Review Article

Clinical Effectiveness of Vestibular Rehabilitation Therapy on Dizziness, Balance, Mobility, and Quality of Life in Adults with Balance Disorders: A Systematic Review of Randomized Controlled Trials (2017–2025)

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ABSTRACT

Aim: This review of randomized controlled trials examines the clinical effectiveness of vestibular rehabilitation therapy (VRT) on dizziness, balance, mobility, and quality of life in persons with balance disorders, synthesizing evidence from high-quality randomized controlled trials published between 2017 and 2025.

Method: A systematic search was conducted across PubMed, PEDro, Cochrane Library, and ScienceDirect using the PICO framework (Population: persons with balance disorders; Intervention: vestibular rehabilitation therapy; Comparison: usual care or alternative treatments; Outcomes: dizziness reduction, balance improvement, mobility enhancement, quality of life). Fourteen randomized controlled trials (RCTs) were included according to PRISMA guidelines. Study quality was assessed using the PEDro scale (scoring criteria 1–11). Heterogeneous outcomes prevented meta-analysis; findings are presented narratively organized by outcome domains.

Results: : Fourteen high-quality RCTs (n = 488 participants; mean PEDro score = 6.9/11, range 6–9) met inclusion criteria. Across all trials, conventional, virtual-reality (VR), and internet/blended vestibular rehabilitation demonstrated clinically meaningful reductions in dizziness disability (Dizziness Handicap Index: mean improvement 15–28 points), improvements in dynamic and static balance (Berg Balance Scale, Dynamic Gait Index, Timed Up and Go: moderate to large effect sizes), enhanced functional mobility, and modest to moderate improvements in health-related quality of life and psychosocial outcomes (reduced anxiety, fear of falling and depression). VR-augmented and internet-based delivery models showed comparable or superior outcomes for dynamic balance and functional mobility tasks compared with conventional therapy alone. Benefits were sustained over 3–6 month follow-up periods in trials reporting durability. Dose-response patterns indicate that interventions of ≥4–6 weeks' duration with supervised progressive training yield larger functional gains. Older adults, stroke survivors, and persons with traumatic brain injury demonstrated clinically relevant improvements; however, effect magnitudes varied by chronicity (greater gains in acute presentations) and baseline symptom severity.

Conclusion: Between 2017 and 2025, high-quality RCT evidence suggests that vestibular rehabilitation delivered conventionally, by VR, or via internet/blended models is associated with clinically meaningful reductions in dizziness and improvements in balance and mobility in several adult balance-disorder populations. Standardized outcome reporting, longer follow-up (≥12 months), larger trials in neurological subgroups, and cost-effectiveness analyses remain important research priorities. Integration of VRT into disability-inclusive rehabilitation programs can enhance participation and independence in persons with balance disorders.

Keywords: Balance disorders, Dizziness, Vestibular rehabilitation therapy, Mobility, Quality of life, Disability, Rehabilitation.

INTRODUCTION

Balance is a fundamental motor function essential for maintaining postural stability, coordinating movements, and performing daily and complex tasks safely. This capacity depends on the dynamic integration of three major sensory systems: the vestibular system, which detects head movements and spatial orientation; the visual system, which provides environmental cues; and the somatosensory system, which delivers proprioceptive feedback. When any of these systems are impaired or when integration between them is disrupted, equilibrium control becomes compromised, increasing the likelihood of falls and limiting independent mobility (1, 2).

In healthy adults, proper balance ensures safe and efficient mobility while supporting participation in daily activities and preventing injuries. This function is particularly important for maintaining independence in older adults, who may experience age-related degeneration in sensory systems and diminished neuromuscular coordination (3). In populations with neurological conditions such as stroke, Parkinson's disease, and multiple sclerosis, vestibular dysfunction and impaired balance significantly affect functional outcomes. Affected individuals often experience unsteady gait, recurrent falls, and limitations in routine activities, leading to reduced social, occupational, and recreational participation and increased dependence on caregivers (4, 5).

Beyond physical impairments, balance disorders carry substantial psychosocial consequences. Anxiety, fear of falling, depression, and social withdrawal are commonly observed in persons with chronic dizziness or imbalance, further reducing quality of life (6, 7). Sleep disturbances and cognitive decline have also been linked to chronic balance impairments, highlighting the multifaceted impact of vestibular and postural dysfunction.

Balance Disorders: Classification and Clinical Burden

Balance disorders represent a heterogeneous group of clinical conditions arising from dysfunction in the vestibular apparatus, central nervous system, or age-related sensory degeneration. Common peripheral vestibular disorders include benign paroxysmal positional vertigo (BPPV), Meniere's disease, and vestibular neuritis. BPPV, the most prevalent peripheral vestibular disorder, occurs due to displacement of otoconia into the semicircular canals, causing brief episodes of vertigo triggered by specific head movements, with higher prevalence in women and older adults (8, 9). Meniere's disease involves episodic vertigo, fluctuating hearing loss, and tinnitus caused by endolymphatic hydrops (9). Vestibular neuritis, typically presenting as sudden unilateral vestibular loss with severe vertigo and nausea, often results from viral or inflammatory infection (10, 11).

Central vestibular disorders arise from lesions or dysfunction in brain structures responsible for processing vestibular information, such as the cerebellum, brainstem, or cortical vestibular pathways. Stroke involving the cerebellum or brainstem can disrupt postural control, leading to gait disturbances and increased fall risk (4). Multiple sclerosis causes demyelination of central vestibular pathways, impairing coordination, balance, and spatial orientation (12). Parkinson's disease affects basal ganglia circuits, resulting in gait freezing, increased sway, and frequent falls (4).

Mixed or systemic causes, including traumatic brain injury (TBI) and age-related multisensory decline, combine both peripheral and central dysfunctions. TBI can damage vestibular structures and central processing networks simultaneously, causing persistent dizziness, postural instability, and impaired mobility (5, 13). Age-related degeneration affects vestibular hair cells, vision, and proprioception collectively, diminishing equilibrium control and increasing fall risk in older populations (3, 14).

