Auditory and Vestibular Research

Cognition Behavioural Therapy–Informed Tele-Vestibular Rehabilitation for Persistent Postural-Perceptual Dizziness: A Clinical Case Study

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Abstract

Background: Persistent Postural-Perceptual Dizziness (PPPD) is a chronic functional vestibular disorder characterized by persistent non-spinning dizziness aggravated by motion, upright posture, and visually complex environments. Multimodal management including vestibular rehabilitation therapy (VRT) and cognitive behavioral therapy (CBT) is recommended; however, evidence supporting cognition-integrated tele-vestibular rehabilitation remains limited. This case aimed to examine the clinical utility of a CBT-informed tele-vestibular rehabilitation model in PPPD secondary to peripheral vestibular dysfunction.

The Case: A 31-year-old female presented with a two-year history of persistent dizziness, episodic vertigo, motion sensitivity, and visual dependence, along with anxiety and depressive symptoms. Audiological findings were normal. Vestibular evaluation revealed spontaneous left-beating nystagmus, right-sided utricular involvement on oVEMP (prolonged latencies, reduced amplitudes), and corrective saccades in the right lateral canal on vHIT; MRI findings were unremarkable. Baseline scores indicated severe handicap (DHI: 76/100) and high functional limitation (VADL; Niigata PPPD Questionnaire: 83/114). The patient underwent a 10-month structured program comprising four months of tele-VRT followed by six months of cognition-integrated tele-rehabilitation incorporating psychoeducation, self-monitoring, cognitive restructuring, and graded exposure. Post-intervention outcomes demonstrated reduced symptom severity (NPQ: 45/114), improved VADL scores,

decreased DHI (53/100), increased right oVEMP amplitudes, and resolution of corrective saccades on vHIT.
Conclusion: Cognition-integrated tele-vestibular rehabilitation was associated with meaningful functional, psychological, and partial objective vestibular improvements. This case highlights the feasibility and potential benefit of remotely delivered, multidimensional rehabilitation in PPPD and underscores the need for larger controlled studies.

Keywords: Balance assessment, functional mobility, vestibular rehabilitation, visual vertigo, patient-reported outcomes

Highlights

- cognitive behavioral therapy -informed tele-VRT improved PPPD symptoms and function
- Objective vestibular changes noted post-intervention
- Remote rehabilitation feasible for chronic vestibular disorders

Introduction

Persistent Postural-Perceptual Dizziness (PPPD) is a chronic functional vestibular disorder characterized by persistent dizziness and unsteadiness exacerbated by upright posture, motion (whether self-initiated or external), and visually complex environments. The condition was formally defined by the Bárány Society in 2017 and has since been incorporated into the 11th edition of the International Classification of Diseases (ICD-11) [1]. PPPD is believed to result from maladaptive interactions among the visual, vestibular, and proprioceptive systems, compounded by psychological factors such as anxiety, heightened vigilance, and maladaptive behavioral responses [2].

Despite absence of structural or vestibular abnormalities, individuals with PPPD report persistent non-spinning vertigo triggered by visually complex or motion-rich settings, such as navigating supermarkets, managing traffic, or sitting in crowded environments like restaurants [3, 4]. Although PPPD shares symptomatic overlap with certain psychiatric conditions, it is patho-physiologically distinct. Secondary psychological comorbidities, particularly anxiety and depression are frequently observed and may intensify symptom severity [5], contributing to significantly reduced quality of life [6] Notably, the Bárány Society recognizes that PPPD can develop secondary to a peripheral or central vestibular insult and related to precipitating condition, objective vestibular abnormalities may coexist with PPPD throughout the clinical observation [2].

Contemporary evidence-based management of PPPD emphasizes a multimodal approach, incorporating cognitive behavioral therapy (CBT), selective serotonin reuptake inhibitors (SSRIs), and vestibular rehabilitation therapy (VRT) [7]. VRT comprises of structured and progressively challenging exercises designed to stimulate and integrate the visual, vestibular, as well as somatosensory systems facilitating multisensory integration, and neuroplastic adaptation [8].

