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Comparative Effects of Gaze Stability Exercises and Optokinetic Exercises on Dizziness, Balance, and Kinesiophobia in Patients with Vestibular Hypofunction

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ABSTRACT

Background: *Vestibular hypofunction is a disorder of the vestibular system characterized by dizziness, oscillopsia, imbalance, and impaired postural control, which negatively affect daily activities and may lead to fear of movement and reduced quality of life. Rehabilitation interventions such as gaze stability exercises (GSE) and optokinetic exercises (OKE) promote central vestibular compensation and functional recovery.* ***Objective:*** *To compare the effects of GSE and OKE on dizziness, balance, and kinesiophobia in patients with vestibular hypofunction.* ***Methods:*** *Forty adults aged 23–63 years with clinically diagnosed unilateral vestibular hypofunction were recruited from the physiotherapy department of the Center of Advanced Studies in Health & Technology Clinic, Rawalpindi, Pakistan. Participants were randomly assigned to Group 1 (GSE + routine physiotherapy) or Group 2 (OKE + routine physiotherapy), with interventions delivered five sessions per week for four weeks. Eligibility included dizziness provoked by head or body movements; exclusions were neurological or psychological disorders, benign paroxysmal positional vertigo, prior vestibular surgery, or conditions affecting balance. Outcomes were measured using the Dizziness Handicap Inventory (DHI), Mini Balance Evaluation Systems Test (Mini-BESTest), and Tampa Scale of Kinesiophobia at baseline and post-intervention. Data were analyzed using paired and independent t-tests ($p < 0.05$).* ***Results:*** *Both groups improved significantly in dizziness and balance. GSE showed greater dizziness reduction ($p < 0.05$), whereas OKE produced greater balance improvement. Changes in kinesiophobia were similar between groups.* ***Conclusion:*** *Both GSE and OKE effectively improve symptoms in vestibular hypofunction. GSE is superior for dizziness, OKE enhances balance, and both reduce kinesiophobia, supporting integrated rehabilitation approaches.*

Keywords: *Vestibular hypofunction, gaze stability exercises, optokinetic exercises, dizziness, balance, kinesiophobia.*

INTRODUCTION

Vestibular hypofunction, also known as vestibulopathy, vestibular dysfunction, vestibular hyporeflexia, or vestibular deficiency, was described as a heterogeneous condition affecting the peripheral and occasionally the central vestibular system. It commonly resulted in symptoms such as dizziness, imbalance, and oscillopsia that significantly impaired daily functioning and mobility. The disorder could arise from peripheral or central causes, and degenerative changes within the vestibular system—particularly the loss or reduced function of inner ear hair cells—reduced the reliability of vestibular sensory input. Vestibular dysfunction could also occur due to trauma, infections, toxins, genetic disorders, neurodegenerative diseases, or idiopathic causes. Epidemiological evidence indicated that vestibular hypofunction affected approximately 6.7% of the general population, highlighting its considerable clinical burden (1,2).

Vestibular disorders are often presented suddenly, and benign paroxysmal positional vertigo (BPPV) was among the most common forms of acute peripheral vestibular dysfunction (3).

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Bilateral vestibular hypofunction (BVH) occurred when both vestibular organs demonstrated reduced responsiveness to stimulation. Individuals with BVH typically experienced progressive unsteadiness, worsening symptoms in low-light conditions, and oscillopsia during walking due to impaired gaze stabilization. These symptoms were often associated with etiologies such as ototoxic medications, bilateral Ménière's disease, meningitis, genetic conditions, or cerebellar pathologies (4).

