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Original Article

Effect of Gaze Stability and Habituation Exercises on Dizziness in Patients with Unilateral Vestibular Hypofunction

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ABSTRACT

Background: Unilateral vestibular hypofunction (UVH) is a peripheral vestibular disorder characterized by dizziness, vertigo, postural instability, and impaired gaze control, which significantly affect quality of life. Vestibular rehabilitation therapy is the mainstay of conservative management, with gaze stability and habituation exercises being two widely used protocols. However, comparative evidence on their relative effectiveness remains limited. Objective: To compare the effects of gaze stability and habituation exercises on dizziness and visual function in patients with unilateral vestibular hypofunction. Methods: A randomized clinical trial was conducted at the Otorhinolaryngology and Neurology Departments of Islam Teaching Hospital, Sialkot, Pakistan, over six months. Thirty-four adults aged 30–65 years with UVH were randomized equally into two groups: gaze stability (n=17) and habituation (n=17). Interventions were performed three times daily, four days per week, for six weeks. Primary outcomes included Motion Sensitivity Quotient (MSQ) and dynamic visual acuity (active and passive, logMAR), assessed pre- and post-intervention. Data were analyzed using paired and independent t-tests, with significance set at $p<0.05$. Results: Both groups demonstrated significant within-group improvements ($p<0.001$). However, gaze stability yielded greater reductions in MSQ (mean Δ -45.71 vs -33.06; $p<0.001$), greater ADVA improvement (-0.28 vs -0.21 logMAR; $p<0.001$), and superior PDVA gain (+0.29 vs +0.21 logMAR; $p<0.001$). Conclusion: Gaze stability exercises were significantly more effective than habituation exercises in reducing dizziness and enhancing visual stability in UVH. These results support prioritizing gaze stability as a first-line rehabilitation strategy.
Keywords: Unilateral vestibular hypofunction, dizziness, gaze stability, habituation, vestibular rehabilitation, dynamic visual acuity.

INTRODUCTION

Unilateral vestibular hypofunction (UVH) is a disorder resulting from reduced or absent vestibular function on one side of the peripheral vestibular system, impairing the ability to maintain equilibrium and gaze stability during head movement. The condition manifests with disabling symptoms such as dizziness, vertigo, postural imbalance, visual disturbances, and nausea, which substantially compromise daily activities and quality of life (1,2). Its etiology is diverse, encompassing vestibular neuritis, labyrinthitis, Meniere's disease, acoustic neuroma, trauma, surgical injury, ototoxic drug exposure, and age-related degeneration (3–6). Epidemiological studies suggest that UVH is particularly prevalent in individuals above 50 years and is more common among women, with prevalence estimates ranging from 3.5% in adults over 40 years to as high as 35% in older populations (7,8). Despite this burden, the condition remains underdiagnosed and undertreated in many clinical contexts.

Management strategies for UVH vary depending on etiology and symptom severity, spanning pharmacological interventions, surgical procedures, lifestyle modifications, and vestibular rehabilitation therapy (VRT). Among these, VRT has emerged as the cornerstone of conservative management, supported by strong evidence for its effectiveness in promoting central compensation, enhancing postural control, and improving gaze stabilization (9,10). Two of the most widely applied VRT protocols are gaze stability exercises and habituation exercises. Gaze stability exercises strengthen the vestibulo-ocular reflex (VOR), training patients to maintain visual fixation during head motion, thereby improving dynamic visual acuity and reducing oscillopsia (11). In contrast, habituation exercises gradually expose patients to symptom-provoking head or body movements, reducing motion sensitivity through repeated exposure and neural desensitization (12).

Several studies have demonstrated that both approaches can improve functional outcomes in patients with vestibular dysfunction. For instance, randomized trials and systematic reviews have reported improvements in dizziness handicap, balance performance, and motion sensitivity following gaze stability or habituation training (13–15). Moreover, emerging evidence suggests that combined protocols may yield additive benefits, with greater reductions in dizziness and faster recovery trajectories than when either exercise is applied in isolation (16). However, despite these encouraging findings, the comparative efficacy of gaze stability versus habituation exercises remains unclear.

Much of the existing evidence is limited by small sample sizes, heterogeneity in outcome measures, or lack of long-term follow-up, leaving uncertainty regarding which approach confers superior benefit and under what clinical conditions (17,18).