Given the need for sustained and individualized intervention in PPPD, delivering VRT through tele-rehabilitation becomes essential to ensure continuity of care [9]. In recent years, the evolution of tele-rehabilitation has expanded access to vestibular care, particularly for individuals in underserved or geographically remote settings [9,6]. The synchronous model of tele-VRT, incorporating real-time video-based instruction and monitoring, has demonstrated promising outcomes for chronic vestibular disorders [10,11] offering enhanced accessibility , reduced travel burden, and efficient resource utilization without compromising clinical efficacy [12,13]. Despite the growing evidence supporting tele-rehabilitation for vestibular dysfunction broadly, its application specifically for PPPD remains underexplored.

To address this gap, the present case study aimed to document the clinical utility of CBT- informed tele-vestibular rehabilitation therapy in a patient diagnosed with PPPD, highlighting its role in digital neurotological rehabilitation.

Case Presentation:

A 31-year-old female presented with a two-year history of persistent dizziness, episodic vertigo, and nausea. She reported non-positional tinnitus attributed to temporomandibular joint (TMJ) dysfunction, bilateral otalgia, right-sided aural fullness, self-perceived bilateral hearing loss, and long-standing visual disturbances (blurred vision, diplopia, floaters, reduced visual acuity). Comorbidities consisted of major depressive disorder, generalized anxiety disorder with panic attacks, migraine, and visual vertigo.

Dizziness episodes occurred two to three times weekly, lasting 5–15 minutes each, triggered by vehicular travel, head movements, and lateral gaze. Prior VRT overseas had yielded minimal improvement. Multidisciplinary evaluation identified features of migraine neurologically and disequilibrium otolaryngologically. MRI revealed no abnormalities. Ophthalmological assessment revealed convergence and accommodative insufficiency, vertical heterophoria, and visual-vestibular integration deficits; specialized glasses and 16 sessions of vision therapy improved convergence but dizziness and motion sensitivity persisted. Video-Frenzel oculography revealed spontaneous left-beating nystagmus suggesting right-sided vestibular involvement. BPPV was considered but not confirmed due to inconsistent positional nystagmus; migraine-associated vertigo remained a diagnosis of exclusion.

At current assessment, pure-tone and speech audiometry indicated normal bilateral hearing sensitivity. Subjective vestibular testing showed leftward sway on the Sharpened Romberg test and forward displacement on the Fukuda stepping test; gaze, spontaneous nystagmus, and finger-to-nose tests were negative.
Objective evaluation included cervical vestibular evoked myogenic potentials (cVEMP), ocular vestibular evoked myogenic potentials (oVEMP), Videonystagmography (VNG), and video Head Impulse Test (vHIT) (air-conducted 500 Hz tone-burst at 95 dB nHL; 100–150 sweeps averaged; head impulses at 150–250°/s for vHIT). cVEMP indicated normal bilateral sacculo-collic function. oVEMP revealed prolonged N1–P1 latencies and reduced amplitudes in the right ear, indicating right-sided utricular involvement (Figure 1); transient spinning was reported during left-ear stimulation. VNG ruled out central vestibular dysfunction. vHIT demonstrated normal VOR gain across all canals with corrective saccades in the right lateral canal (Figure 2).

Patient-reported outcome measures included the Vestibular Disorders Activities of Daily Living (VADL) scale, the revised Niigata PPPD questionnaire, and the Dizziness Handicap Inventory (DHI). The VADL scores were 46/120 (functional), 36/90 (ambulatory), and 40/70 (instrumental), indicating significant functional limitations [14]. The revised Niigata PPPD questionnaire yielded scores of 15/24 for upright posture/standing, 15/24 while moving, 18/24 for visual factors, 24/24 for associated symptoms, and 11/18 for symptom behaviour, resulting in a total score of 83/114. The DHI score was 76/100, indicating severe handicap [15].
Although conventional vestibular testing can often appear normal or inconclusive in PPPD, diagnosis was informed by integration of patient history, symptom persistence and triggers, visual dependence, and psychological comorbidities. Based on these findings, a provisional diagnosis of Persistent Postural-Perceptual Dizziness (PPPD) secondary to right-sided peripheral vestibular dysfunction was established, with coexisting visual vertigo and possible episodic vestibular migraine. This diagnosis followed the Bárány Society criteria described by Staab et al. , which include persistent non-spinning dizziness lasting at least three months and exacerbation by upright posture, motion, and complex visual stimuli [16].