Unilateral vestibular hypofunction (UVH) involves partial or complete impairment of one vestibular organ or the vestibular nerve. It is most commonly associated with vestibular neuritis but may also result from trauma, surgical procedures, Ménière's disease, or ototoxic medications. Acute UVH creates an imbalance in vestibular input between the two sides, leading to symptoms such as vertigo, nausea, spontaneous nystagmus, oscillopsia, and postural instability. Patients often experience gait disturbances and difficulty maintaining balance during head movements. The underlying pathophysiology involves disruption of the vestibulo-ocular reflex (VOR), which maintains visual stability during head motion. Damage to one side of the vestibular system reduces neural firing and produces asymmetrical vestibular signals, resulting in involuntary eye movements, vertigo, and impaired postural control. Although central compensation mechanisms may restore equilibrium within weeks, persistent deficits can lead to long-term impairments in gaze stabilization and balance, thereby increasing the risk of falls (5,6)

Management of vestibular disorders commonly involved pharmacological therapy to control symptoms such as vertigo, nausea, and vomiting. Medications including vestibular suppressants, antidepressants, anticonvulsants, and tranquilizers provided temporary relief, but prolonged use could delay central compensation. Consequently, several non-pharmacological interventions were introduced, including vestibular rehabilitation therapy, noisy galvanic vestibular stimulation, posturography training, and virtual reality-based rehabilitation (8).

Vestibular rehabilitation therapy was widely recognized as an effective physiotherapeutic approach aimed at promoting central compensation through exercises targeting gaze stability and balance. These interventions helped reduce dizziness, improve visual stability during head movements, enhance postural control, and decrease fall risk. Vestibular dysfunction also affected psychological well-being by increasing fear of movement and limiting participation in daily and social activities (7).

Gaze stabilization referred to the ability to maintain a visual target on the retina during head movement. When impaired, patients experienced blurred vision, dizziness, and imbalance. The vestibulo-ocular reflex played a key role in maintaining clear vision during motion, and improving VOR gain was considered a major goal of vestibular rehabilitation. Improved VOR function also contributed to better balance through integration of vestibular, visual, and somatosensory inputs (9).

Gaze stability exercises were designed to promote vestibular adaptation and substitution by inducing retinal slip during controlled head movements, thereby enhancing vestibular responsiveness and neural adaptation. Optokinetic exercise training was another commonly used intervention that exposed patients to moving visual stimuli to stimulate eye movements and improve visual-vestibular interaction. Studies demonstrated that optokinetic stimulation using rotating patterns or computer-generated visual stimuli improved balance and reduced visually induced dizziness in individuals with vestibular dysfunction (10).

Both gaze stability and optokinetic exercises relied on visual input to indirectly stimulate the vestibular system and facilitate neural adaptation. However, they differed in the nature of visual stimulation. Gaze stability exercises emphasized maintaining fixation on a stationary target during head movements, whereas optokinetic exercises used moving visual patterns to provoke controlled eye movements and sensory adaptation.

Despite the widespread use of both interventions in vestibular rehabilitation, limited evidence directly compares their effectiveness on dizziness, balance, and Kinesio phobia in patients with vestibular hypofunction. Therefore, this study aimed to compare the effects of gaze stability exercises and optokinetic exercises in improving these outcomes. The findings were expected to provide evidence-based guidance for clinicians in selecting the most effective rehabilitation approach to enhance functional recovery and quality of life in individuals with vestibular hypofunction.

