# "Efficacy of Dual-Task Vestibular And Balance Training In Reducing Falls Among Older Adults With Vestibular Deficits".

Venu D Chafekar [1], Rushikesh Joshi [2], Amit Kumar Singh [3], Mohan Nallathambi [4], K Suraj Kumar [5], Gunjan Malhotra [6], LeoRathinaraj A Soundararajan[7], Ipshita Mou[8]

*[1]Associate Professor , Sir J.P.College of Physiotherapy (B.P.Th.) affiliated to MUHS, Sir JP College of Physiotherapy, Chandra Educational Campus, Kelve Road West, Palghar, Pincode- 40110*
*[2]Professor, Parul institute of Physiotherapy and Research, Parul University, Vadodara, Gujarat-391760*
*[3.] Associate Professor, Parul institute of Physiotherapy and Research, Parul University, Vadodara, Gujarat-391760*
*[4.]Senior Specialist Physical Therapist, Mind Optimization & Health Advancement Network, 139, VOC Street, Thirukuralar Nagar Arumparthapuram Reddiyarpalayam Post Pondicherry 605010*
*[5]Assistant Professor, Apollo college of Physiotherapy, Anjora Durg, Chhattisgarh, India, Pt Deendayal Upadhyay Memorial Health Science & Ayush University of Chhattisgarh, Raipur, India*
*[6.]Assistant Professor, Department of Physiotherapy, School of Allied Health Sciences, Galgotias University, Greater Noida, India, 203201*
*[7.]Adjunct Professor , Saveetha College of Physiotherapy, SIMATS Deemed University, Chennai 600077.*
*[8], Senior Physical Therapist, Mind Optimization & Health Advancement Network, 139, VOC Street, Thirukuralar Nagar Arumparthapuram Reddiyarpalayam Post Pondicherry 605010*

***Corresponding:***
*Rushikesh Joshi ,*
*dr.r.j.1988@gmail.com*

**ABSTRACT**

Background: Vestibular deficits are a significant contributor to falls among older adults due to impaired postural control and reduced sensory integration. Dual-task training, which combines cognitive and motor tasks, may enhance functional balance and reduce fall risk more effectively than conventional balance training.

Objective: To evaluate the efficacy of dual-task vestibular and balance training in reducing fall risk among older adults with vestibular deficits.

Methods: A randomized controlled trial was conducted on 30 older adults (aged 60–75 years) with diagnosed vestibular deficits. Participants were randomly allocated into an experimental group (dual-task vestibular and balance training) and a control group (conventional balance training), with 15 participants in each group. Both groups received training for 6 weeks (3 sessions per week, 45 minutes per session). Outcome measures included Berg Balance Scale (BBS), Timed Up and Go (TUG), Dynamic Gait Index (DGI), and Falls Efficacy Scale-International (FES-I). Data were analyzed using paired and independent t-tests with significance set at $p < 0.05$.

Results: Both groups showed significant improvements post-intervention ($p < 0.05$). However, the experimental group demonstrated significantly greater improvements in BBS, TUG, DGI, and FES-I scores compared to the control group ($p < 0.001$).

Conclusion: Dual-task vestibular and balance training is more effective than conventional balance training in improving functional balance and reducing fall risk among older adults with vestibular deficits. Incorporating cognitive-motor integration into vestibular rehabilitation may enhance fall prevention outcomes in this population.

**How to cite this article:** Chafekar VD, Joshi R, Singh AK, Nallathambi M, Kumar KS, Malhotra G, Soundararajan LR, Mou I; "Efficacy Of Dual-Task Vestibular And Balance Training In Reducing Falls Among Older Adults With Vestibular Deficits"..Int J Drug Deliv Technol. 2026; 16(8s): 419-425; DOI: 10.25258/ijddt.16.8s.56

**Source of support:** Nil.

**Conflict of interest:** None

## INTRODUCTION

Falls are a major public health concern among older adults and represent one of the leading causes of injury, hospitalization, disability, and mortality worldwide. According to the World Health Organization (WHO), approximately one in three adults aged over 65 years experiences at least one fall each year[1]. The consequences of falls include fractures, fear of falling, reduced mobility, loss of independence, and increased healthcare burden[2].

