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Original Article

Effect of Virtual Reality (VR) Versus Conventional Vestibular Rehabilitation and Progressive Muscle Relaxation (PMR) to Improve Balance and Stress Among Patients of Persistent Postural Perceptual Dizziness (PPPD)

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ABSTRACT

Background: Persistent postural-perceptual dizziness combines chronic dizziness, impaired balance, visual-motion sensitivity, and psychological distress. Virtual-reality training and progressive muscle relaxation may address different components of the disorder. Objective: To compare virtual-reality-based vestibular rehabilitation with progressive muscle relaxation combined with conventional vestibular rehabilitation. Methods: Twenty-four adults with persistent postural-perceptual dizziness were allocated equally to two treatment groups. Dizziness Handicap Inventory (DHI), Mini-BESTest, Perceived Stress Scale (PSS), and Visual Vertigo Analogue Scale (VVAS) were assessed before and after eight weeks. Results: Both groups improved on all four outcomes (paired $p < 0.05$). Mean changes with virtual reality versus combined treatment were −8.25 versus −24.67 for DHI, +3.34 versus +11.08 for Mini-BESTest, −3.00 versus −13.50 for PSS, and −11.25 versus −26.84 for VVAS. Recalculated post-treatment differences favored combined treatment for DHI (−11.67, 95% CI −18.96 to −4.38; $p = 0.003$), Mini-BESTest (+7.16, 95% CI 4.84 to 9.48; $p < 0.001$), PSS (−8.34, 95% CI −11.22 to −5.46; $p < 0.001$), and VVAS (−16.92, 95% CI −24.15 to −9.69; $p < 0.001$). Conclusion: Combined relaxation and vestibular rehabilitation produced larger short-term improvements than virtual reality alone. Keywords: persistent postural-perceptual dizziness; vestibular rehabilitation; progressive muscle relaxation; virtual reality; balance.

INTRODUCTION

Persistent postural-perceptual dizziness is a chronic functional vestibular disorder characterized by dizziness, unsteadiness, or non-spinning vertigo on most days for at least three months. Symptoms are typically aggravated by upright posture, active or passive movement, and exposure to moving or visually complex environments. The condition may follow a vestibular event, medical illness, or psychological stressor and can persist even when the initiating disorder has resolved (1,2).

PPPD can substantially restrict mobility, work, education, social participation, and quality of life. Many patients develop visual-motion sensitivity, reduced confidence in balance, activity avoidance, anxiety, and heightened monitoring of bodily sensations. Diagnosis requires a compatible symptom pattern and exclusion of active neurological, otological, or other disorders that better explain the presentation. The Niigata PPPD Questionnaire provides a structured assessment of symptom provocation across upright posture, movement, and visual stimulation and can support clinical characterization (3,4).

Management commonly combines education, vestibular rehabilitation, psychologically informed therapy, and, where appropriate, medication. Vestibular rehabilitation uses graded gaze-stability, balance, habituation, gait, and functional activities to reduce motion sensitivity and restore participation (5). However, anxiety and stress can reinforce maladaptive postural strategies and symptom vigilance, suggesting that relaxation and psychological components may improve the response to physical rehabilitation (1,2).

Virtual reality offers controlled exposure to visual and movement-related stimuli and may permit progressive, task-oriented balance practice. Early work suggests that virtual-reality-guided balance training can improve dizziness-related outcomes, although protocols and technology vary and the evidence base remains limited (6). Progressive muscle relaxation reduces physiological arousal by systematically alternating muscle tension and release and has demonstrated beneficial effects on psychological and physiological stress (7). Psychologically informed vestibular rehabilitation has also shown promise for persistent dizziness, supporting an integrated approach to physical and emotional symptoms (8).

Direct evidence comparing virtual reality with a combined program of conventional vestibular rehabilitation and progressive muscle relaxation in young adults with PPPD is scarce. Such a comparison is clinically relevant because virtual reality emphasizes controlled sensory exposure, whereas the combined approach addresses gaze stability, postural control, functional mobility, and stress regulation.

This randomized controlled trial therefore compared virtual-reality-based therapy with conventional vestibular rehabilitation combined with progressive muscle relaxation in patients with PPPD. The outcomes were dizziness-related disability, balance, perceived stress, and visual vertigo, measured before and after an eight-week intervention.