METHODS

This study employed a single blinded randomized controlled trial (RCT) design to compare the effects of gaze stability exercises (GSE) and optokinetic exercises (OKE) on dizziness, balance, and Kinesio phobia in patients with vestibular hypofunction. Conducted at Center Of Advanced Studies in Health & Technology Clinic Rawalpindi, Pakistan, over six months from 01/08/2024 to 31/01/2025, the study received approval from the Institutional Review Board. Participants were recruited through convenience sampling from patients presenting to physiotherapy department with symptoms suggestive of vestibular hypofunction. 40 participants were enrolled & randomly assigned into two equal groups of 20 each (10). Eligible participants were adults aged 23–63 years, of either gender, diagnosed with unilateral vestibular hypofunction by an ENT specialist, with dizziness provoked by head or body movements. Exclusion criteria included neurological or psychological disorders, benign paroxysmal positional vertigo (BPPV), prior vestibular surgery, or conditions interfering with balance. Written informed consent was obtained and baseline assessments were conducted. Participants were randomly allocated to Group 1 (gaze stability exercises) or Group 2 (optokinetic exercises). Group 1 performed gaze stabilization exercises including saccadic eye movements, smooth pursuit exercises, and vestibulo-ocular reflex (VOR) training for approximately 40 minutes per session, five days per week for four weeks, alongside routine physiotherapy for postural control and functional mobility. Group 2 received optokinetic training with moving visual stimuli to improve visual-vestibular coordination and reduce motion-induced dizziness, with sessions matching Group 1 in duration, frequency, and inclusion of routine physiotherapy. Primary outcomes included dizziness, assessed using the Dizziness Handicap Inventory (DHI), balance evaluated with the Mini-Balance Evaluation Systems Test (Mini-BESTest), and kinesiophobia measured by the Tampa Scale of Kinesiophobia (TSK). Assessments were conducted at baseline and after 4 weeks of intervention to evaluate within-group improvements and between-group differences. Data analysis using SPSS version 24 included descriptive statistics for demographic characteristics, paired t-tests for within-group comparisons, and independent t-tests for between-group differences, with significance set at $p < 0.05$. Ethical approval was obtained from the Institutional Review Board, and the study adhered to the Declaration of Helsinki, ensuring voluntary participation, confidentiality, and the right to withdraw at any time.

RESULTS

A total of 40 participants were included in this study, of whom 20 were allocated to Group 1 and 20 to Group 2. The mean age of participants in Group 1 was 45.30 ± 5.98 years, whereas the mean age in Group 2 was 43.95 ± 5.62 years. An independent sample t-test was used to determine the differences in outcome measures. At baseline, there was no statistically significant difference between the groups in terms of the Dizziness Handicap Inventory

(DHI), Mini-BESTest, and Tampa Scale of Kinesio phobia scores ($p > 0.05$), indicating that both groups were comparable before the intervention.

After the intervention, the total mean DHI score in Group 1 improved from 73.45 ± 7.47 to 30.90 ± 3.28, whereas in Group 2 the mean DHI score improved from 70.35 ± 6.92 to 37.45 ± 7.04. A statistically significant difference was observed between the groups in post-intervention DHI scores ($p = 0.001$), favoring Group 1. Similarly, the Mini-BESTest score improved from 14.40 ± 2.23 to 17.75 ± 0.85 in Group 1, while in Group 2 it improved from 15.10 ± 2.02 to 20.65 ± 0.75. A highly significant difference was observed between the groups ($p < 0.001$), favoring Group 2 in terms of balance improvement.

However, the Tampa Scale of Kinesiophobia scores improved in both groups, decreasing from 51.75 ± 6.26 to 38.85 ± 4.87 in Group 1 and from 51.65 ± 6.47 to 38.05 ± 5.84 in Group 2. The difference between groups was not statistically significant ($p = 0.641$).

Table 1: Between-Group Comparison of Outcome Measures (Pre- and Post-Intervention)

Variable	Pre-Intervention Group 1 (Mean ± SD)	Pre-Intervention Group 2 (Mean ± SD)	P-value	Post-Intervention Group 1 (Mean ± SD)	Post-Intervention Group 2 (Mean ± SD)	P-value
Total DHI Score	73.45 ± 7.47	70.35 ± 6.92	0.181	30.90 ± 3.28	37.45 ± 7.04	0.001
Mini-BESTest	14.40 ± 2.23	15.10 ± 2.02	0.306	17.75 ± 0.85	20.65 ± 0.75	<0.001
Tampa Scale Score	51.75 ± 6.26	51.65 ± 6.47	0.961	38.85 ± 4.87	38.05 ± 5.84	0.641

Within-group comparisons were conducted using the paired sample t-test. The results demonstrated statistically significant improvements in both groups after the intervention ($p < 0.001$).