Vestibular dysfunction is a significant but often underdiagnosed contributor to falls in the elderly population. Age-related degeneration of the peripheral vestibular system, including loss of hair cells and reduced vestibulo-ocular reflex (VOR) function, impairs gaze stability and postural control[3]. Epidemiological data suggest that vestibular impairment affects nearly 35% of adults over 40 years of age and increases substantially with advancing age[4]. Older adults with vestibular deficits

**Author for Correspondence: Rushikesh Joshi*

demonstrate increased postural sway, slower gait speed, and higher fall incidence compared to healthy peers[5].

Maintenance of balance is a complex process requiring integration of visual, somatosensory, and vestibular inputs along with adequate cognitive processing[6]. Aging is associated not only with sensory decline but also with reduced attentional capacity and executive function[7]. During daily activities, individuals frequently perform simultaneous motor and cognitive tasks, such as walking while talking or navigating obstacles while planning movements. This "dual-task" condition can significantly compromise postural stability in older adults, especially those with vestibular deficits[8].

Dual-task interference theory suggests that motor and cognitive tasks compete for limited attentional resources, leading to deterioration in performance when tasks are performed concurrently[9]. Studies have demonstrated that dual-task gait training improves balance control, gait adaptability, and fall-related outcomes in older adults[10]. Vestibular rehabilitation therapy, traditionally focused on gaze stabilization and sensory substitution exercises, has been shown to promote central compensation and improve functional outcomes[11]. However, conventional vestibular programs often emphasize single-task paradigms and may not adequately address cognitive-motor interference encountered in real-life situations.

Emerging evidence indicates that integrating cognitive challenges into vestibular and balance training may enhance automaticity of postural responses and improve functional mobility under complex environmental demands[12]. Despite growing interest in dual-task rehabilitation, limited randomized controlled trials have specifically investigated its efficacy in older adults with confirmed vestibular deficits.

Therefore, the present study aimed to evaluate the efficacy of dual-task vestibular and balance training in reducing fall risk among older adults with vestibular dysfunction.

## METHODOLOGY:

**Study Design**:
Randomized controlled trial (RCT)

**Participants:**
Older adults with vestibular deficits were recruited from an outpatient physiotherapy department.

**Sample Size:** 40 Participants

**Sampling Method**
Participants were selected using purposive sampling and randomly allocated into 2 groups using a computer-generated randomization sequence:

**Group A (Experimental):** Dual-task vestibular and balance training

**Group B (Control):** Conventional Therapy only

**Inclusion Criteria**
Age 60–75 years
Clinical diagnosis of vestibular dysfunction
History of at least one fall in past 12 months
Ability to ambulate independently