ENT referral for otalgia and aural fullness led to antibiotic therapy. Psychological counselling and structured vestibular rehabilitation were subsequently initiated.
Based on the provisional diagnosis of PPPD secondary to right-sided peripheral vestibular dysfunction with visual vertigo and psychological comorbidities, a personalized tele-rehabilitation plan was developed following an evidence-based framework (Table 1). It incorporated adaptation, habituation, balance and gait training, oculomotor and visual-vestibular integration, and CBT-informed strategies, each tailored to the patient's symptom profile. A tele-rehabilitation model was adopted given limited access to in-person therapy.

Sessions were delivered via a secure, synchronous video-conferencing platform supporting real-time clinician-patient interaction, with exercises additionally prescribed for twice-daily home practice. Prior to commencing, the patient received orientation on platform use, safe exercise execution, and precautions. Progression was guided by symptom tolerance, and confidentiality was maintained per institutional ethical guidelines.
Baseline assessments were obtained approximately ten months before final reassessment. The intervention comprised two sequential phases:
Phase 1 (four months): Tele-VRT focusing on gaze stabilization, habituation, balance training, and functional mobility.
Phase 2 (six months): Cognition-integrated tele-VRT combining ongoing vestibular therapy with CBT-informed strategies including psychoeducation, self-monitoring, journaling, cognitive restructuring, and problem-solving techniques.

Each daily session lasted 20–30 minutes. Individual exercises were performed for 30 seconds to one minute with 10–15 repetitions; balance and gait activities lasted 2–5 minutes. Progression, involving increased movement speed, reduced visual cues, and dual-task demands, was permitted when post-exercise symptoms resolved within 15–20 minutes. Adherence was monitored via daily logs reviewed at weekly sessions. No adverse events occurred and the patient completed the program without dropout.

CBT-informed strategies were integrated within the vestibular rehabilitation plan to reduce dizziness-related anxiety and improve emotional regulation. Based on Ellis's ABC model, wherein beliefs (B) about activating events (A) determine emotional and behavioral consequences (C) [17], the rehabilitation program targeted maladaptive beliefs (e.g., fear of fainting, avoidance of daily tasks) arising from dizziness episodes [18]. Psychoeducation reframed dizziness as functional and non-threatening. Self-monitoring through structured journaling enabled identification of triggers, thoughts, and emotional responses. Cognitive restructuring guided the patient to examine distressing thoughts (e.g., "I might fall," "Something is seriously wrong") and generate balanced alternatives (e.g., "This dizziness is unpleasant but not dangerous"). Problem Solving Therapy [18] and graded behavioral exposure through progressively complex gaze-stabilization and habituation exercises were also incorporated. Breathing and relaxation techniques reduced autonomic arousal and improved distress tolerance. Formal CBT psychotherapy was not provided; strategies were embedded within VRT (Table 2).
Post-intervention, VADL scores improved to 23/120 (functional), 26/90 (ambulatory), and 17/70 (instrumental). Revised Niigata PPPD Questionnaire scores reduced to 8/24 (upright posture), 8/24 (moving), 8/24 (visual), 16/24 (associated symptoms), and 5/18 (symptom behaviour), yielding a total of 45/114. DHI improved from 76 to 53, indicating a reduction from severe to moderate handicap. Objectively, post-intervention evaluation demonstrated persistent bilateral cVEMP responses, increased right-ear oVEMP amplitude, and resolution of corrective saccades on vHIT, reflecting partial vestibular recovery (Table 3).

