

Effectiveness of Adapted Vestibular Activities on Fall Risk Among Clients with Vestibulopathy

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Abstract

Aim: This investigation aims to study effectiveness of adapted vestibular activities on fall risk among clients with vestibulopathy.

Materials and Methods: This research used an RCT design to test whether adapted vestibular activities can decrease fall hazards for older adults who have vestibulopathy. Ethical permission was secured prior to conducting the research through the CARE-IHEC (Protocol No: IHEC-I/3754/25) and researchers registered the study with the Clinical Trials Registry-India (CTRI/2025/05/087969). Researchers selected 60 participants who had vestibulopathy and belonged to the age group 60 to 85 years through convenient sampling from Chettinad Hospital and Research Institute and other Chennai-based neurological and ENT clinics. The researchers used the chit method with sealed opaque envelopes to assign participants into experimental and control groups while the study used a single-blind design. The researchers used the Timed Up and Go (TUG) test to ascertain propensity for falls and functional mobility during both baseline testing and post-intervention evaluation. The experimental group completed their adapted vestibular activities for 4 weeks through two daily 48-session activity periods while the control group maintained their standard treatment. The researchers assessed the intervention's effectiveness through analysis of pre- and post-test data.

Results: The study involved 60 participants who had vestibulopathy and were aged between 60 and 85 years. The mean age of participants in the control group was 66.37 ± 3.36 years, in contrast, the experimental group had a mean age of 67.23 ± 5.78 years and both groups showed no significant age difference according to the statistical test ($p = 0.475$). The study found that both groups had similar gender distribution patterns because analysis of the data did not demonstrate a notable difference ($p = 0.43$). The two groups demonstrated TUG score enhancements based on the results of within-group testing. The control group improved from 25.50 ± 0.90 seconds (pre-test) to 20.53 ± 1.17 seconds (post-test), $t(29) = 24.09$, $p < 0.001$. The Participants in the experimental group exhibited greater progress from 25.67 ± 1.54 seconds to 11.30 ± 3.53 seconds, $t(29) = 34.49$, $p < 0.001$. The analysis revealed that time exerted a significant effect, as shown by repeated measures analysis of variance (ANOVA) ($F(1, 58) = 920.5$, $p < 0.001$), while the interaction effect between group and time was also significant ($F(1, 58) = 410.3$, $p < 0.001$), showing that the experimental group decreased fall risk more than the control group. Effect size analysis also revealed very large improvements in the experimental group.

Conclusion: The results underscore that adapted vestibular rehabilitation activities help older adults with vestibulopathy by decreasing their risk of falling and boosting their ability to move around. The

control group showed improvement through standard care yet the participants who followed the adapted vestibular activity program achieved greater Timed Up and Go (TUG) score reductions together with a larger effect size. The significant group \times time interaction shows that the intervention had a major impact on balance and mobility improvements which occurred during the four-week assessment period. The elderly with vestibular dysfunction can use adapted vestibular activities as a safe effective rehabilitation method which helps them decrease fall risk while maintaining their ability to perform daily tasks. The study needs larger sample groups together with extended study periods to confirm the results and assess the long-term effects.

Keywords: Vestibulopathy, Fall risk, Vestibular Rehabilitation, Vestibular activities, Adapted vestibular activities

1. Introduction

Vestibulopathy includes disorders of the vestibular system, which affect how we perceive head movement and where we are located in the environment. Common symptoms include dizziness, vertigo, imbalance, and problems with postural stability (i.e., bad balance). The vestibular system is critical for stabilizing one's gaze and for maintaining balance through integration with visual and somatosensory inputs; thus, dysfunction of the vestibular system can substantially impair an individual's ability to execute normal daily activities and can profoundly affect mobility.[1]

Vestibulopathy is one of the most prevalent disorders of the vestibular system, particularly in older (i.e., ≥ 60 years) adults, in whom degenerative changes that occur due to age are thought to contribute to the development of vestibulopathy. [2] In individuals aged 60–85 years, vestibular problems typically present as persistent problems with balance as opposed to the more common episodic nature of vestibular disorders. Vestibular dysfunction is considered one of the main factors leading to a reduced level of independence in older adults and an increased risk of falling. Epidemiological studies support the view that vestibular disorders and vertigo occur more frequently in females than males, indicating a clear gender difference in the prevalence of vestibular dysfunction.[3]