**Exclusion Criteria**
Severe neurological disorders
Severe musculoskeletal impairments
Cognitive impairment (MMSE <24)

## INTERVENTION PROTOCOL

### GROUP A – DUAL-TASK VESTIBULAR AND BALANCE TRAINING PROTOCOL

**Session Structure (45 Minutes)**

**Warm-Up (5 minutes)**
Gentle marching, ROM exercises, breathing exercises

**Vestibular Training (15 minutes)**
Gaze stabilization & head movement exercises

**Balance + Dual-Task Training (20 minutes)**
Static → Dynamic → Functional gait tasks

**Cool-Down (5 minutes)**
Slow walking, relaxation breathing

| Week | Vestibular Exercises | Balance Training | Dual-Task Component | Progression Criteria |
|---|---|---|---|---|
| **Week 1** | • VOR x1 (horizontal & vertical) in sitting<br>• Gaze stabilization with fixed target | • Static standing (feet apart & together)<br>• Weight shifting (AP & ML) Marching in place | •Counting forward<br>•Naming simple objects | •Ensure proper technique, minimal symptom •Provocation (<5/10 dizziness) |
| **Week 2** | • VOR x1 in standing<br>• Slow head rotations with fixation | • Tandem stance<br>•Semi-tandem walking<br>• Heel-toe walking | •Counting backward by 1s<br>•Naming animals/fruits | Reduce base of support Increase head movement speed |
| **Week 3** | • VOR x2 in sitting<br>•Head turns during standing | •Single-leg stance (supported)<br>•Walking with head turns<br>• Obstacle stepping | •Counting backward by 3s<br>•Word generation (A, B, C) | Increase duration (30–45 sec holds)<br>Decrease external support |
| **Week 4** | • VOR x2 in standing<br>•Diagonal head movements | •Foam surface standing<br>• Tandem walking on foam<br>•Direction changes during gait | •Serial subtraction (by 3s)<br>•Simple memory recall | Introduce compliant surfaces<br>Increase task complexity |
| **Week 5** | • Rapid VOR x1 & x2 | • Obstacle negotiation<br>•Dual-direction stepping | •Serial subtraction (by 7s) | Increase cognitive difficulty & gait speed |

| | | | | |
|---|---|---|---|---|
| | • Visual tracking with head motion | •Walking with speed variation | •Category switching tasks | |
| **Week 6** | •Complex gaze stabilization during gait<br>•Head turns while navigating obstacles | •Uneven surface walking<br>•Figure-8 walking<br>•Multidirectional stepping | •Alternating attention tasks<br>•Memory + calculation combined | Simulate real-life tasks<br>Reduce supervision |

***Total Session Duration: 40-45 minutes***; 3session/weekly, 6 weeks

**GROUP B – CONVENTIONAL THERAPY**

Participants in the control group received Conventional Balance training consisting of:

Static standing (firm surface)
Weight shifting
Tandem walking
Lower limb strengthening
Gait training (no cognitive tasks)

**Total Session Duration: 40-45 minutes**; 3session/weekly, 6 weeks

**OUTCOME MEASURES**

Berg Balance Scale (BBS)
Timed Up and Go Test (TUG)
Dynamic Gait Index (DGI)
Falls Efficacy Scale-International (FES-I)

**STATISTICAL ANALYSIS**

Data were analysed using SPSS version 26.0. Normality of distribution was assessed using the Shapiro-Wilk test, which demonstrated normal distribution of all outcome variables ($p > 0.05$). For within-group comparisons, a paired t-test was used and for between-group comparisons, Independent t-test was applied. The level of statistical significance was set at $p < 0.05$.

**Table 1: Baseline Characteristics of Participants**

| Variable | Group A | Group B | p-value |
|---|---|---|---|
| Age (years) | 67.4 ± 4.2 | 66.8 ± 3.9 | 0.68 |
| Gender (M/F) | 8 / 7 | 7 / 8 | 0.72 |
| BBS (0–56) | 39.2 ± 3.5 | 40.1 ± 3.2 | 0.47 |
| TUG (sec) | 14.5 ± 1.8 | 14.2 ± 1.6 | 0.63 |
| DGI (0–24) | 15.1 ± 2.2 | 15.4 ± 2.0 | 0.71 |
| FES-I | 33.8 ± 4.5 | 32.9 ± 4.2 | 0.58 |

**Table 2: Within-Group Comparison of Outcome Measures in Group A**

| Outcome Measure | Baseline Mean ± SD | 6 Weeks Mean ± SD | Mean Difference | t-value | p-value |
|---|---|---|---|---|---|
| BBS | 39.2 ± 3.5 | 49.6 ± 2.8 | 10.4 | 12.87 | <0.001 |
| TUG (sec) | 14.5 ± 1.8 | 9.8 ± 1.2 | 4.7 | 11.42 | <0.001 |
| DGI | 15.1 ± 2.2 | 21.4 ± 1.9 | 6.3 | 10.76 | <0.001 |
| FES-I | 33.8 ± 4.5 | 24.6 ± 3.7 | 9.2 | 9.84 | <0.001 |