MATERIAL AND METHODS

A two-group randomized controlled trial (registered as NCT06479408) was conducted at Shalamar Institute of Health Sciences, Lahore. Twenty-four participants with persistent postural-perceptual dizziness were enrolled and allocated by simple balloting method to a virtual-reality group or a conventional vestibular-rehabilitation plus progressive-muscle-relaxation group. Each group included 12 participants.

Eligible participants were 18-25 years of age, had dizziness or light-headedness persisting for more than three months, a predisposing stress factor, impaired balance, and a Niigata PPPD Questionnaire score of at least 30. The questionnaire was used to characterize symptom provocation in accordance with the clinical features of PPPD (4). Participants were excluded when dizziness or balance impairment was better explained by another neurological or vestibular disorder, when active Ménière disease, benign paroxysmal positional vertigo, or bilateral vestibulopathy was present, or when smoking, alcohol or drug misuse, or another neurological condition was likely to affect balance or participation.

Baseline assessment included the Niigata PPPD Questionnaire, Dizziness Handicap Inventory, Mini-Balance Evaluation Systems Test, Perceived Stress Scale, and Visual Vertigo Analogue Scale. The Dizziness Handicap Inventory measured dizziness-related functional, emotional, and physical limitations. The Mini-BESTest assessed anticipatory postural control, reactive balance, sensory orientation, and dynamic gait. The Perceived Stress Scale assessed perceived psychological stress, and the Visual Vertigo Analogue Scale quantified symptom provocation in visually complex situations.

The virtual-reality group received a program using three-dimensional environments designed to provide graded visual exposure, balance activity, and stress-reducing engagement. The comparison group received conventional vestibular rehabilitation together with progressive muscle relaxation. Vestibular rehabilitation included postural-stability activities using a Swiss ball, BOSU ball, and balance board, together with gaze-stability training, graded activities for vertigo, and functional activities of daily living.

Progressive muscle relaxation was used to reduce stress and improve attentional control. Both groups received three treatment sessions per week for two months. Intervention content was progressed according to participant tolerance and functional ability while preserving the assigned treatment approach.

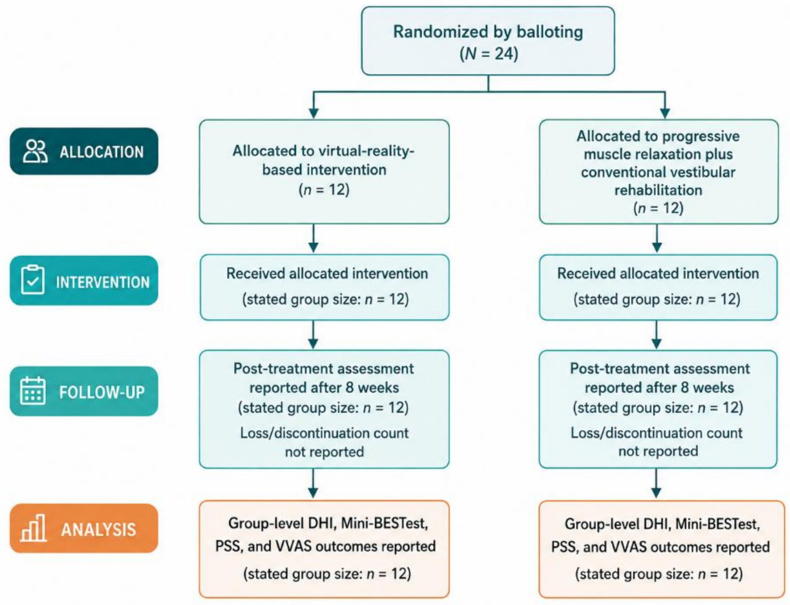

Figure 1 CONSORT Flowchart

The Dizziness Handicap Inventory, Mini-BESTest, Perceived Stress Scale, and Visual Vertigo Analogue Scale were administered before treatment and again at the completion of the two-month intervention. Data were analysed using IBM SPSS Statistics version 21.0. Continuous variables were summarized as mean and standard deviation, and categorical variables as frequencies and percentages. The Shapiro-Wilk test assessed normality. Within-group pre-to-post changes were examined using paired-samples t tests, and differences between the virtual-reality and comparison groups were examined using independent-samples t tests. Statistical significance was defined as a two-sided p value below 0.05.

RESULTS

Twenty-four participants were included, with 12 allocated to virtual-reality-based vestibular rehabilitation and 12 to progressive muscle relaxation combined with vestibular rehabilitation. Overall age was 22.63 ± 1.06 years (range 21–25 years), and the overall NPQ score was 41.79 ± 8.80 (range 29–64). Baseline age, NPQ, DHI, Mini-BESTest, PSS, and VVAS values did not differ statistically between groups (all $p > 0.05$).