The loss of dynamic visual acuity and postural control from vestibulopathy significantly limits a person's ability to ambulate, turn, and navigate in complex settings. As a result, vestibulopathy greatly increases the likelihood of falling due to combinations of physical decline associated with age coupled with vestibulopathy-related impairments; this places older adults at increased risk for injury, hospitalization, and loss of independence.[4]

Vestibular Rehabilitation Therapy (VRT) utilizes evidence-based interventions to improve balance, lessen symptoms of dizziness, and enhance functional mobility through central compensatory mechanisms using adaptation, habituation, and sensory substitution strategies. Older adults may benefit greatly from modified vestibular activity programs which target an individual's needs and abilities to achieve the highest level of safety while providing enough difficulty to facilitate improved balance.[5]

From an occupational therapy point of view, incorporating vestibular-based activities into the performance of valued daily occupations improves occupational performance as well as allows individuals to maintain independence.[6] Additional, these programs will address the psychological aspects of an individual's fear of falling which may further limit participation in valued occupations. While numerous studies documented improvement from vestibular rehabilitation in the areas of symptoms and balance, there have been very few studies that investigated the impact of vestibular

rehabilitation specifically as it relates to fall risk reduction using standardized outcome measures in older adults with vestibulopathy. [7]

2. Related Literature

Recent literature strongly supports vestibular rehabilitation as an effective intervention for improving balance, reducing dizziness, and decreasing fall risk in individuals with vestibular disorders. Hall et al. (2016), Hillier and McDonnell (2016), and Huang et al. (2024) reported that vestibular rehabilitation significantly enhances postural stability, gait, and functional mobility in patients with vestibular dysfunction. Herssens et al. (2020, 2022) further highlighted that individuals with bilateral vestibulopathy experience severe balance impairments and increased fall incidence, emphasizing the need for targeted rehabilitation. [7,8]

Recent advancements such as virtual reality-based vestibular rehabilitation have also shown promising outcomes. Heffernan et al. (2021) and Xie et al. (2021) found improvements in balance confidence, postural control, and dizziness reduction using technology-assisted rehabilitation approaches. Similarly, Meng et al. (2023) demonstrated that vestibular rehabilitation improves gait and balance stability in neurological populations.[9]

Theoretical studies by Horak (2006) and Peterka (2002) explained that balance depends on the integration of vestibular, visual, and somatosensory inputs, providing the scientific basis for vestibular rehabilitation. Standardized assessment tools such as the Berg Balance Scale, Timed Up and Go Test, and Functional Gait Assessment were identified as reliable measures for evaluating balance and fall risk (Berg et al., 1992; Podsiadlo & Richardson, 1991; Wrisley & Kumar, 2010). [7,8,9,10,11]

Additionally, the American Occupational Therapy Association Practice Framework (2020) and the World Health Organization report (2007) emphasized the importance of multidisciplinary interventions and therapeutic activities in improving functional independence and preventing falls. Overall, the literature indicates that vestibular rehabilitation plays a vital role in enhancing balance, mobility, and quality of life among individuals with vestibular and neurological disorders. [12,13]

3. Aim & Objective of study

3.1 Aim of the study

- To study effectiveness of adapted vestibular activities on fall risk among clients with vestibulopathy.

3.2 Objectives

- To determine association of demographical variables
- To determine pre-test of control group using Timed Up and Go (TUG) Test
- To determine post-test of control group using Timed Up and Go (TUG) Test
- To determine pre-test of experimental group using Timed Up and Go (TUG) Test
- To determine post-test of experimental group using Timed Up and Go (TUG) Test
- To compare the pre-test and post-test of control group using Timed Up and Go (TUG) Test
- To compare the pre-test and post-test of experimental group using Timed Up and Go (TUG) Test
- To compare control and experimental group using Timed Up and Go Test

4 Methodology

The research aimed to assess how well adapted vestibular activities helped decrease fall hazards for patients with vestibulopathy. The study used a RCT design which required participants to be divided into

experimental and control groups. The researchers acquired ethical approval from CARE-IHEC while they registered their study in the CTRI before starting their research work.