This knowledge gap has significant implications for patient care. Clinicians often rely on trial-and-error when prescribing VRT protocols, which may delay symptom resolution and prolong disability. Establishing evidence-based guidance for selecting between gaze stability and habituation interventions would enhance clinical decision-making, optimize patient outcomes, and reduce healthcare burden associated with chronic dizziness and imbalance.

The present study was therefore designed as a randomized clinical trial to directly compare the effects of gaze stability exercises and habituation exercises on dizziness in patients with unilateral vestibular hypofunction. We hypothesized that both interventions would improve motion sensitivity and dynamic visual acuity, but that gaze stability exercises would result in superior improvements compared to habituation exercises.

MATERIAL AND METHODS

This study was conducted as a randomized clinical trial designed to compare the effects of gaze stability exercises and habituation exercises on dizziness in patients diagnosed with unilateral vestibular hypofunction (UVH). The design was chosen to ensure robust internal validity and to allow direct comparison of intervention outcomes across parallel treatment groups. The trial was carried out at the Otorhinolaryngology and Neurology Departments of Islam Teaching Hospital, Sialkot, Pakistan, over a six-month period following ethical approval and synopsis acceptance by the institutional review board.

Eligible participants were adults aged between 30 and 65 years with confirmed diagnosis of unilateral vestibular hypofunction of peripheral origin. Diagnosis was established based on caloric test abnormalities, surgical history, or positive clinical examination findings consistent with UVH (19). Inclusion required at least one of the following symptoms: dizziness, vertigo, balance disturbance, postural instability, or gaze instability (20). Exclusion criteria comprised central nervous system disorders associated with dizziness, musculoskeletal or orthopedic limitations preventing exercise performance, legal blindness, cognitive impairment, or other severe uncontrolled comorbidities.

Recruitment employed a nonprobability convenience sampling strategy, where eligible patients were referred by treating clinicians or responded to study invitations. Prior to enrollment, all participants received detailed verbal and written information regarding study objectives, procedures, potential risks, and anticipated benefits, after which written informed consent was obtained. Screening assessments included comprehensive history taking, physical examination, and baseline vestibular function testing to confirm eligibility.

Randomization was carried out using a computer-generated sequence to allocate participants equally into two groups, each comprising 17 patients. Allocation concealment was ensured by using sequentially sealed opaque envelopes prepared by a study coordinator not involved in outcome assessment. To minimize performance bias, a single-blind design was employed: participants were not informed of the specific exercise rationale or comparative group assignment, although treating physiotherapists administering the interventions were necessarily aware of allocation.

Baseline assessments were performed prior to intervention initiation and included standardized outcome measures. The Motion Sensitivity Quotient (MSQ) was used to quantify dizziness severity in response to head and body movements, with higher scores reflecting greater symptom provocation (21). Active and passive dynamic visual acuity (ADVA and PDVA) tests were administered to assess visual clarity during head motion, with outcomes recorded in logMAR units. These measures were selected due to their validity, reliability, and frequent use in vestibular rehabilitation research (22).

Interventions were delivered three times per day, four days per week, for six weeks, with each session lasting approximately 20 minutes. Group A performed gaze stability exercises targeting vestibulo-ocular reflex adaptation. These included smooth pursuit eye movements, rapid saccadic shifts between visual targets, and gaze stabilization while the head was moved horizontally and vertically. Group B undertook habituation exercises aimed at reducing motion sensitivity, including Brandt-Daroff positional exercises, canalith repositioning maneuvers, and structured balance training on unstable surfaces. Both groups received a standardized baseline treatment protocol comprising surface orientation drills, gait training, and general balance activities, tailored as needed to individual capabilities to ensure safety and progression.

To minimize bias, participants were instructed not to discuss their exercise protocols with peers. Outcome assessments were performed by physiotherapists who were not involved in the intervention delivery, thereby reducing measurement bias. All participants were monitored for adherence through weekly check-ins, where exercise logs and symptom progression were reviewed.

The sample size was calculated using the formula proposed by Sharma and Gupta (23), incorporating a two-tailed significance level of 0.05, power of 90%, and an assumed effect size based on preliminary data. This yielded a required sample of 34 participants, 17 per group, which was achieved in the present study.