Discussion

The objective findings in this case which were spontaneous left-beating nystagmus, right oVEMP abnormalities, and corrective saccadic eye movements during vHIT indicated a prior peripheral vestibular lesion on the right side. However, these findings do not exclude the diagnosis of Persistent Postural-Perceptual Dizziness (PPPD). Rather, they support the possibility of secondary PPPD developing following an earlier vestibular insult, with persistent symptoms arising from maladaptive central compensation and abnormal sensory integration of visual, vestibular, and proprioceptive inputs. The Bárány Society definition recognizes this subcategory, noting that residual peripheral vestibular dysfunction may coexist at the time of PPPD diagnosis [2]. Even when vestibulo-ocular reflexes appear largely preserved and central ocular findings seem normal, dizziness may persist due to the complex interaction between central and peripheral mechanisms rather than a purely structural deficit.

oVEMP findings showed prolonged N1–P1 latencies and significantly reduced amplitudes in the right ear, indicating right-sided dysfunction. Interestingly, transient dizziness occurred during left ear stimulation. This apparent lateralization mismatch may reflect centrally mediated sensory conflict rather than a contralateral vestibular lesion. In PPPD, symptom provocation during vestibular testing does not always correspond to the side of objective vestibular deficit but may arise from abnormal sensory reweighting and altered processing of vestibular input at the cortical level [2]. Neuroimaging studies further demonstrate impaired vestibulo-visual cortical integration in PPPD, which may explain dizziness without corresponding contralateral vestibular pathology [4].

The patient-centered rehabilitation protocol targeted visual–vestibular mismatch, postural instability, and maladaptive sensory processing through gaze stabilization, habituation, and balance training. Delivered remotely, the program was associated with improvements in dizziness perception, visual motion sensitivity, and dynamic balance confidence. Cognitive strategies, particularly reflective self-journaling, may also have contributed to improved psychological well-being, highlighting the potential value of integrated approaches in functional vestibular disorders. Clinical outcomes were reflected in reductions in VADL scores and the revised Niigata-PPPD questionnaire. A comparative study by Kriz et al. demonstrated significant symptom improvement across in-clinic, telehealth, and hybrid vestibular rehabilitation formats [19]. However, greater reductions in DHI scores were observed with in-person therapy, suggesting that direct clinician supervision and hands-on correction may provide additional benefits when feasible. These findings suggest that while telerehabilitation can be a viable alternative—particularly for patients in geographically remote or resource-limited settings—hybrid care models may offer optimal outcomes.

Teh et al. reported comparable improvements in dizziness severity, anxiety, and quality of life between home-based and hospital-based vestibular rehabilitation in PPPD, supporting the premise that appropriately monitored home-based rehabilitation can achieve outcomes equivalent to clinic-based care [20]. This is particularly relevant for patients whose symptoms worsen with travel or sensory overload. Eldøen G et al. reported positive outcomes from a web-based vestibular rehabilitation platform but noted that participants struggled to maintain motivation without real-time professional support [21]; the therapist-guided structure in this case likely enhanced adherence through timely feedback and individualized adjustments. Additionally, Zang et al. demonstrated in a meta-analysis of six RCTs that combining CBT with conventional therapy significantly improved DHI scores in PPPD compared to conventional therapy alone [22], consistent with the reductions in VADL, revised Niigata-PPPD, and DHI scores observed in this case.

Conclusion

Despite encouraging outcomes, several limitations of telerehabilitation must be acknowledged. The absence of in-person interaction restricts procedures such as canalith repositioning maneuvers and instrumented balance assessments, and subtle oculomotor or compensatory movement patterns may go undetected virtually, underscoring the value of hybrid rehabilitation models. As a single-case observation, generalizability is limited. The VADL scale and revised Niigata-PPPD questionnaire are subjective measures susceptible to patient perception, recall bias, and expectancy effects; furthermore, MCID values for these tools have not been established in PPPD, requiring cautious interpretation of observed improvements. Adherence was documented via patient exercise logs, but the absence of objective monitoring limits assessment of compliance and exercise intensity. This case study provides preliminary evidence for the feasibility of cognition-integrated tele-vestibular rehabilitation in PPPD; however larger controlled studies incorporating hybrid designs are needed to evaluate effectiveness and identify predictors of success.