The study recruited 60 vestibulopathy patients between 60 and 85 years old through convenient sampling from Chettinad Hospital and Research Institute and multiple neurological and ENT clinics located in Chennai. The study included both male and female participants who could complete the intervention program according to its requirements. The researchers excluded patients who had undiagnosed vestibulopathy or serious medical conditions or neurological degenerative disorders or who had received spine or hip or knee surgical procedures.

The researcher used the chit method to assign participants into experimental and control groups because this method used sealed envelopes to hide the randomization sequence. The researchers designed the study to operate as a single-blinded experiment which prevented participants from knowing their assigned treatment.

The Timed Up and Go (TUG) Test served as the outcome measure to evaluate both fall risk and functional mobility capabilities. All participants underwent baseline assessment which took place before their intervention. The TUG test quantifies the time needed by an individual to rise from a chair walk 3 meters turn around and return to the chair because longer times show greater fall danger.

The experimental group participants received customized vestibular activities through a structured intervention program that required them to practice head movements and eye-head coordination and balance activities and functional mobility activities in both sitting and standing positions. The intervention lasted four weeks with two daily sessions which took place in the morning and evening on six days each week to complete a total of 48 sessions. Participants needed to execute the activities at a slow pace while they could take breaks whenever necessary and needed to stop when they experienced extreme dizziness or discomfort. The activities were performed under the supervision of the researcher, either independently or with caregiver assistance.

The control group continued with their usual or existing treatment without receiving the new intervention during the study period.

The researchers conducted a post-test assessment after the four-week intervention period ended using the TUG test which they administered to both study groups. The researchers used statistical methods to analyze the pre-test and post-test data which they accumulated to study how adapted vestibular activities affected fall risk among clients with vestibulopathy.

4.1. Flow chart of study:



5 Result and Analysis

This randomized controlled trial investigated the effectiveness of adapted vestibular activities in reducing fall risk among patients with vestibulopathy using the Timed Up and Go (TUG) test.

Demographic Characteristics

Table 5.1. Baseline Demographic Characteristics of Participants

Variable	Control Group (n=30)	Experimental Group (n=30)	p-value
Age (years), Mean \pm SD	66.37 \pm 3.36	67.23 \pm 5.78	0.475
Male, n (%)	14 (46.7%)	11 (36.7%)	0.43
Female, n (%)	16 (53.3%)	19 (63.3%)	

Both groups were comparable at baseline with no statistically significant differences in age or gender distribution.

Within-Group Analysis

Table 5.2. Within-Group Comparison of TUG Scores

Group	Pre-test Mean \pm SD	Post-test Mean \pm SD	Mean Difference	t-value	p-value	Cohen's d
Control	25.50 \pm 0.90	20.53 \pm 1.17	4.97	24.09	<0.001	4.4
Experimental	25.67 \pm 1.54	11.30 \pm 3.53	14.37	34.49	<0.001	6.3

Both groups demonstrated significant improvement in TUG scores following intervention; however, the experimental group showed substantially greater improvement.

Between-Group Comparison

Table 5.3. Post-Test Comparison Between Groups

Variable	Control Group Mean \pm SD	Experimental Group Mean \pm SD	t-value	p-value	Cohen's d
TUG Post-test	20.53 \pm 1.17	11.30 \pm 3.53	13.57	<0.001	3.51

Post-test comparison revealed significantly lower TUG scores in the experimental group, indicating superior improvement in functional mobility and reduction in fall risk.