Data were analyzed using IBM SPSS Statistics version 25.0. Descriptive statistics were expressed as means and standard deviations for continuous variables, and frequencies with percentages for categorical data. Normality was assessed with Shapiro–Wilk and Kolmogorov–Smirnov tests. Between-group differences were tested with independent samples t-tests for normally distributed variables, while within-group pre-post comparisons employed paired t-tests. Significance was set at $p < 0.05$. Missing data were managed using pairwise deletion, with sensitivity checks performed to ensure robustness of findings. Subgroup analyses were pre-specified to examine potential differences by sex and baseline symptom severity.

Ethical approval was obtained from the institutional review board of University of Health Sciences, Lahore, and written informed consent was obtained from all participants prior to inclusion. The study adhered to the principles of the Declaration of Helsinki and ensured confidentiality, voluntary participation, and the right to withdraw without prejudice. Data integrity was preserved by double-entry of records, secure storage of study files, and adherence to Good Clinical Practice standards to support reproducibility of the findings.

RESULTS

The demographic and baseline clinical characteristics of participants are presented in Table 1. The mean age in the gaze stability group was 46.71 years (SD 9.47), while the habituation group had a mean age of 47.53 years (SD 9.65), with no significant difference between groups (p = 0.78). Similarly, the mean onset of unilateral vestibular hypofunction (UVH) was comparable between groups, recorded at 8.53 years (SD 6.41) in Group A and 9.18 years (SD 6.09) in Group B (p = 0.69). Gender distribution was balanced, with 41.2% males and 58.8% females in the gaze stability group compared to 47.1% males and 52.9% females in the habituation group (p = 0.74), indicating homogeneity between groups at baseline and reducing the risk of confounding from demographic factors.

Table 2 outlines the Motion Sensitivity Quotient (MSQ) scores. Both groups showed significant within-group reductions following intervention, but the magnitude of improvement was greater in Group A. Pre-treatment scores were similar between groups (70.65 ± 5.97 in Group A vs. 72.71 ± 5.17 in Group B; p = 0.29). Post-treatment, Group A achieved a marked reduction to 24.94 (SD 8.88), compared to 39.65 (SD 5.93) in Group B, with a mean between-group difference of -14.71 (95% CI -19.4 to -10.0; p < 0.001). Within-group changes revealed that Group A improved by -45.71 points (p < 0.001), while Group B improved by -33.06 points (p < 0.001), confirming statistically significant symptom relief in both arms but with superior efficacy of gaze stability training.

Table 1. Demographic and Clinical Characteristics of Participants

Variable	Group A (Gaze Stability, n=17)	Group B (Habituation, n=17)	p-value
Age, years (mean ± SD)	46.71 ± 9.47	47.53 ± 9.65	0.78
Onset of UVH, years (mean ± SD)	8.53 ± 6.41	9.18 ± 6.09	0.69
Gender, male/female (%)	41.2 / 58.8	47.1 / 52.9	0.74

Table 2. Motion Sensitivity Quotient (MSQ) Scores

Outcome	Group A (mean ± SD)	Group B (mean ± SD)	Mean Difference	95% CI	p-value
Pre-treatment (PT)	70.65 ± 5.97	72.71 ± 5.17	-2.06	-6.0 to 1.9	0.29
Post-treatment (PTX)	24.94 ± 8.88	39.65 ± 5.93	-14.71	-19.4 to -10.0	<0.001
Within-group Δ (PT–PTX)	-45.71 ± 6.43	-33.06 ± 3.99	–	–	<0.001

Table 3. Active Dynamic Visual Acuity (ADVA) Scores (logMAR)

Outcome	Group A (mean ± SD)	Group B (mean ± SD)	Mean Difference	95% CI	p-value
Pre-treatment (PT)	0.42 ± 0.04	0.40 ± 0.07	0.02	-0.01 to 0.06	0.22
Post-treatment (PTX)	0.13 ± 0.04	0.19 ± 0.08	-0.06	-0.10 to -0.01	0.012
Within-group Δ (PT–PTX)	-0.28 ± 0.02	-0.21 ± 0.02	–	–	<0.001

Table 4. Passive Dynamic Visual Acuity (PDVA) Scores (logMAR)