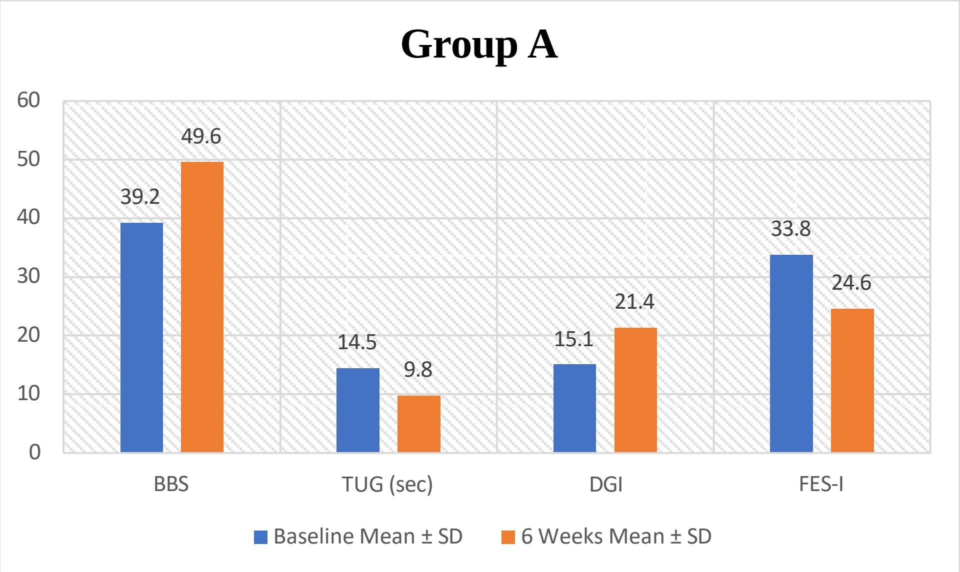



**Table 3: Within-Group Comparison of Outcome Measures in Group B**

| Outcome Measure | Baseline Mean ± SD | 6 Weeks Mean ± SD | Mean Difference | t-value | p-value |
|---|---|---|---|---|---|
| BBS | 40.1 ± 3.2 | 44.2 ± 3.0 | 4.1 | 3.12 | 0.01 |
| TUG (sec) | 14.2 ± 1.6 | 12.3 ± 1.4 | 1.9 | 2.67 | 0.02 |
| DGI | 15.4 ± 2.0 | 18.1 ± 1.8 | 2.7 | 3.01 | 0.01 |
| FES-I | 32.9 ± 4.2 | 29.8 ± 3.9 | 3.1 | 2.41 | 0.03 |