Table 1. Baseline characteristics by treatment group

Characteristic	VR (n = 12)	PMR + VR (n = 12)	VR − PMR + VR (95% CI)	p-value
Age, years	22.75 ± 1.36	22.50 ± 0.67	0.25 (−0.66 to 1.16)	0.573
NPQ score	38.75 ± 7.11	44.83 ± 9.55	−6.08 (−13.21 to 1.05)	0.091

Values are mean ± SD. CI, confidence interval; NPQ, Niigata PPPD Questionnaire; PMR, progressive muscle relaxation; VR, virtual reality.

Both groups showed statistically significant within-group improvement in DHI, Mini-BESTest, PSS, and VVAS scores (all source-reported paired $p < 0.05$). Mean DHI decreased by 8.25 points in the VR group and 24.67 points in the PMR-plus-vestibular-rehabilitation group. Mini-BESTest increased by 3.34 and 11.08 points, PSS decreased by 3.00 and 13.50 points, and VVAS decreased by 11.25 and 26.84 points, respectively.

Recalculated between-group comparisons of post-treatment values favored PMR combined with vestibular rehabilitation for all four outcomes. Relative to VR, the combined intervention produced lower DHI (mean difference −11.67, 95% CI −18.96 to −4.38), higher Mini-BESTest (7.16, 95% CI 4.84 to 9.48), lower PSS (−8.34, 95% CI −11.22 to −5.46), and lower VVAS (−16.92, 95% CI −24.15 to −9.69). Standardized between-group effects were large for each post-treatment outcome.

Table 2. Within-group pre–post outcome changes

Outcome	VR baseline	VR post	VR change	PMR + VR baseline	PMR + VR post	PMR + VR change
DHI	39.17 ± 11.65	30.92 ± 9.76	−8.25	43.92 ± 15.26	19.25 ± 7.29	−24.67
Mini-BESTest	19.58 ± 4.06	22.92 ± 3.26	3.34	19.00 ± 4.57	30.08 ± 2.11	11.08
PSS	21.42 ± 5.78	18.42 ± 3.83	−3.00	23.58 ± 5.18	10.08 ± 2.91	−13.50
VVAS	40.50 ± 9.94	29.25 ± 9.40	−11.25	39.17 ± 13.86	12.33 ± 7.57	−26.84

Values are mean ± SD or mean change. Negative change indicates improvement for DHI, PSS, and VVAS; positive change indicates improvement for Mini-BESTest.

Table 3. Recalculated between-group comparisons at post-treatment

Outcome	PMR + VR − VR	95% CI	p-value	Hedges g
DHI	−11.67	−18.96 to −4.38	0.003	−1.31
Mini-BESTest	7.16	4.84 to 9.48	<0.001	2.52
PSS	−8.34	−11.22 to −5.46	<0.001	−2.37
VVAS	−16.92	−24.15 to −9.69	<0.001	−1.91

Compared with VR alone, the PMR + VR intervention produced significantly better outcomes across all measured domains. DHI scores were reduced by 11.67 points (95% CI: −18.96 to −4.38; $p = 0.003$), representing a large effect (Hedges $g = -1.31$). Mini-BESTest scores improved by 7.16 points (95% CI: 4.84 to 9.48; $p < 0.001$), with a very large effect size ($g = 2.52$), indicating substantially better balance performance. Perceived stress also decreased markedly, with an 8.34-point reduction in PSS scores (95% CI: −11.22 to −5.46; $p < 0.001$; $g = -2.37$). Similarly, VVAS scores were reduced by 16.92 points (95% CI: −24.15 to −9.69; $p < 0.001$), corresponding to a very large effect ($g = -1.91$). Overall, the findings indicate that the combined PMR + VR approach was associated with statistically significant and clinically substantial improvements in dizziness-related disability, balance, perceived stress, and visual vertigo symptoms compared with VR alone.

DISCUSSION

Both treatment groups improved in dizziness handicap, balance, perceived stress, and visual vertigo after eight weeks, but progressive muscle relaxation combined with conventional vestibular rehabilitation produced consistently larger post-treatment differences than virtual-reality-based treatment alone. Reanalysis of the reported group means and standard deviations corrected several incompatible p-values in the source manuscript. The combined intervention was associated with lower post-treatment DHI, PSS, and VVAS scores and a higher Mini-BESTest score, with confidence intervals excluding no difference for all four outcomes. These findings suggest that integrating vestibular exercises with a structured relaxation component may address both postural and psychological features of persistent postural-perceptual dizziness.