Table 2: Within-Group Comparison of Outcome Measures (Pre- and Post-Intervention)

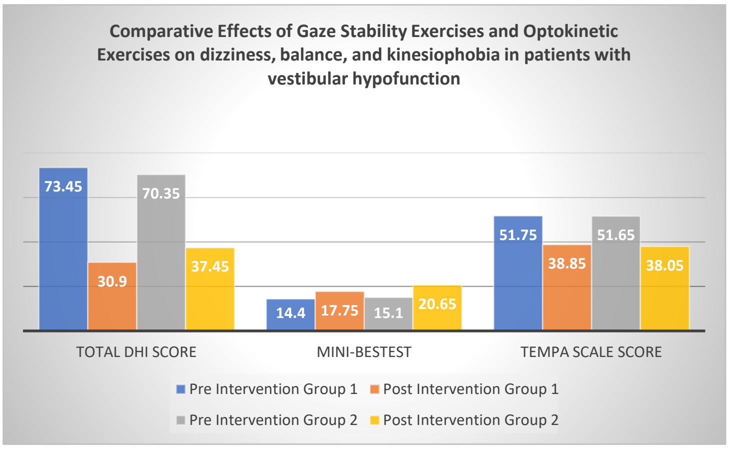
Variable	Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	P Value
Total DHI Score	**Group 1**	73.45 ± 7.47	30.90 ± 3.28	<0.001
	Group 2	70.35 ± 6.92	37.45 ± 7.04	<0.001
Mini-BESTest	**Group 1**	14.40 ± 2.23	17.75 ± 0.85	<0.001
	Group 2	15.10 ± 2.02	20.65 ± 0.75	<0.001
Tampa Scale of Kinesiophobia	**Group 1**	51.75 ± 6.26	38.85 ± 4.87	<0.001
	Group 2	51.65 ± 6.47	38.05 ± 5.84	<0.001

In Group 1, the mean DHI score decreased from 73.45 ± 7.47 to 30.90 ± 3.28, indicating a significant reduction in dizziness after four weeks of gaze stability exercises. The Mini-BESTest score increased from 14.40 ± 2.23 to 17.75 ± 0.85, showing improvement in balance performance. Similarly, the Tampa Scale score decreased from 51.75 ± 6.26 to 38.85 ± 4.87, indicating reduced kinesiophobia. In Group 2, the mean DHI score improved from 70.35 ±

6.92 to 37.45 ± 7.04, the Mini-BESTest score improved from 15.10 ± 2.02 to 20.65 ± 0.75, and the Tampa Scale score decreased from 51.65 ± 6.47 to 38.05 ± 5.84 after the intervention.

These findings indicate that both interventions significantly improved dizziness, balance, and Kinesio phobia within each group, although gaze stability exercises were more effective in reducing dizziness, while optokinetic exercises showed greater improvement in balance.

Graph 1: Between Group Comparison of Outcome Measures (Pre- and Post-Intervention)



DISCUSSION

The present randomized controlled trial examined the comparative effects of gaze stability exercises (GSE) and optokinetic exercises (OKE) on dizziness, balance, and kinesiophobia in patients with vestibular hypofunction. The findings demonstrated that both interventions produced significant improvements across outcome measures after the intervention period. However, gaze stability exercises were more effective in reducing dizziness, while optokinetic exercises resulted in greater improvements in balance. These results highlight the differential yet complementary roles of vestibular rehabilitation strategies targeting distinct mechanisms of sensory adaptation and integration.