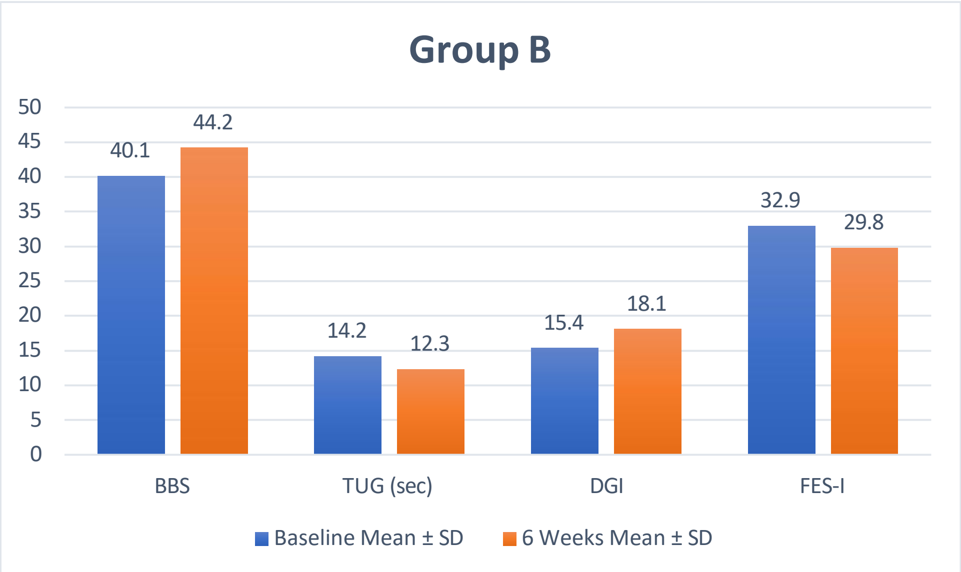
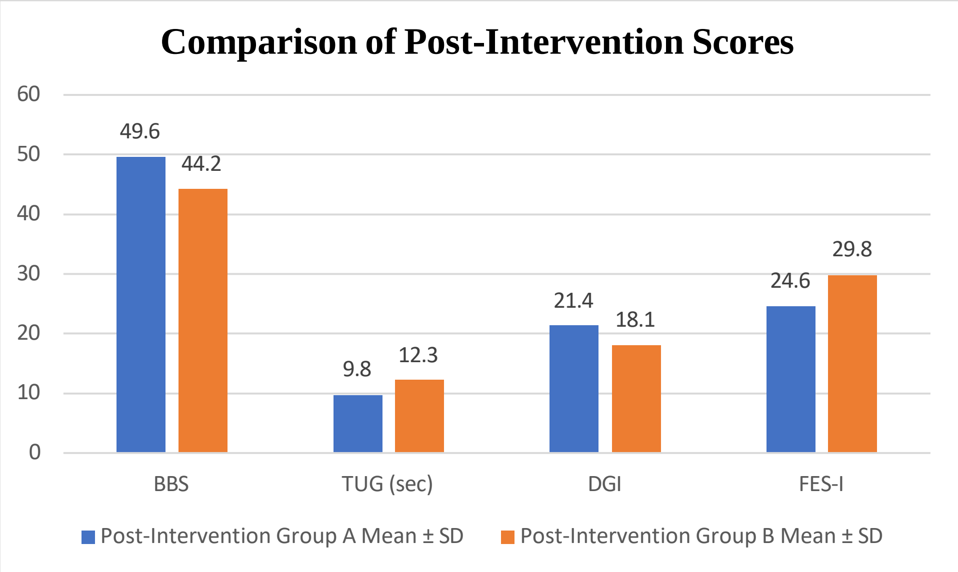



**Table 4: Between-Group Comparison of Post-Intervention Scores Using Independent t-Test at 6 Weeks**

| Outcome Measure | Post-Intervention Group A Mean ± SD | Post-Intervention Group B Mean ± SD | Independent t-Test | p-value |
|---|---|---|---|---|
| BBS | 49.6 ± 2.8 | 44.2 ± 3.0 | 5.08 | <0.001 |
| TUG (sec) | 9.8 ± 1.2 | 12.3 ± 1.4 | 5.27 | <0.001 |
| DGI | 21.4 ± 1.9 | 18.1 ± 1.8 | 4.89 | <0.001 |
| FES-I | 24.6 ± 3.7 | 29.8 ± 3.9 | 3.74 | <0.001 |




## RESULTS

The present study demonstrated significant improvements in balance and fall-related outcomes following 6 weeks of intervention. Within-group analysis using paired t-tests revealed that the experimental group (dual-task vestibular and balance training) showed statistically significant improvements in all outcome measures, including Berg Balance Scale (BBS), Timed Up and Go (TUG), Dynamic Gait Index (DGI), and Falls Efficacy Scale-International (FES-I) ($p < 0.001$). The mean BBS score increased from 39.2 ± 3.5 to 49.6 ± 2.8, while TUG time decreased from 14.5 ± 1.8 seconds to 9.8 ± 1.2 seconds. Similarly, DGI improved from 15.1 ± 2.2 to 21.4 ± 1.9, and FES-I scores reduced from 33.8 ± 4.5 to 24.6 ± 3.7, indicating reduced fear of falling. The control group also demonstrated moderate but statistically significant improvements ($p < 0.05$) across all measures; however, the magnitude of change was smaller compared to the experimental group. Between-group comparison using independent t-tests showed a statistically significant difference in post-intervention scores favoring the experimental group for BBS ($t = 5.08$), TUG ($t = 5.27$), DGI ($t = 4.89$), and FES-I ($t = 3.74$), all with $p < 0.001$. These findings indicate that dual-task vestibular and balance training was more effective than conventional balance training in improving functional balance and reducing fall risk among older adults with vestibular deficits.

