6th week. The standard deviation values were 7.637, 6.913, and 6.114 respectively. Median values also showed gradual improvement across the assessment periods. The number of participants remained constant at 10 throughout the study. The calculated F value was 42.14 with a significance level of $p<0.001$ indicating a statistically significant difference over time. Tukey's post-hoc comparison demonstrated significant improvements between baseline and 3rd week, baseline and 6th week, and between 3rd week and 6th week. These findings suggest that balance performance significantly improved within Group B during the study period.



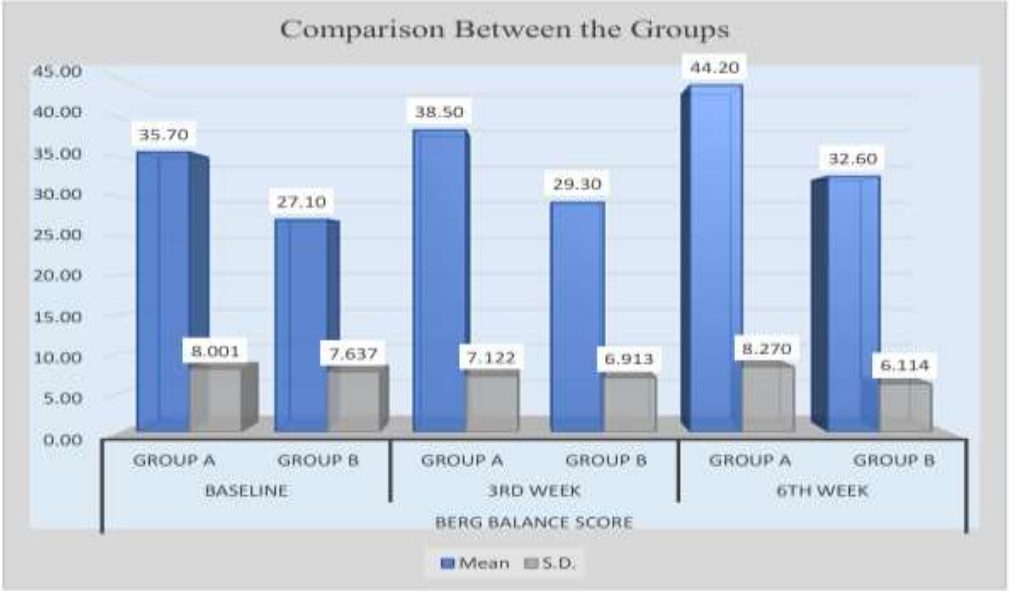

**Graph 3.2 – Comparison of berg balance score within the group B**

### 3.2 Between the Group Analysis of Berg Balance Score

**Table 3.3: Between-Group Comparison of Berg Balance Score at Baseline, 3rd Week and 6th Week (Unpaired t-test)**

| Unpaired T Test | BERG BALANCE SCORE | | | | | |
|---|---|---|---|---|---|---|
| | BASELINE | | 3rd WEEK | | 6th WEEK | |
| | Group A | Group B | Group A | Group B | Group A | Group B |
| Mean | 35.70 | 27.10 | 38.50 | 29.30 | 44.20 | 32.60 |
| S.D. | 8.001 | 7.637 | 7.122 | 6.913 | 8.270 | 6.114 |
| Number | 10 | 10 | 10 | 10 | 10 | 10 |
| Maximum | 44 | 39 | 46 | 40 | 50 | 42 |
| Minimum | 18 | 15 | 23 | 19 | 26 | 24 |
| Range | 26 | 24 | 23 | 21 | 24 | 18 |
| Mean Difference | 8.60 | | 9.20 | | 11.60 | |
| Unpaired T Test | 2.459 | | 2.931 | | 3.567 | |
| P value | 0.0243 | | 0.0089 | | 0.0022 | |
| Table Value at 0.05 | 2.10 | | 2.10 | | 2.10 | |
| Result | Significant | | Significant | | Significant | |

The twenty-first table presents the comparative analysis of Berg Balance Score between both the groups at baseline, 3rd week, and 6th week using an unpaired t-test. At baseline, the mean balance score was 35.70 in Group A and 27.10 in Group B. At the 3rd week, the mean scores increased to 38.50 in Group A and 29.30 in Group B, while at the 6th week the means further improved to 44.20 and 32.60 respectively. The calculated t-test values were 2.459 at baseline, 2.931 at the 3rd week, and 3.567 at the 6th week, all of which were higher than the table value of 2.10. The corresponding p-values were less than 0.05 at all assessment periods, indicating statistically significant differences between the groups. These findings demonstrate that Group A showed significantly better improvement in balance performance in relation to Group B across the duration of study.




**Graph 3.3 – Comparison of berg balance scale between the groups**

## 4. Discussion

Two-thirds of diabetics are assumed to have clinical or subclinical neuropathy. DPN symptoms include pain, weakness, ataxia, unsteadiness, and falls. Additionally, it brings about altered gait biomechanics, diminished balance, and an increased probability of falls.

In some clinical populations, motor unit firing patterns in specific gait-related muscles and gait kinematic metrics are improved by rhythmic auditory stimulation (RAS). As far as we are aware, only one study has been conducted to assess effect of rhythmic auditory stimulation (RAS) on diabetic peripheral neuropathy. The focus of this scientific study was to assess how rhythmic auditory stimulation affected individuals with diabetic peripheral neuropathy associated with type 2 diabetes mellitus in terms of balance. This research will be essential for improving balance in DPN patients as well as for better understanding how auditory signals affect balance.