Ethics approval: The study was performed as per the Declaration of Helsinki and cleared by the research advisory committee of the institution. Ethical Code: BVDUMC/IEC/122

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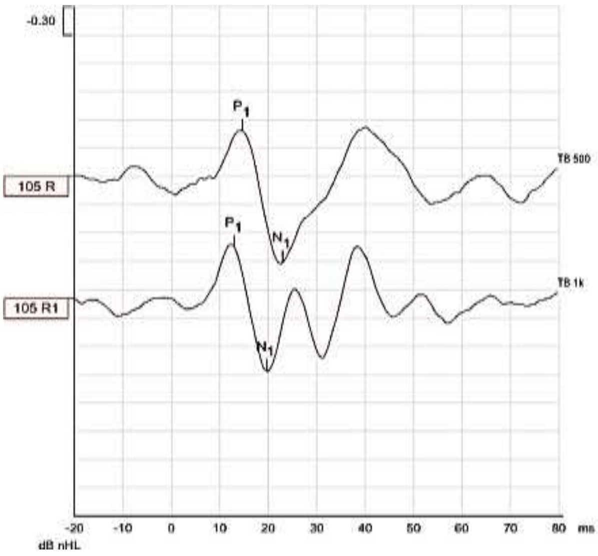
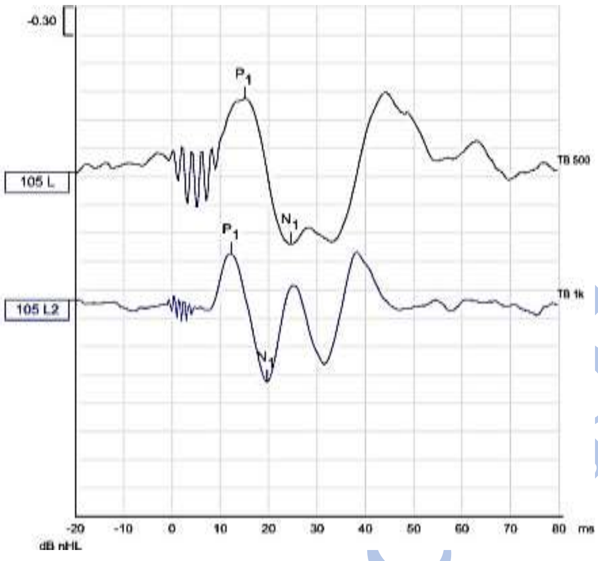
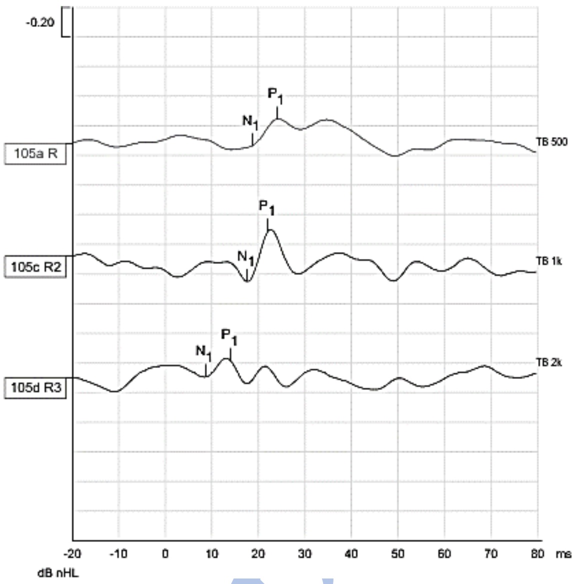


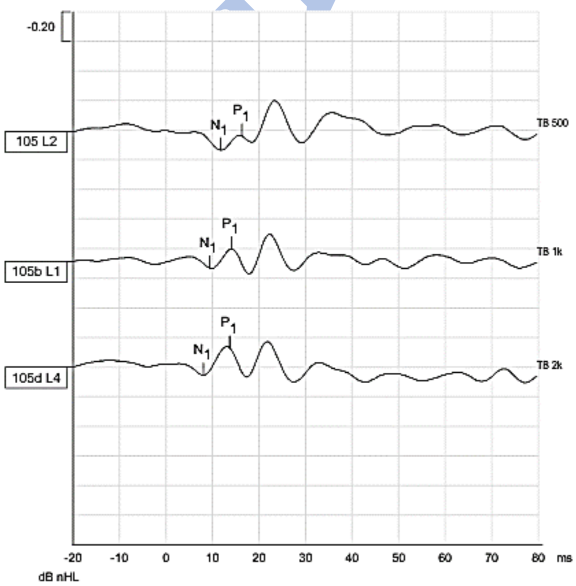
(A) Right ear



(B) Left ear



(C) Right ear



(D) Left ear

Figure 1. Illustration of the cervical Vestibular Evoked Myogenic Potential responses. (A.—Right ear; B.—Left ear) and ocular Vestibular Evoked Myogenic Potential (C.—Right ear; D.—Left ear) responses for 500 Hz, 1000 Hz and 2000 Hz tone burst stimulation in the patient.