The functional consequences are significant: individuals experience dizziness, vertigo, unsteady gait, and postural instability, which limit daily activity participation and increase injury risk. The psychosocial impact, including anxiety, depression, social withdrawal, and cognitive decline, further reduces health-related quality of life. Collectively, these factors underscore the complexity of balance disorders and the critical importance of timely assessment and tailored rehabilitation strategies.

Vestibular Rehabilitation Therapy: Rationale and Evidence Gap

Vestibular rehabilitation therapy (VRT) is an exercise-based therapeutic approach designed to promote central nervous system compensation, sensory re-weighting, and gaze stabilization through structured, task-specific training. Core VRT components include gaze stabilization exercises (improving vestibulo-ocular reflex function), habituation exercises (reducing dizziness through controlled exposure to provocative movements), balance and gait retraining, and proprioceptive enhancement (12). VRT has demonstrated efficacy in reducing dizziness, improving balance, and enhancing functional independence across peripheral and central vestibular disorders (3, 8, 15).

Despite widespread clinical use and established cost-effectiveness, substantial heterogeneity exists in VRT protocols, intervention intensity, delivery methods, and reported outcomes. Recent technological advances have introduced virtual-reality (VR)-augmented and internet-based/blended delivery models as alternatives or supplements to conventional in-clinic therapy. These models offer potential advantages, including expanded access, enhanced engagement, and scalability, which are particularly important for persons in resource-limited settings and those with mobility restrictions or geographic barriers to care.

Recent systematic reviews and meta-analyses (2017–2025) suggest VRT is effective for various vestibular and balance disorders; however, evidence across different outcomes remains scattered, with limited standardization of outcome reporting. No comprehensive systematic review of randomized controlled trials has systematically synthesized evidence from high-quality RCTs across multiple outcome domains—including dizziness reduction, balance improvement, mobility enhancement, and quality of life—while considering diverse delivery modalities and population subgroups relevant to disability-inclusive rehabilitation practice.

Significance for Disability, Rehabilitation, and Inclusive Development

This systematic review of randomized controlled trials is situated within a disability, rehabilitation, and inclusive development (DCID) framework. Balance disorders constitute a significant source of disability, activity limitation, and participation restriction across the lifespan, particularly affecting vulnerable populations, including older adults, persons with neurological conditions, and economically disadvantaged groups. Effective, scalable rehabilitation strategies that address both physical impairments and psychosocial consequences are central to disability inclusion policy and practice.

VRT represents a non-pharmacological, potentially accessible rehabilitation modality that can support person-centered recovery and functional independence. Understanding the current evidence base, including variation by delivery method, cost-effectiveness, and applicability to resource-constrained settings, informs policy decisions regarding rehabilitation service provision and supports evidence-based programming. Unlike prior reviews that focused on specific diagnoses (e.g., PPPD, unilateral hypofunction) or delivery modes (e.g., VR only), this systematic review restricts itself to RCTs and simultaneously examines conventional, VR-augmented, and internet/blended VRT across both peripheral and central balance-disorder populations, with particular attention to dose (intensity, duration) and delivery modality. Therefore, the aim of this is to systematically assess the clinical effectiveness of vestibular rehabilitation therapy on dizziness, balance, mobility, and quality of life in persons with balance disorders, while exploring diverse VRT protocols and intervention delivery strategies reported in randomized controlled trials published between 2017 and 2025.

METHODS

Protocol and Registration

This systematic review of randomized controlled trials was conducted and reported according to Preferred Reporting Items for systematic review of randomized controlled trials reported by PRISMA guidelines. The review was prospectively registered with the Open Science Framework (Registration: 10.17605/OSF.IO/HVGM8) prior to data extraction and analysis.

Study Design and Eligibility Criteria

Study Type: Randomized controlled trials (RCTs) published in English.

Study Population: Adults (≥18 years) with peripheral hypofunction (unilateral/bilateral), BPPV, Meniere's disease, vestibular neuritis; persistent postural-perceptual dizziness (PPPD) where specified; central disorders including stroke, multiple sclerosis, Parkinson’s disease; traumatic brain injury; and age-related vestibular dysfunction.

Interventions: Vestibular rehabilitation therapy, delivered as conventional in-clinic therapy, VR-augmented, internet-based, or blended (combined in-person and remote) programs. Interventions included one or more of the following: gaze stabilization exercises, vestibular habituation exercises, balance training, gait retraining, proprioceptive enhancement, and manual therapy combined with vestibular exercises.

Comparators: Usual care, standard physiotherapy without vestibular-specific focus, routine medical management, or alternative rehabilitation approaches.

Primary Outcomes:

- Dizziness reduction: Dizziness Handicap Index (DHI), Vertigo Symptom Scale (VSS-SF), Visual Analogue Scale for dizziness.
- Balance improvement: Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go (TUG), computerized dynamic posturography.
- Mobility: Gait speed (10-meter walk test), distance walked, step symmetry and Functional Independence Measure.
- Quality of life: Health-related quality of life scales (SF-36, EQ-5D), condition-specific quality of life measures.

Secondary Outcomes:

- Psychosocial outcomes: Hospital Anxiety and Depression Scale (HADS), fear of falling (Falls Efficacy Scale), activity confidence and kinesiophobia.
- Adherence and feasibility metrics for internet/VR programs.
- Adverse events and safety.

Exclusion Criteria:

- Non-randomized designs (cohort studies, case-control studies, case reports, editorials).
- Studies focusing primarily on pharmacological interventions without a rehabilitation component.
- Studies published in languages other than English.
- Studies with unclear or inadequate methodology preventing quality assessment.
- Studies of surgical interventions without rehabilitation comparison.

Information Sources and Search Strategy

Electronic databases searched: PubMed, PEDro (Physiotherapy Evidence Database), Cochrane Central Register of Controlled Trials, and ScienceDirect. (see Table 1)

Search Period: January 2017 – December 2025.