The improvements observed in the optokinetic exercise group, particularly in balance performance, are supported by previous research emphasizing the role of visual motion stimulation in vestibular rehabilitation. A study by Ertunc Gulcelik and colleagues reported that a web-based vestibular rehabilitation program incorporating oculomotor and optokinetic stimuli significantly improved postural stability measures and reduced dizziness and kinesiophobia in patients with unilateral vestibular hypofunction. The authors suggested that controlled visual motion exposure facilitates central compensation by enhancing visuo-vestibular interaction and sensory reweighting processes (11). Similarly, research by Sang-Yun Choi and colleagues demonstrated that vestibular exercises combined with optokinetic stimulation delivered through virtual reality significantly improved dizziness severity and balance in patients with persistent postural-perceptual dizziness (12).

In addition, a randomized trial conducted by Marios Pavlou and colleagues evaluating supervised versus unsupervised optokinetic exercises in individuals with peripheral vestibular disorders reported meaningful improvements in dizziness symptoms and functional balance, particularly when exercises were performed under supervision. Together, these findings support the role of optokinetic stimulation in promoting habituation to visual motion and improving postural stability through enhanced visuo-vestibular integration (13).

In contrast, the greater reduction in dizziness observed in the gaze stability exercise group in the present study aligns with previous literature highlighting the importance of gaze stabilization in restoring vestibular function. A study by Wajiha Maham demonstrated that gaze stability exercises produced significantly greater improvements in dizziness severity and dynamic visual acuity compared with habituation exercises in individuals with unilateral vestibular hypofunction. These findings emphasize the importance of exercises targeting VOR adaptation to improve visual stability during head movements (14). Similarly, earlier work by Richard A. Clendaniel reported that gaze-stability and habituation exercises significantly reduced symptoms and improved functional performance in patients with unilateral vestibular hypofunction through mechanisms related to VOR adaptation and central compensation (15).

Additional evidence supporting the broader effectiveness of vestibular and oculomotor exercise protocols was reported by Nida Khan and colleagues, who conducted a randomized trial examining the effectiveness of gaze stability exercises and Brandt-Daroff exercises on dizziness and quality of life in patients with benign paroxysmal positional vertigo (BPPV). Although the study involved a BPPV population rather than vestibular hypofunction, both exercise protocols resulted in significant reductions in dizziness severity and improvements in quality of life. These findings suggest that exercise-based vestibular rehabilitation approaches can produce clinically meaningful benefits across different vestibular disorders despite variations in underlying pathophysiology (16).

Overall, the findings of the present trial contribute to the growing body of evidence supporting mechanism-based vestibular rehabilitation approaches. While gaze stability exercises primarily promote vestibulo-ocular reflex adaptation and reduce dizziness symptoms, optokinetic exercises appear to facilitate visual-vestibular integration and improve postural control. The inclusion of evidence from studies across related vestibular conditions, including BPPV, underscores the broad therapeutic relevance of exercise-based interventions. Clinically, these results suggest that individualized rehabilitation programs incorporating both targeted gaze stabilization and visual motion stimuli may offer a more comprehensive strategy for addressing the multidimensional impairments associated with vestibular hypofunction

However, this study has several limitations, including a relatively modest sample size, a short four-week follow-up period, and reliance on patient-reported and clinical measures without complementary objective vestibular metrics such as computerized dynamic posturography or instrumented gait analysis. Future research should include larger, multicenter cohorts, extended follow-up to assess durability of benefits, and integration of objective vestibular function tests to further elucidate physiologic changes underlying clinical improvements.

CONCLUSION

Both gaze stability exercises and optokinetic exercises are effective interventions for vestibular hypofunction. Gaze stability exercises demonstrated superior improvement in dizziness, whereas optokinetic exercises showed greater enhancement in balance. Both interventions produced comparable effects in reducing kinesiophobia.

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DECLARATIONS

Ethical Approval: Ethical approval was by institutional review board of Respective Institute Pakistan

Informed Consent: Informed Consent was taken from participants.

Authors' Contributions:

Concept: AA; Design: NK; Data Collection: AM, FUN; Analysis: MN; Drafting: SZ

Conflict of Interest: The authors declare no conflict of interest.

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Data Availability: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Study Registration: ___________