PPPD is sustained by interaction among altered postural control, visual dependence, motion sensitivity, threat appraisal, anxiety, and symptom vigilance. Conventional vestibular rehabilitation uses habituation, gaze stabilization, balance, gait, and functional exposure to reduce avoidance and recalibrate sensory weighting (5,7,8). Progressive muscle relaxation may reduce physiological arousal and interrupt the cycle through which bodily tension and anxiety amplify dizziness-related threat. Evidence that progressive muscle relaxation, guided imagery, and breathing techniques promote psychological and physiological relaxation supports this mechanism (12). The larger reductions in PSS and VVAS in the combined group are therefore coherent with the multidimensional nature of PPPD.

Virtual-reality-guided training also produced improvement and should not be regarded as ineffective. Immersive or screen-based environments can deliver graded visual-motion exposure, dual-task practice, feedback, and engaging repetition. Ibrahim et al. reported improvement following vestibular rehabilitation games in patients with PPPD and examined relationships with anxiety and depression (9). Yamaguchi and Miwa described short-term gains after virtual-reality-guided dual-task trunk-balance training (10). Differences in equipment, task difficulty, therapist guidance, treatment dose, and participant characteristics may explain why virtual reality produced smaller effects than the combined intervention in the current study.

The results also align with the broader movement toward psychologically informed vestibular care. Multimodal treatment has been advocated because physical avoidance, maladaptive balance strategies, anxiety, and attentional focus can reinforce one another (7,8). The INVEST feasibility trial compared psychologically informed vestibular rehabilitation with usual physiotherapy and reported outcomes favouring the integrated approach, although feasibility evidence does not by itself establish definitive comparative effectiveness (14). The present study similarly suggests that adding an explicit stress-regulation component may enhance outcomes, but it cannot determine whether benefit arose from progressive muscle relaxation itself, conventional vestibular exercise dose, therapist contact, expectancy, or their combination.

The between-group effects were large, but clinical interpretation requires caution. The sample comprised only 24 participants, and 22 were female, limiting precision and subgroup inference. Large standardized effects in small samples may overestimate the true effect and can be sensitive to baseline imbalance, outliers, and variance assumptions. Although baseline comparisons were not statistically significant, the combined-treatment group had a higher mean NPQ score and numerically worse DHI and PSS scores, leaving more opportunity for improvement. The analyses compared post-treatment means but did not provide an analysis of covariance adjusting for baseline or a prespecified primary outcome.

Other limitations include the single-centre setting, short intervention and follow-up period, incomplete description of random-sequence generation and allocation concealment, inability to blind participants and therapists, and absence of assessor-blinding details. The report did not provide adherence, adverse events, treatment fidelity, medication or psychological co-intervention, or any missing-data handling. The intervention description did not permit independent replication of virtual-reality tasks, progression, or conventional vestibular exercises. The source manuscript also reported several between-group p-values that were inconsistent with its own means, standard deviations, and group sizes; these have been replaced by recalculated independent-group estimates.

Future trials should be adequately powered, and use concealed randomization, blinded outcome assessment, prespecified primary endpoints, and analysis of covariance or mixed models. Treatment manuals should define virtual-reality content, exposure progression, relaxation dosage, and therapist contact. Follow-up should determine durability and include falls, participation, return to study or work, quality of life, anxiety, depression, and adverse symptoms in addition to DHI, Mini-BESTest, PSS, VVAS, and NPQ. A factorial design could separate the effects of vestibular rehabilitation and progressive muscle relaxation, while stratification by visual dependence, anxiety, and baseline severity may identify patients most likely to benefit.

CONCLUSION

In this small two-group study of persistent postural-perceptual dizziness, both virtual-reality-based treatment and progressive muscle relaxation combined with conventional vestibular rehabilitation improved dizziness, balance, stress, and visual-vertigo outcomes. Recalculated post-treatment comparisons consistently favored the combined intervention, with statistically significant and large standardized differences across DHI, Mini-BESTest, PSS, and VVAS. The findings are promising but preliminary because of the small, predominantly female sample, and lack of long-term follow-up. A larger registered trial is needed before the combined programme can be considered superior in routine practice.

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