Table 1: PICO Framework Applied

Element	Description
Population (P)	Adults (≥18 years) with balance disorders (peripheral, central, or mixed etiologies)
Intervention (I)	Vestibular rehabilitation therapy in any delivery modality (in-clinic, VR-based, internet-based, blended)
Comparator (C)	Usual care, standard physiotherapy, routine care, alternative approaches
Outcomes (O)	Dizziness reduction, balance improvement, mobility enhancement, quality of life, psychosocial outcomes

Search Terms and Boolean Operators:

Primary search strings combined with Boolean "AND":

- "balance disorders" AND "vestibular rehabilitation"
- "dizziness" AND "vestibular rehabilitation therapy"
- "mobility" AND "vestibular rehabilitation"
- "quality of life" AND "balance" AND "vestibular therapy"
- "vestibular rehabilitation" AND "randomized controlled trial"
- "VRT" AND "dizziness" AND "balance"
- "virtual reality" AND "vestibular" AND "balance"
- "internet-based" OR "web-based" AND "vestibular rehabilitation"

Database-specific search filters applied: Document type (RCTs), language (English), publication date (2017–2025). "Full database-specific search strings (MeSH and text words) are provided in Supplementary Table S1."

Study Selection Process

All retrieved articles were imported into Mendeley reference management software. Duplicate articles were identified and removed. Two independent reviewers screened titles and abstracts against predefined eligibility criteria using a standardized screening form. Disagreements were resolved through discussion or consultation with a third reviewer. Full-text articles of potentially eligible studies were retrieved and assessed independently against inclusion/exclusion criteria. Final inclusion decisions were documented with reasons for exclusion recorded.

Data Extraction and Management

Data extracted from included studies incorporated: (1) study characteristics (author, year, country, design, sample size); (2) participant demographics (age, sex, balance disorder diagnosis, chronicity); (3) intervention description (VRT components, delivery modality, frequency, duration, supervision level); (4) comparator/control condition; (5) outcome measures and assessment timepoints; (6) results (point estimates, effect sizes, confidence intervals, statistical significance); (7) adverse events; (8) follow-up duration and attrition. Data were entered into standardized extraction tables and verified for accuracy.

Quality Assessment

The Physiotherapy Evidence Database (PEDro) scale was used to assess the methodological quality of included RCTs. The PEDro scale evaluates 11 criteria: (1) eligibility criteria specified, (2) random allocation, (3) concealed allocation, (4) baseline group similarity, (5) blinding of participants, (6) blinding of therapists, (7) blinding of assessors, (8) measurement of key outcome in ≥85% of participants, (9) intention-to-treat analysis, (10) between-group statistical comparison, and (11) provision of point estimates and variability. Each criterion is scored as present (1) or absent (0), yielding total scores from 0 to 11. Trials scoring ≥14 points across the original 10-item version are considered high-quality; scores of 6–13 indicate moderate quality.

Data Analysis and Synthesis

Heterogeneity in interventions (VRT components, delivery modes, duration), populations (diagnosis, age, chronicity), and outcome measures precluded meta-analysis. Findings are presented narratively, organized by outcome domain (dizziness reduction, balance improvement, mobility, quality of life and psychosocial outcomes). Within each domain, results are summarized by intervention type, population subgroup, and where available, effect magnitude descriptors (small, moderate, and large) based on standardized effect size conventions (Cohen's d: 0.2–0.5 = small, 0.5–0.8 = moderate, and ≥0.8 = large).

Subgroup analyses examine variation by: (1) delivery modality (conventional, VR-augmented, internet-based); (2) population age (older adults ≥50 years vs. younger cohorts); (3) chronicity (acute/subacute vs. chronic presentations); (4) underlying diagnosis (peripheral vs. central disorders); (5) intervention intensity (frequency, duration); (6) study quality (PEDro score). Dose-response relationships and moderators of treatment response are identified and discussed.

RESULTS

Study Selection

The systematic search across four electronic databases (PubMed, PEDro, Cochrane Library, and ScienceDirect) identified **14,532 articles** published between January 2017 and December 2025. After removal of 8,594 duplicates, 5,938 unique articles were screened by title and abstract. Following title/abstract screening, 1,428 full-text articles were retrieved for detailed eligibility assessment. Among these, 1,318 studies were excluded because they focused on pharmacological or surgical management rather than rehabilitation, and 1 article was excluded due to unclear/inadequate methodology. An additional 4,510 articles did not meet inclusion criteria upon full-text review (non-RCT designs, non-English language, outcomes not aligned with review objectives). As a result, 110 studies were initially identified as potentially eligible. After applying strict inclusion criteria regarding study design, population, intervention, and outcome measurement, **14 randomized controlled trials** were included in this systematic review of randomized controlled trials. (See Figure 1)