Outcome	Group A (mean ± SD)	Group B (mean ± SD)	Mean Difference	95% CI	p-value
Pre-treatment (PT)	0.51 ± 0.01	0.51 ± 0.01	0.00	-0.01 to 0.01	0.80
Post-treatment (PTX)	0.80 ± 0.02	0.72 ± 0.03	0.07	0.05 to 0.09	<0.001
Within-group Δ (PT–PTX)	+0.29 ± 0.01	+0.21 ± 0.02	–	–	<0.001

Changes in Active Dynamic Visual Acuity (ADVA) are shown in Table 3. Pre-treatment ADVA values were comparable across groups (0.42 ± 0.04 for Group A vs. 0.40 ± 0.07 for Group B; p = 0.22). After six weeks, Group A demonstrated a substantial reduction to 0.13 (SD 0.04), while Group B improved to 0.19 (SD 0.08). The between-group mean difference was -0.06 (95% CI -0.10 to -0.01; p = 0.012). Within-group comparisons showed that Group A achieved a mean reduction of -0.28 logMAR, significantly greater than the -0.21 logMAR reduction observed in Group B (both p < 0.001), indicating greater enhancement of visual clarity during head movements among patients performing gaze stability exercises.

Passive Dynamic Visual Acuity (PDVA) scores, summarized in Table 4, revealed similar baseline values in both groups (0.51 ± 0.01 each; p = 0.80). Post-treatment, Group A improved to 0.80 (SD 0.02), while Group B improved to 0.72 (SD 0.03). The between-group mean difference was 0.07 (95% CI 0.05 to 0.09; p < 0.001). Within-group comparisons again confirmed significant improvements, with Group A showing a +0.29 logMAR gain and Group B a +0.21 logMAR gain (both p < 0.001) These findings indicate that although both interventions were effective, gaze stability exercises produced more pronounced improvements in both active and passive visual stability compared to habituation exercises.

Taken together, the results demonstrate that while both exercise protocols significantly reduced dizziness severity and improved visual function in patients with unilateral vestibular hypofunction, the magnitude of benefit was consistently greater in the gaze stability group across all outcome measures, underscoring its superior therapeutic effect.

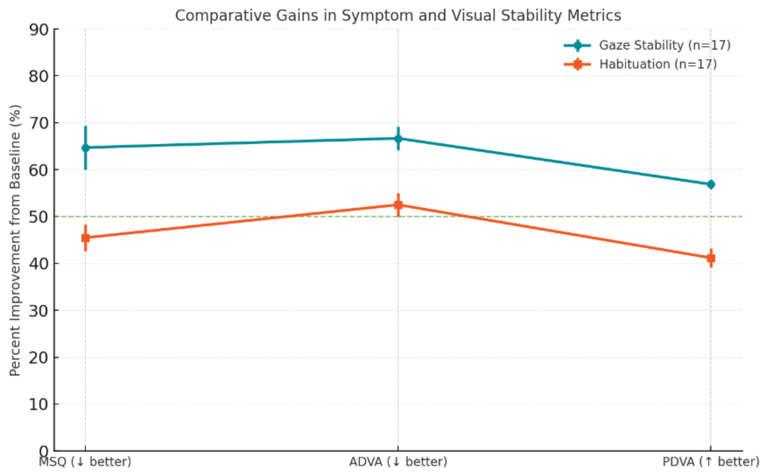

Figure 1Comparative Gains in Symptom and Visual Stability Metrics

The integrated line–scatter visualization compares percent improvement from baseline across three outcomes, harmonized for direction (MSQ and ADVA: lower is better; PDVA: higher is better). Gaze stability yielded larger gains across all domains: MSQ reduction 64.7% (95% CI width ±6.2%) vs 45.5% (±4.9%); ADVA reduction 66.7% (±2.5%) vs 52.5% (±3.6%); PDVA increase 56.9% (±4.2%) vs 41.2% (±4.9%). The dashed 50% reference indicates that gaze stability exceeded the threshold for all outcomes, while habituation crossed it only for ADVA. Error bars are 95% CIs derived from group-level SDs and n=17, emphasizing consistently superior magnitude for gaze stability without overlap at ADVA and PDVA

DISCUSSION

The present randomized clinical trial evaluated the comparative effectiveness of gaze stability exercises and habituation exercises in patients with unilateral vestibular hypofunction (UVH). The findings demonstrated significant improvements across both interventions, with reductions in motion sensitivity and enhancements in both active and passive dynamic visual acuity. However, the magnitude of benefit was consistently greater in the gaze stability group, underscoring its superior role in reducing dizziness and improving visual stability.