Repeated Measures ANOVA

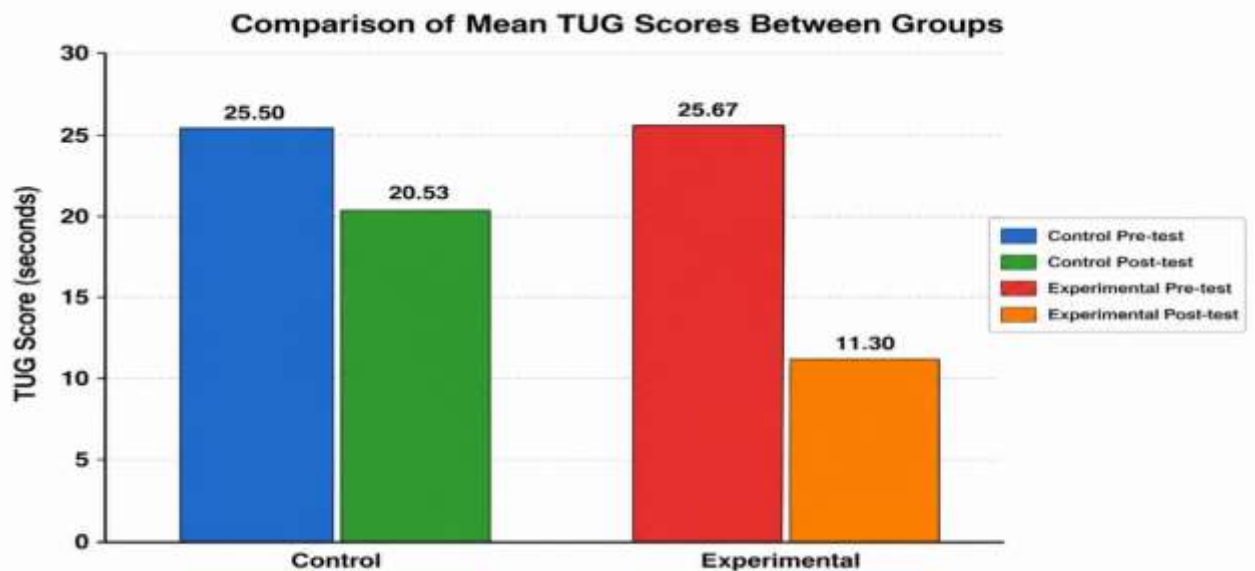
Table 5.4. Repeated Measures ANOVA

Source	F-value	p-value
Group	185.2	<0.001
Time	920.5	<0.001

Group × Time	410.3	<0.001
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Repeated measures ANOVA demonstrated significant effects for group, time, and group × time interaction, confirming that the experimental group improved significantly more than the control group over time.

Figure 5.1. Comparison of Mean TUG Scores Between Groups TUG Score (seconds)



The experimental group demonstrated a markedly greater reduction in TUG scores compared to the control group, indicating improved balance, mobility, and reduced fall risk following adapted vestibular activities.

6 Discussion & Conclusion

Both groups were comparable at baseline with no significant differences in age or gender distribution ($p > 0.05$). The control group showed significant improvement in TUG scores (mean difference = 4.97, $p < 0.001$), but the experimental group demonstrated substantially greater improvement (mean difference = 14.37, $p < 0.001$) with a very large effect size (Cohen’s $d = 6.30$). Post-test comparison revealed significantly better outcomes in the experimental group (mean difference = 9.23, $p < 0.001$). Repeated measures ANOVA showed significant effects of time, group, and group × time interaction ($p < 0.001$), confirming that adapted vestibular activities were highly effective in reducing fall risk and improving functional mobility in vestibulopathy patients. Vestibulopathy commonly causes dizziness, balance impairment, and increased fall risk in older adults. This study evaluated the effectiveness of adapted vestibular activities on fall risk using the Timed Up and Go (TUG) test among 60 participants divided into control and experimental groups. Both groups were comparable at baseline. The experimental group showed significantly greater improvement in TUG scores compared to the control group ($p < 0.001$) with very large effect sizes. Repeated measures ANOVA confirmed significant group × time interaction effects, demonstrating the effectiveness of the intervention. The findings indicate that adapted vestibular activities effectively improve balance, mobility, and functional independence while reducing fall risk in individuals with vestibulopathy. The study supports the integration of activity-based vestibular rehabilitation into occupational therapy practice. [14]

7 Limitations and Future Recommendations

The study had a relatively small sample size and short study duration, limiting generalizability and long-term interpretation of results. Lack of follow-up assessment prevented evaluation of sustained benefits, and individual differences among participants may have influenced post-test outcomes. Future studies should include larger multi-center samples and longer follow-up periods to assess long-term effectiveness. Researchers should use additional outcome measures such as balance, gait, quality of life, and psychological factors. Further research is recommended on virtual reality, tele-rehabilitation, personalized vestibular interventions, and community-based occupational therapy programs for fall prevention.

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