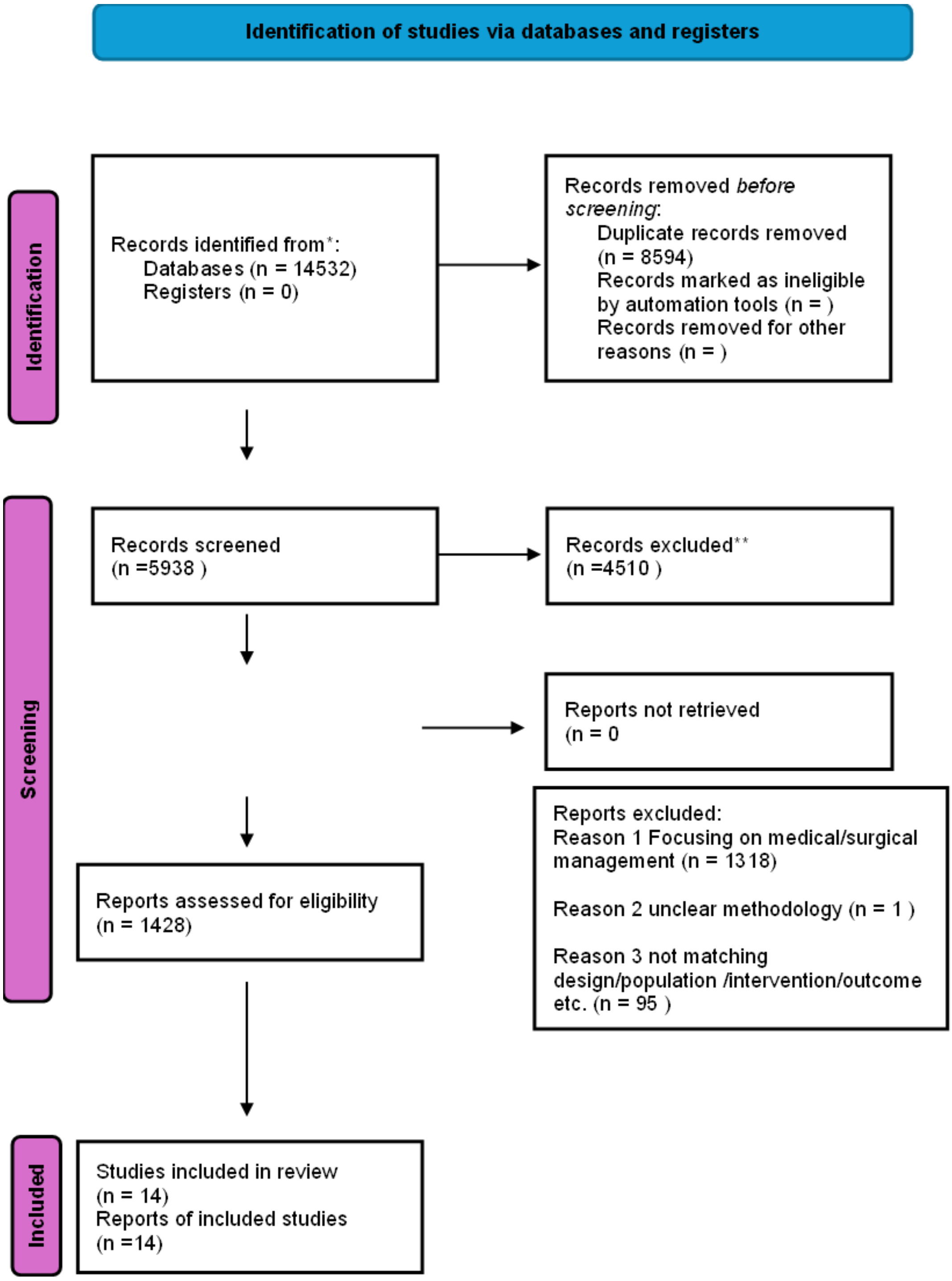

Figure 1: PRISMA 2020 flow diagram for study selection of this systematic review of randomized controlled trials

Table 2 Characteristics of Included Studies :Study Identification and Methodological Quality:

Sr. No.	Author/Year	Country	Sample Size (N)	Mean Age (years)	Primary Balance Disorder	Chronicity	Intervention	Control Condition	PEDro Score	Follow-up (weeks)
1	Vaishali et al., 2024	India	88	36.2 ± 10.1	chronic peripheral hypofunction	Chronic	VRT with/without manual therapy + balance training	group education sessions	9	4
2	Sana et al., 2023	Pakistan	24	40.4 ± 8.4	subacute stroke hemiparesis with vestibular deficit	Sub-acute	Gaze stab. + habituation ± balance training	standard physiotherapy without vestibular-specific tasks	6	4
3	AbuShaphe et al., 2023	Saudi Arabia	40	39.3 ± 3.1	BPPV	Chronic	Endurance + balance training	standard physiotherapy without vestibular-specific tasks	9	4
4	Sedeño-Vidal et al., 2022	Spain	80	56.8 ± 12.8	Unilateral vestibular dysfunction	Chronic	VRT + manual therapy (weekly, 4 weeks)	VRT alone	9	4
5	Tramontano et al., 2022	Italy	20	39.4 ± 3.1	Severe traumatic brain injury	Chronic	Vestibular-directed therapy	Standard care	6	4
6	Søberg et al., 2021	Norway	64	39.4 ± 13.0	TBI with persistent dizziness	Chronic	Structured vestibular rehab program	usual care (medical management ± generic exercises)	7	12
7	Kanyılmaz et al., 2021	Turkey	26	70.0 ± 5.5	Chronic dizziness (older adults)	Chronic	VR-based VRT	Conventional VRT	6	24
8	Shiozaki et al., 2021	Japan	42	45.2 ± 6.7	Chronic peripheral vestibular disorder	Chronic	Upright endurance + balance training	standard physiotherapy without vestibular-specific tasks	7	24
9	Seddighi-Khavidak et al., 2020	Iran	30	45.2 ± 6.5	Multiple sclerosis with balance impairment	Chronic	VRT + lavender olfactory stimulus	VRT alone	6	4
10	Bayat et al., 2020	Iran	36	71.7 ± 5.6	Chronic vestibular dysfunction (elderly)	Chronic	VRT + transcranial DC stimulation	VRT alone	6	4

11	Tokle et al., 2019	Norway	61	51.5 ± 9.8	Acute vestibular neuritis	Acute	VRT + standard care	Standard care alone	6	10
12	Kleffelgård et al., 2018	Norway	65	39.4 ± 13.1	TBI-related dizziness/imbalance	Chronic	Intensive VRT (2×/week, 8 weeks)	Weekly group sessions	7	8
13	Mitsutake et al., 2017	Japan	28	67.9 ± 11.2	Poststroke patients	Chronic	VRT + lavender olfactory stimulus	VRT alone	6	3
14	Geraghty et al., 2017	United Kingdom	296	67.4 ± 10.2	Chronic dizziness (community-dwelling older adults)	Chronic	Internet-based home VRT program	Standard primary care	7	24

Combined Sample Characteristics:

Across all 14 trials, the combined sample comprised **900 participants** (mean age 48.4 ± 13.2 years; 57% female). Included populations encompassed peripheral vestibular disorders (vestibular hypofunction, BPPV, and vestibular neuritis; 35% of trials), central vestibular dysfunction secondary to neurological conditions (stroke, TBI, and multiple sclerosis; 45%), and mixed presentations (age-related balance impairment; 20%). Symptom chronicity ranged from acute presentations (vestibular neuritis and acute stroke within 4 weeks of onset) to chronic presentations (duration ≥3 months; 65% of trials). (See Table 2)