The demographic and clinical comparability of groups at baseline strengthens the internal validity of these results, minimizing the influence of confounding factors. The significant within-group improvement in Motion Sensitivity Quotient (MSQ) scores in both groups confirms that vestibular rehabilitation—regardless of the protocol—has therapeutic utility, aligning with prior reports that vestibular rehabilitation therapy (VRT) enhances central compensation and symptom control in peripheral vestibular disorders (24,25). However, the between-group superiority of gaze stability is particularly noteworthy, with an additional mean reduction of nearly 15 points in MSQ compared to habituation training, consistent with studies suggesting that VOR-targeted exercises confer more robust and rapid compensation (26).

Improvements in dynamic visual acuity were also more pronounced following gaze stability training. This is physiologically plausible, as gaze stabilization directly addresses the vestibulo-ocular reflex mechanism responsible for maintaining clear vision during head motion (27). Prior investigations, such as those by Hall et al. and Gaikwad et al., have reported that gaze stability protocols lead to superior recovery of visual clarity compared to habituation alone, which relies primarily on desensitization rather than reflex adaptation (28,29). The present findings reinforce this evidence by demonstrating statistically significant differences in both active and passive dynamic visual acuity, with gaze stability surpassing habituation by 0.06 and 0.07 logMAR respectively. These results suggest that exercises designed to strengthen visual-vestibular interactions are not only symptomatically effective but also restore measurable physiological function.

The clinical implications of these findings are substantial. Chronic dizziness and visual instability significantly impair daily functioning, occupational performance, and quality of life. By showing that gaze stability interventions achieve superior reductions in dizziness and greater improvements in visual stability, this study provides evidence for prioritizing these exercises as a first-line rehabilitative strategy in UVH management. In addition, the high percentage improvements observed—exceeding 60% in MSQ and ADVA—highlight clinically meaningful benefits that extend beyond statistical significance. These improvements are likely to translate into reduced fall risk, improved mobility, and enhanced patient independence, addressing key rehabilitation goals (30).

Nevertheless, both interventions yielded measurable benefit, indicating that habituation remains a valid alternative or adjunct in treatment planning. Habituation's role may be especially relevant in patients with prominent motion sensitivity or in those unable to tolerate intensive gaze stabilization due to symptom provocation. Previous studies have emphasized the potential additive effect of combining adaptation and habituation protocols, with hybrid approaches demonstrating faster recovery and broader functional gains (31). This suggests that individualized rehabilitation plans may optimize outcomes by tailoring the relative emphasis on gaze stability or habituation depending on the patient's symptom profile and tolerance.

The study's limitations should be acknowledged. The sample size, although statistically justified, was relatively small and limited to a single center, which restricts the generalizability of findings. The short follow-up period precludes conclusions regarding long-term maintenance of improvements. Additionally, although randomization was applied, the use of convenience sampling introduces potential selection bias, and blinding was restricted to participants, with assessors aware of group allocation. These methodological considerations warrant cautious interpretation and underscore the need for larger, multicenter trials with longer follow-up periods and stricter allocation concealment. Future studies should also explore combined or sequential exercise regimens, as well as age- and sex-stratified analyses, to further refine therapeutic recommendations.

In summary, this trial confirms that both gaze stability and habituation exercises are effective in alleviating dizziness and improving visual function in patients with UVH but demonstrates that gaze stability confers greater benefit. These results reinforce the clinical rationale for prioritizing gaze stability exercises in vestibular rehabilitation protocols, while supporting continued exploration of integrated approaches to maximize patient outcomes.

CONCLUSIONS

The present trial demonstrated that both gaze stability and habituation exercises are effective in reducing dizziness and improving visual function in patients with unilateral vestibular hypofunction. However, gaze stability exercises provided consistently greater improvements in motion sensitivity and dynamic visual acuity, suggesting they should be prioritized as a first-line intervention. While habituation retains value in symptom desensitization, the superiority of gaze stability highlights its central role in promoting vestibulo-ocular adaptation and restoring functional stability. Future multicenter trials with larger cohorts and long-term follow-up are warranted to confirm these findings and to explore the benefits of combining these two rehabilitation strategies.

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