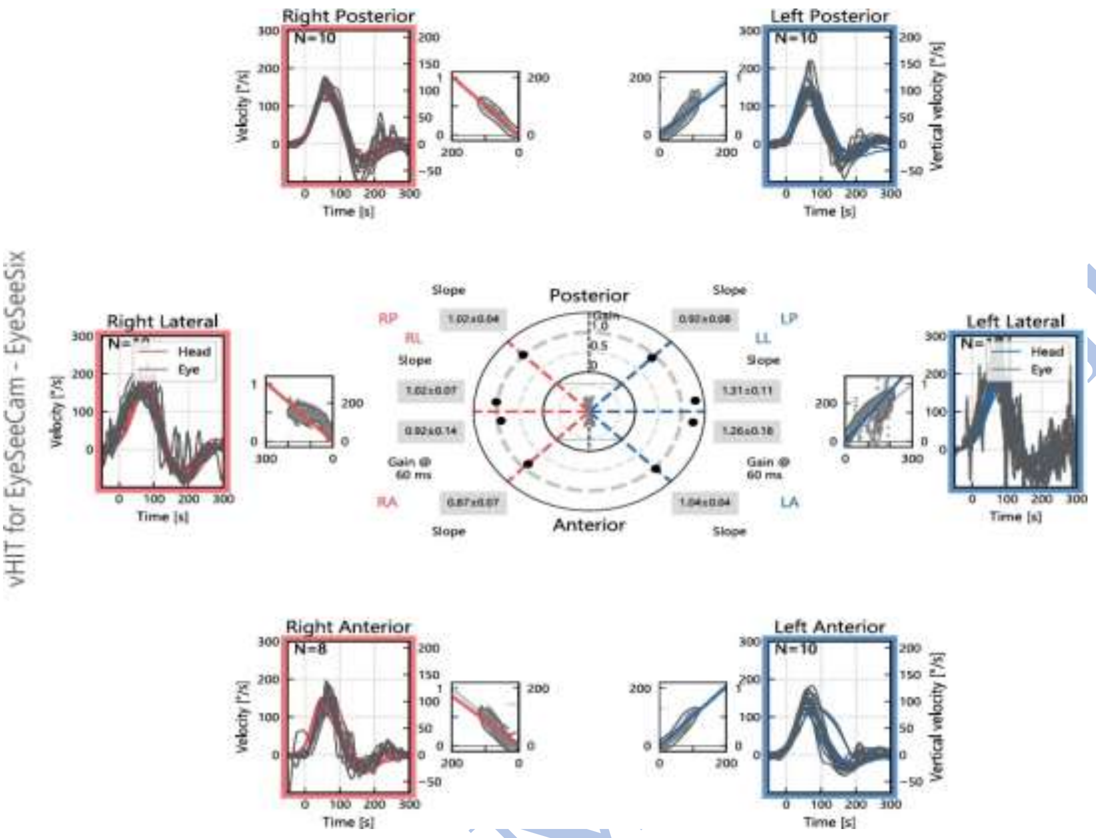


Figure 2. Illustration of the video head impulse test for all six semicircular canals in a patient with Persistent Postural Perceptual Dizziness.