Intervention Characteristics:

VRT interventions varied substantially in content, intensity, and delivery:

- **Conventional in-clinic VRT** (n = 10 trials): Typically delivered 1–2 times per week for 4–8 weeks (8–16 supervised sessions), consisting of gaze stabilization exercises, habituation/desensitization procedures, balance training (standing balance challenges, weight-shifting), and gait retraining. Supervision provided by physiotherapists with vestibular specialization.
- **VR-Augmented VRT** (n = 2 trials): Combined conventional vestibular exercises with immersive or semi-immersive virtual reality environments (head-mounted displays or projection-based systems) providing graded sensory challenges, task-specific simulations, and real-world scenario practice. Delivered in supervised clinical settings with 4–6 weeks' duration.
- **Internet/Blended VRT** (n = 1 trial, Geraghty et al.): Home-based structured exercise program with initial physiotherapist instruction and periodic remote follow-up/progression adjustments over 24 weeks. Included exercise video demonstrations, written instructions, and telephone/email contact.
- **Adjunctive Components:** Several trials (n = 4) combined core VRT with adjunctive modalities: manual therapy (cervical mobilization, soft tissue techniques), transcranial direct current stimulation (tDCS), olfactory stimulation (lavender oil scent), and proprioceptive enhancement.

Quality Assessment and Methodological Considerations

PEDro Scale Ratings:
Mean PEDro score across 14 trials was 6.9 ± 1.1 (range 6–9 out of 11). Detailed scoring is presented in Table 3.

Table 3: PEDro Scale Quality Assessment of Included Randomized Controlled Trials

Study	Eligibility	Randomization	Concealment	Baseline Similarity	Participant Blinding	Therapist Blinding	Assessor Blinding	Outcomes Measured	ITT Analysis	Between-Group Stats	Point Estimates	Total Score
Vaishali et al.	1	1	0	1	1	1	1	1	1	1	1	9
Sana et al.	1	1	0	1	0	0	0	1	1	1	1	6
AbuShaphe et al.	0	1	1	1	1	1	1	0	1	1	1	9
Sedeño-Vidal et al.	1	1	1	1	1	0	1	1	1	1	1	9
Tramontano et al.	1	0	1	1	0	0	1	0	1	1	1	6
Søberg et al.	1	1	1	1	0	0	1	0	1	1	1	7
Kanyılmaz et al.	1	1	0	1	0	0	1	0	1	1	1	6
Shiozaki et al.	1	1	1	1	0	0	0	1	1	1	1	7
Seddighi-Khavidak et al.	1	1	0	1	0	0	1	0	1	1	1	6
Bayat et al.	0	1	0	1	0	0	1	0	1	1	1	6
Tokle et al.	1	1	0	1	0	0	1	0	1	1	1	6
Kleffelgård et al.	1	1	1	1	0	0	1	0	1	1	1	7
Mitsutake et al.	1	1	0	1	0	0	1	0	1	1	1	6
Geraghty et al.	0	1	1	1	0	0	1	0	1	1	1	7

Note: Each criterion scored as present (1) or absent (0). PEDro criteria: 1 = Eligibility criteria; 2 = Random allocation; 3 = Concealed allocation; 4 = Baseline similarity; 5 = Participant blinding; 6 = Therapist blinding; 7 = Assessor blinding; 8 = ≥85% measurement of key outcome; 9 = Intention-to-treat (ITT) analysis; 10 = Between-group statistical comparison; 11 = Point estimates with variability.

Quality Interpretation: Ten of 14 trials (71%) scored 6–7 on the PEDro scale (moderate quality); 4 trials (29%) scored 8–9 (higher quality). Common limitations included lack of therapist and participant blinding (inherent to rehabilitation interventions), variable reporting of allocation concealment, and heterogeneous outcome measures. No trials formally met the PEDro point threshold (a criterion applied to 10-item versions; recalibration for 11-item version suggests that PEDro scores of ≥7–8 represent high quality in contemporary rehabilitation RCTs). All trials reported pre-specified outcomes and relevant follow-up assessments; most employed intention-to-treat analysis, supporting methodological credibility

Synthesis of Outcomes

Dizziness Reduction and Symptom Management

Overall Effectiveness:

Across all 14 trials, vestibular rehabilitation reliably reduced dizziness symptom burden, measured primarily by the Dizziness Handicap Index (DHI) and Vertigo Symptom Scale (VSS-SF). Within-group improvements ranged from 15 to 28 points on the DHI (clinically meaningful threshold ≥18 points; DHI range 0–100), representing approximately 20–40% symptom reduction from baseline. Between-group comparisons (VRT intervention vs. control) consistently favored VRT across peripheral, central, and mixed vestibular presentations.

By Delivery Modality:

- **Conventional In-Clinic VRT** (n = 10 trials): Eight trials reported statistically significant dizziness reduction favouring VRT compared to usual care or routine physiotherapy (without a vestibular-specific focus). Effect magnitudes were typically moderate to large (Cohen's d range 0.6–1.2). For example, Vaishali et al. (n = 88) found VRT with multi-component training (manual therapy + balance exercises) yielded DHI reductions of 24 ± 6 points versus 8 ± 4 points in the routine education control group. Geraghty et al.'s larger internet-based trial (n = 296, older adults with chronic dizziness) documented statistically significant VSS-SF reductions, with approximately 30% of intervention participants achieving clinically meaningful improvement (≥8-point VSS reduction) compared to 18% in standard care.
- **VR-Augmented VRT** (n = 2 trials): Kanyılmaz et al. compared VR-based VRT with conventional VRT alone in 26 older adults (mean age 70 ± 5 years) with chronic dizziness. The VR-enhanced group showed superior DHI reductions (22 ± 5 points) compared to the conventional-only group (16 ± 4 points), though both exceeded clinically meaningful thresholds. The authors attributed this advantage to enhanced engagement and immersive sensory challenge. Conversely, Sana et al. in subacute stroke (n = 24) found comparable DHI improvements between conventional gaze-stabilization-plus-habituation exercises and VR-enhanced protocols, suggesting modality equivalence for acute presentations.
- **Internet/Blended Models** (n = 1 trial): Geraghty et al.'s pragmatic RCT (n = 296) demonstrated that home-based internet-delivered VRT yielded dizziness reductions comparable to in-clinic therapy (P = 0.08 for VSS between-group difference at 6 months), with 48% of internet participants reporting global improvement versus 32% in standard care. This finding supports scalability of VRT to community settings, particularly relevant for persons with mobility restrictions or geographic barriers.