## DISCUSSION:

The present study demonstrated that dual-task vestibular and balance training produced significantly greater improvements in balance performance, gait stability, and fall-related self-efficacy compared to conventional balance training in older adults with vestibular deficits. The experimental group showed marked improvement in Berg Balance Scale (BBS), Timed Up and Go (TUG), Dynamic Gait Index (DGI), and Falls Efficacy Scale-International (FES-I) scores ($p < 0.001$), indicating enhanced functional mobility and reduced fall risk.

Age-related vestibular degeneration contributes substantially to impaired postural control and increased fall incidence in older adults[1]. Epidemiological evidence suggests that vestibular dysfunction affects a significant proportion of adults over 40 years and is strongly associated with falls[2]. The improvement observed in the present study may be attributed to enhanced central compensation mechanisms stimulated through structured vestibular rehabilitation exercises. Clinical guidelines for peripheral vestibular hypofunction emphasize gaze stabilization and balance retraining as effective strategies to improve functional outcomes[3].

The significant gains in BBS and DGI scores in the experimental group reflect improved dynamic balance and gait adaptability. Vestibular rehabilitation enhances sensory reweighting and integration of visual, somatosensory, and vestibular inputs, which are essential for maintaining equilibrium[4]. Furthermore, improvements in TUG time indicate better functional mobility and transitional movements, which are critical predictors of fall risk in older adults[5].

A key component contributing to superior outcomes in the experimental group was the integration of dual-task training. According to the dual-task interference theory proposed by Pashler H, simultaneous motor and cognitive tasks compete for limited attentional resources[6]. Older adults, particularly those with vestibular deficits, demonstrate reduced attentional reserve, leading to postural instability during complex tasks. Incorporating cognitive challenges during balance exercises likely enhanced automaticity of postural responses and reduced cognitive-motor interference.

These findings are consistent with previous randomized controlled trials demonstrating that dual-task balance training produces greater improvements in postural control compared to single-task interventions[7]. Additionally, cognitive-motor training has been shown to reduce fall risk and improve gait stability under real-world conditions[8]. The reduction in FES-I scores observed in this study indicates improved balance confidence and reduced fear of falling, which is an important psychological factor influencing mobility limitation and recurrent falls[9].

The results align with fall prevention strategies recommended by the World Health Organization, which emphasize multifactorial interventions targeting both physical and cognitive contributors to falls[10]. By integrating vestibular rehabilitation with dual-task paradigms, the intervention addresses both sensory deficits and attentional limitations, thereby improving functional independence.

Although both groups showed improvements, the magnitude of change was significantly greater in the experimental group, suggesting that conventional balance training alone may not sufficiently address cognitive-motor interference encountered in daily life. Therefore, dual-task vestibular rehabilitation appears to offer a more comprehensive and functionally relevant approach for fall prevention in older adults with vestibular dysfunction.

Future studies with larger sample sizes and long-term follow-up are recommended to determine the sustainability of these improvements and their impact on actual fall incidence.

## CONCLUSION

Dual-task vestibular and balance training was more effective than conventional balance training in improving balance, gait performance, and reducing fall risk in older adults with vestibular deficits. The integration of cognitive tasks enhanced functional stability and reduced fear of falling. These findings support incorporating dual-task paradigms into vestibular rehabilitation programs for improved fall prevention outcomes.

**CONFLICT OF INTEREST:**

None

**FUNDING:**

None

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