Table 1: Categorization of vestibular rehabilitation therapy exercises

Category	Purpose	Subtypes / Examples
1. Gaze stability exercises (vestibular adaptation)	Enhance VOR function and reduce retinal slip	-Head turns (horizontal/vertical) with visual fixation - Head-trunk turns while fixating on a target - Head turns while walking - Exercises inducing retinal slip
2. Eye movement exercises	Improve oculomotor control and visual substitution	- Saccades (eye-only shifts) - Smooth pursuit (eye-only tracking) - Saccade + head turns (combined VOR/saccade training) - Imagery pursuit (remembered target)
3. Postural stability exercises	Improve balance control and sensory integration	- Standing on one leg - Heel-to-toe stance - Anterior-posterior sway - Marching in place
4. Habituation exercises	Desensitize motion-provoked dizziness and vertigo	- Provocative movement repetition - Brandt-Daroff type habituation - Diagonal arm movement with gaze fixation - Optokinetic stimulus exposure
5. Functional and ADL integration	Translate gains into daily life activities	- Gait with head/body turns - Sit-to-stand transitions - Walking on uneven surfaces - Turning during gait
6. Postural strategy training	Reeducate compensatory motor responses	- Ankle strategy (small sway) - Hip strategy (fast large sway) - Step strategy (stepping in response to perturbations)
7. Substitution exercises	Compensate for vestibular loss using other sensory cues	- Use of visual fixation in head movements - Use of somatosensory surfaces (foam, carpet) - COR-enhancing (cervico- ocular reflex) tasks - Practicing on altered visual or somatosensory inputs

Table 2: Six-month telerehabilitation regimen for Persistent Postural Perceptual Dizziness: categorization of exercises and patient-reported outcomes

Exercise	**Type**	**Frequency**	**Category**	**Reported Outcome**
1. Eye movement R- C-L without head	Gaze stabilization	Twice daily	Adaptation	Improved visual coordination; reduced disorientation
2. Finger tracking L-C- R with pause	Gaze stabilization	Twice daily	Adaptation	Better visual fixation and stability
3. Head tilts with eye movement (up-down)	Gaze stabilization	Twice daily	Adaptation	Enhanced eye-head coordination
4. Finger tracking with head tilts	Gaze stabilization	Twice daily	Adaptation	Helped in dynamic gaze control
5. Head rotation with center fixation	Gaze stabilization / Visual refixation	Twice daily	Adaptation	Reduced dizziness during head movements
6. Near-far gaze shifts	Vergence / visual-vestibular integration	Twice daily	Oculomotor/Visual-vestibular	Helped with convergence and motion sensitivity
7. Tracking ball on black background	Screen-based gaze stabilization	Twice daily	Habituation	Reduced visual motion sensitivity
8. Bottle shifting with eye tracking	Dynamic balance + visual tracking	Twice daily	Balance & gait training	Improved postural control and eye- hand coordination
9. Tracking cars, birds in video	Screen-based visual motion exposure	Twice daily	Habituation	Better visual tolerance in busy scenes
10. Self-journaling/ Manifestation	Cognitive-behavioural VRT	Daily	Cognitive integration	Reduced anxiety, improved emotional regulation
11. Walking (as coping strategy)	Functional Mobility	As needed	Balance & Gait Training	Helped with grounding, reduced anxiety episodes

Table 3: Baseline and post-intervention findings on objective evaluation including cervical Vestibular Evoked Myogenic Potential (cVEMP), ocular Vestibular Evoked Myogenic Potential (oVEMP) and video Head Impulse Test (vHIT)

Test	Parameter	Baseline Findings		Post-intervention findings		Individuals with normal hearing	
		Right Ear	**Left Ear**	**Right Ear**	**Left Ear**	**Right Ear**	**Left Ear**
cVEMP	P1 latency	14.67	15	14.67	15.25	14.67	15.33
	N1 latency	23.00	24.67	24.67	24.00	25.00	26.67
	P1-N1 amplitude	1.40	1.54	1.71	1.52	1.34	1.37
oVEMP	N1 latency	18.67	11.67	18.30	11.65	12.60	12.60
	P1 latency	24.00	16.33	23.00	16.20	17.50	17.50
	N1 – P1 amplitude	0.29	0.90	0.68	0.92	0.97	0.97
vHIT	Vestibular Ocular Reflex gain and corrective saccades	Vestibular Ocular Reflex gain within normal limits, corrective saccades noted in the right lateral canal		Vestibular Ocular Reflex gain within normal limits, no corrective saccades noted		Vestibular Ocular Reflex gain within normal limits, no corrective saccades present	

Note: Normative data for cVEMP and oVEMP responses were sourced from the research conducted by *Neupane & Lodha [20] and **Shahnaz & David [21] respectively