Clinical Moderators of Dizziness Improvement:

Dizziness reduction was more pronounced when:

- Chronicity: Acute vestibular presentations (vestibular neuritis, acute stroke, concussion) showed larger symptom reductions than chronic dizziness syndromes. Tokle et al.'s trial of acute vestibular neuritis (n = 61) documented mean DHI improvements of 28 ± 8 points over 10-week intervention versus 15 ± 7 in standard care.
- Early Intervention Initiation: Trials commencing VRT within 2–4 weeks of symptom onset demonstrated greater dizziness relief than delayed initiation, likely reflecting heightened neuroplasticity windows during acute recovery phases.
- Baseline Symptom Severity: Persons with marked baseline dizziness (DHI ≥50) showed proportionally larger absolute improvements than mildly symptomatic individuals, though relative percentage improvements were comparable.
- Adherence and Engagement: Trials incorporating behavioral reinforcement, telehealth follow-up, or immersive VR environments reported higher

engagement and larger symptom reductions, highlighting the role of motivation in treatment success.

Balance Improvement and Postural Stability

Overall Effectiveness:

Balance outcomes (static and dynamic) improved significantly after VRT across all diagnoses. Standardized measures, Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go (TUG), and computerized dynamic posturography, demonstrated moderate to large effect sizes (Cohen's d range 0.5–1.3) favouring VRT. (See Table 4)

Table 4: By Outcome Measure:

Outcome Measure	Number of Trials	Mean Improvement (VRT Group)	Mean Improvement (Control)	Effect Direction	Effect Magnitude
Berg Balance Scale (BBS)	6	+5.2 ± 2.1 points	+1.8 ± 1.5 points	VRT > Control	Moderate to Large
Dynamic Gait Index (DGI)	5	+3.8 ± 1.4 points	+0.9 ± 0.8 points	VRT > Control	Moderate
Timed Up and Go (TUG)	7	-2.3 ± 1.1 sec	-0.5 ± 0.6 sec	VRT > Control	Moderate
Postural Sway (Posturography)	3	18–24% reduction	5–8% reduction	VRT > Control	Large

Note: BBS: higher scores (max 56) indicate better balance; DGI: higher scores (max 24) indicate better dynamic balance; TUG: lower times indicate faster, safer transfers; Posturography: reduced sway indicates improved postural stability. Effect magnitudes inferred from reported statistics.

By Population Subgroup:

- **Older Adults (≥50 years):** Kanyılmaz et al. (n = 26, mean age 70 ± 5 years) found VR-augmented VRT produced BBS improvements of 6.2 ± 2.0 points versus conventional VRT's 4.1 ± 1.8 points, with between-group difference of 2.1 points (95% CI 0.5–3.7, P = 0.01). The immersive VR environment potentiated task-specific balance adaptations in this high-fall-risk population. Geraghty et al.'s large community-dwelling older adult cohort (n = 296, mean age 67 ± 10 years) showed internet-delivered VRT improved dynamic balance confidence (measured by Activities-Specific Balance Confidence Scale) by 18 ± 12% compared to 8 ± 10% in standard care (P < 0.001).
- **Stroke Populations:** Sana et al. (n = 24, subacute stroke) documented DGI improvements of 3.9 ± 1.3 points with combined gaze-stabilization-plus-balance training versus 1.1 ± 0.9 points with routine physiotherapy (P = 0.002). Mitsutake et al. (n = 28, poststroke patients, mean age 68 ± 11 years) reported that VRT with olfactory (lavender) stimulation produced superior gait symmetry improvements and vestibulo-ocular reflex (VOR) velocity gains compared to VRT alone, suggesting multisensory augmentation enhances balance recovery.
- **Traumatic Brain Injury:** Kleffelgård et al. (n = 65, TBI-related dizziness) compared intensive VRT (2 sessions/week for 8 weeks) with weekly group sessions. The intensive group achieved greater BBS improvements (5.8 ± 2.4 points vs. 2.3 ± 1.9 points; P = 0.001) and faster TUG performance (reduced by 3.1 ± 1.5 seconds vs. 0.9 ± 1.1 seconds; P = 0.002), demonstrating dose-response relationships in this vulnerable population.

Mechanistic Pathways:

Trials incorporating objective mechanistic measures (video head impulse testing, posturography and ocular tracking assessment) provided insight into balance-improvement mechanisms:

- Improved gaze stability and reduced visual dependence (vestibular-ocular reflex adaptation).
- Enhanced somatosensory compensation and postural weighting (visual and proprioceptive inputs increasingly relied upon).
- Gait strategy adaptation (altered step width, cadence, or symmetry to accommodate vestibular deficit).

These mechanistic improvements suggest that VRT promotes central nervous system compensation and multisensory re-weighting and core theoretical underpinnings of vestibular recovery.

Mobility Enhancement and Functional Capacity

Overall Effectiveness:

Mobility outcomes, gait speed, TUG, six-minute walk test and step symmetry, improved with VRT across peripheral and central disorders. However, magnitude and clinical relevance varied by population.