Group A showed substantial improvements in berg balance scores, according to within-group analysis, and so did Group B. According to a between-group comparison, there were notable variations in the Berg Balance Score at baseline, the third and sixth weeks.

In comparison to the table value of 2.10, the computed t-test values were 2.459 at baseline, 2.931 at week three, and 3.567 at week six. At every assessment time, the associated p-values were less than 0.05, showing statistically significant group differences.

The positive results in RAS group may be accounted for by the fact that RAS functions as an external pacemaker, supplying an external rhythm that can correct the faulty internal rhythm. Participants' gait becomes entrained to rhythmic signals when they walk while listening to repeating auditory stimuli, leading to more consistent motor unit recruitment patterns.

Balance training via auditory cueing depends on the reinforcement of auditory motor functional connection within associated neural systems. In addition to improving motor excitability in the affected hemisphere, auditory cueing can help identify damaged brain regions and promote motor recovery. By increasing the excitability of spinal motor neurons through the reticulospinal pathway, rhythmic auditory patterns shorten the time it takes for muscles to react to a motor signal. When muscles are used at the right times, gait stability is improved. According to the neurological process underlying RAS, internal unconscious perceptual shaping takes place at the subcortical level when exposed to external rhythmic stimuli. This is handled by auditory motor circuitry at the brainstem level via the reticulospinal route.

**5. Future Scope –**

- A greater number of samples should be used to conduct the investigation.
- Kinematic parameters of gait can be added for better comparison.
- Follow up sessions can be taken up to evaluate long term effects of the study.

**6. Conclusion-**

The findings of the present study demonstrate that Rhythmic Auditory Stimulation (RAS) resulted in significant improvements in the studied outcome measures when compared to conventional training. Statistical analysis revealed significant improvements within both groups following the intervention; however, RAS group exhibited significantly greater improvements than the conventional training group in between group analysis. These results suggest that incorporating rhythmic auditory stimulation into rehabilitation programmes may provide superior therapeutic benefits and enhance functional outcomes more effectively than conventional training alone.

**Acknowledgement**

First and foremost, I express my sincere gratitude to Almighty God for His abundant blessings, strength, guidance, and wisdom throughout the course of this research work. Without His grace, this study would not have been possible.

I would like to extend my heartfelt gratitude to **DAV Institute of Physiotherapy and Rehabilitation** for providing me with the opportunity, facilities, and academic environment necessary for the successful completion of this research.

I am deeply indebted to our respected Principal, Dr. Shilpy Jetly, for her constant encouragement, valuable support, and inspiration throughout my academic journey.

I would like to express my profound and sincere thanks to my guide, Dr. Jaspinder Kaur, for her invaluable guidance, constructive suggestions, unwavering support, and continuous motivation throughout the planning and execution of this study.

I would also like to acknowledge and thank all the participants who willingly took part in this study and contributed significantly to its successful completion.

My heartfelt appreciation goes to my family for their unconditional love, endless support, encouragement, and understanding throughout this endeavor. Their faith in me has been a constant source of strength and

motivation.
I am equally grateful to my friends for their support, cooperation, encouragement, and for being a constant source of positivity during the course of this research.

## 11. References

1. Petersmann A., et al. Definition, classification and diagnostics of diabetes mellitus. J Lab Med 2018; 42 (3): 73-79.
2. Bansal V., et al. Diabetic Neuropathy. Postgrad Med J. 2006; 82: 95-100.
3. Zhu J., et al. Diabetic peripheral neuropathy: pathogenic mechanisms and treatment. Front endocrinol. 2024; 14
4. Li J. et al. Mechanism of Schwann cells in diabetic peripheral neuropathy: a review. Medicine 2023; 102:1
5. Callaghan B.C., et al. Diabetic neuropathy: clinical manifestations and current treatments. Lancet neurol. 2012; 521-34
6. Baum P., et al. Inflammatory Mechanisms in Pathophysiology of Diabetic Peripheral Neuropathy-new aspects. Int J. Mol. Sci. 2021, 22, 10835
7. Tesfaye S. and Selvarajah D. Advances in epidemiology, pathogenesis and management of Diabetic Peripheral Neuropathy. Diabetes Metab Res Rev 2012; 28(Suppl 1): 8–14. 41
8. Alam U., et al. Diabetic Neuropathy and Gait: A Review. Diabetes therapy. 2017 Dec; 8:1253-64.
9. Suzuki K., et al. Effect of exercise with rhythmic auditory stimulation on muscle coordination and gait stability in patients with diabetic peripheral neuropathy. Open journal of therapy and rehabilitation. 2019; 7, 79-91
10. Mustapa A., et al. Postural control and gait performance in the diabetic peripheral neuropathy: a systematic review. BioMed research international. 2016;2016(1):9305025.
11. Baum P., et al. Inflammatory Mechanisms in Pathophysiology of Diabetic Peripheral Neuropathy-new aspects. Int J. Mol. Sci. 2021, 22, 10835
12. Shahraki M., et al. Effect of rhythmic auditory stimulation on gait kinematic parameters of patients with multiple sclerosis. Journal of Medicine and Life Vol. 10, Issue 1, January-March 2017, pp.33-37
13. Scataglini S, et al. Effect of music-based therapy rhythmic auditory stimulation (RAS) using wearable device in rehabilitation of neurological patients: A systematic review. Sensors. 2023 Jun 26;23(13):5933.