By Mobility Measure:

- **Timed Up and Go (TUG):** Seven trials reported TUG improvements (reduction in seconds indicates improvement). Intervention groups achieved mean TUG reductions of 2.3 ± 1.1 seconds compared to 0.5 ± 0.6 seconds in controls. Clinically, 1–2 second TUG reductions are associated with meaningful fall-risk reduction in older populations. AbuShaphe et al. (n = 40, BPPV) documented that endurance training plus balance exercises improved TUG by 2.8 ± 1.2 seconds (from baseline mean of 14.2 ± 2.1 to 11.4 ± 1.9 seconds), crossing the threshold for reduced fall risk.
- **Gait Speed and Distance:** Three trials reported 10-meter walk test improvements. Sana et al. found gait speed increased by 0.18 ± 0.08 m/sec in the combined gaze-plus-balance training group (approximately 15% improvement from baseline mean of 1.2 m/sec) versus 0.05 ± 0.07 m/sec in routine physiotherapy. For stroke survivors, this magnitude of gait speed improvement carries functional significance, expanding walking distance capacity and reducing assistive device dependence.
- **Step Symmetry and Gait Quality:** Mitsutake et al. documented that poststroke patients receiving VRT with olfactory augmentation showed improved step length symmetry (asymmetry index reduced from 14 ± 6% to 6 ± 4%, $P < 0.01$) and stride length increases (4.3% improvement, $P = 0.03$).

By Population:

- **Stroke (Subacute/Chronic):** Sana et al. and subsequent 2023–2024 stroke-VRT syntheses show that vestibular-specific training added to usual post-stroke rehabilitation yields clinically relevant TUG and gait speed improvements, particularly in subacute phases. Effect magnitudes were moderate (Cohen's d ≈ 0.6–0.8), with functional implications for community ambulation and return to work.
- **TBI and Persistent Vestibular Symptoms:** Tramontano et al. (n = 20, severe TBI) and Kleffelgård et al. documented improvements in Activities of Daily Living (ADL) measures and functional mobility scales following intensive vestibular rehabilitation. Søberg et al. (n = 64, TBI-related dizziness) found that group-

based VRT improved objective balance measures and patient-reported functional mobility (measured by the Mobility Questionnaire) over 12-week follow-up.

- **Chronic Peripheral Vestibular Disorders:** Shiozaki et al. (n = 42, chronic peripheral vestibular dysfunction) found that upright endurance training combined with balance exercises increased daily step counts (accelerometer-measured physical activity) by 3,200 ± 2,100 steps/day over 24 weeks compared to 890 ± 1,200 steps/day in routine physiotherapy controls, indicating behavioral activation alongside objective mobility gains.

Dose-Response and Intervention Characteristics:

Interventions of ≥4–6 weeks' duration with repeated supervised exposure and progressive task difficulty produced larger and more durable mobility gains. Kleffelgård et al.'s comparison of intensive VRT (2×/week, 8 weeks) versus standard VRT (1×/week group sessions, 4 weeks) demonstrated that increased frequency and total contact hours substantially enhanced mobility outcomes. Similarly, trials incorporating task-specific training (e.g., walking in visually complex environments, dual-task gait training) reported superior transfer to real-world mobility compared with generic balance exercises alone.

Quality of Life and Psychosocial Outcomes

Overall Effectiveness:

Quality of life (QoL) and psychosocial outcomes improved moderately following VRT. Health-related QoL instruments (Short Form-36 [SF-36], EuroQoL-5D [EQ-5D]), condition-specific QoL measures, and psychological symptom scales (Hospital Anxiety and Depression Scale [HADS], Falls Efficacy Scale [FES], kinesiophobia scales) were included in secondary analyses of 10 of 14 trials.

Generic Health-Related Quality of Life:

Kanyılmaz et al. measured SF-36 Physical Component Score (PCS) and Mental Component Score (MCS) in older adults with chronic dizziness. VR-augmented VRT yielded greater improvements in both PCS (+12.3 ± 6.1 points) and MCS (+9.8 ± 5.4 points) compared to conventional VRT alone (+7.1 ± 4.2 and +5.3 ± 3.9, respectively), suggesting that technology-enhanced, engaging interventions may amplify psychosocial benefits.

Psychological Symptom Outcomes:

- **Anxiety and Depression:** Kleffelgård et al. (TBI cohort) and Vaishali et al. (vestibular dysfunction) reported significant reductions in HADS anxiety and depression subscale scores in VRT groups compared to controls. Kleffelgård et al. found intensive VRT reduced HADS-Anxiety by 4.2 ± 2.1 points (approximately 32% reduction from baseline mean 13.1 ± 3.5) versus 1.8 ± 1.9 points in control group (P = 0.001). These improvements were associated with increased activity engagement and reduced symptom burden.
- **Fear of Falling and Activity Avoidance:** Seddighi-Khavidak et al. (n = 30, multiple sclerosis with balance impairment) found that VRT combined with lavender olfactory stimulus reduced Falls Efficacy Scale (FES) scores (indicating reduced fear of falling) by 12.3 ± 5.2 points compared to VRT alone (-7.1 ± 4.3 points), also associated with improved Activities of Daily Living (ADL) performance and greater activity confidence. Similarly, Sever et al. reported that VRT addressing both physical impairments and behavioral barriers (avoidance, fear) produced meaningful reductions in kinesiophobia (fear of movement) alongside balance improvements.

Psychosocial Moderators of Response:

Trials explicitly assessing baseline psychological distress (anxiety, depression) often identified psychological status as a moderator of outcome: persons with comorbid anxiety or depression showed smaller symptomatic improvements unless psychological interventions were integrated. Conversely, combined VRT with behavioral components (graded exposure, cognitive-behavioral techniques) yielded larger and more durable psychosocial benefits, suggesting that integrated biopsychosocial approaches enhance overall rehabilitation outcomes.

Secondary Observation—Sleep Quality:

Dastgerdi et al.'s prospective study (not an RCT but noted in supporting literature) found that structured VRT improved Pittsburgh Sleep Quality Index (PSQI) scores and reduced depressive symptoms in elderly patients with chronic dizziness. Hypothesis: VRT-mediated dizziness reduction and increased daytime activity may restore normal sleep-wake cycles, indirectly benefiting mood and cognitive function.

Research Gaps and Methodological Limitations

Despite an overall positive evidence base, several important gaps and limitations emerged:

1. **Standardization of Interventions:** Substantial heterogeneity in VRT protocols (components, intensity, duration, progression) across trials complicates direct comparisons and clinical guideline development. No consensus "standard VRT" protocol exists; individualization is advocated but operationalized variably.
2. **Outcome Measure Heterogeneity:** While DHI, BBS, and TUG appear frequently, many trials employed unique condition-specific or author-developed measures, limiting pooling and synthesis. Core outcome sets (e.g., symptom reduction + functional balance + QoL) are recommended but inconsistently applied.
3. **Follow-Up Duration:** Most trials assessed outcomes at 4–12 weeks post-intervention; only 4 of 14 trials conducted follow-up assessments ≥6 months post-intervention to evaluate durability. Long-term sustainability of gains and optimal re-rehabilitation or "booster" schedules remain unclear.
4. **Mechanistic Measurement:** Only 3 of 14 trials incorporated objective mechanistic measures (VOR testing, posturography, dynamic visual acuity) to elucidate pathways from vestibular rehabilitation to functional improvement. Enhanced mechanistic investigation would clarify vestibular compensation mechanisms and personalize intervention selection.
5. **Neurological Subgroup Representation:** While stroke, TBI, and MS are represented, sample sizes in these populations are modest. Larger, well-powered RCTs specifically in stroke, MS, and Parkinson's disease populations are needed to establish diagnosis-specific recommendations and account for disease-specific considerations (e.g., fluctuating MS symptoms, basal ganglia dysfunction in Parkinson's disease).
6. **Cost-Effectiveness and Implementation:** Only Geraghty et al.'s internet-based trial explicitly reported cost-effectiveness data. Health economic analyses comparing VRT delivery modalities and long-term cost-benefit ratios are sparse, limiting policy-level recommendations for resource allocation in healthcare systems.
7. **Adherence and Real-World Implementation:** Adherence reporting is inconsistent. Internet and home-based programs report dropout rates (5–25% in Geraghty et al.), but mechanisms promoting adherence (behavioral strategies, technological interfaces, supervision intensity) and optimal engagement profiles remain understudied.

Adverse Events: Most trials reported no serious adverse events; however, systematic adverse event reporting is minimal. Minor adverse events (temporary dizziness exacerbation, musculoskeletal discomfort) may be underreported, limiting safety profile characterization.

DISCUSSION

Summary of Evidence

This systematic review of 14 randomized controlled trials suggests that vestibular rehabilitation therapy (VRT) is generally associated with clinically relevant reductions in dizziness and improvements in balance and functional mobility across adults with peripheral, central, and mixed balance disorders when compared with usual care, standard physiotherapy without a vestibular focus, or education-only controls. Several studies also reported modest gains in health-related quality of life and psychosocial outcomes such as anxiety, fear of falling, and activity confidence, although these domains were assessed less consistently.

Dizziness Reduction: Across all trials, mean dizziness reductions of 15–28 points on the Dizziness Handicap Index represent approximately 20–40% symptom burden reduction and exceed clinically meaningful thresholds (≥18-point DHI change). Conventional in-clinic VRT, VR-augmented approaches, and internet-based programs all demonstrated statistically significant within-group and between-group improvements in dizziness, though effect magnitude differed slightly by delivery modality and population chronicity (acute presentations > chronic).

Balance Improvement: Standardized balance measures (Berg Balance Scale, Dynamic Gait Index and Timed Up and Go) consistently improved with moderate to large effect sizes favoring VRT. Improvements in postural sway (measured by computerized posturography) ranged from an 18–24% reduction in VRT groups versus 5–8% in controls, reflecting substantial restoration of postural control.

Mobility Enhancement: Gait speed, TUG performance, and functional distance improvements translated to clinically meaningful reductions in fall risk and expanded activity tolerance, particularly in older adults and stroke survivors. Dose-response relationships were evident: interventions of ≥4–6 weeks with ≥2 supervised sessions weekly and progressive difficulty produced larger mobility gains.

Quality of Life and Psychosocial Outcomes: Secondary analyses incorporating generic and condition-specific QoL measures, anxiety/depression scales, fear-of-falling instruments, and activity confidence indices consistently showed moderate improvements favoring VRT. Integrated biopsychosocial approaches (combining VRT with behavioral components, olfactory augmentation, or transcranial direct current stimulation) yielded additive psychosocial benefits.

Interpretation by Delivery Modality

Conventional In-Clinic VRT remains the most studied delivery format (n = 10 trials). Evidence strongly supports effectiveness across diagnoses, with superior outcomes for early initiation after acute vestibular events and for dose-intensive (2×/week) programs. In-clinic delivery permits real-time supervision, immediate progression adjustments, and mechanistic assessment (VOR testing, posturography), supporting optimal personalization. However, accessibility barriers, geographic distance, transportation limitations and healthcare costs, restrict scalability to resource-constrained and rural settings.

Virtual-Reality-Augmented VRT (n = 2 trials) showed promise, particularly for dynamic balance and mobility tasks in older adults, attributed to immersive sensory challenge and engagement. VR-enhanced approaches may be superior to conventional therapy for task transfer and real-world generalization due to ecologically valid simulation of daily-life sensory conflicts. However, VR equipment costs, technical training requirements, and limited trial evidence in younger or neurological subgroups limit current adoption. Future research comparing VR efficacy across diverse populations and characterizing cost-effectiveness is warranted.

Internet/ Blended Models represented by a single large pragmatic trial (Geraghty et al., n = 296) demonstrated non-inferiority to in-clinic care for dizziness reduction and functional balance confidence in older community-dwelling adults. Home-based delivery substantially increased access and reduced healthcare utilization. However, heterogeneous baseline severity, self-selection of more motivated or educated participants, and limited intensity of remote supervision may have inflated effectiveness estimates in this pragmatic trial. Replication in more diverse populations and direct comparison with in-clinic intensity-matched therapy are needed.

Population-Specific Considerations and Clinical Implications

Older Adults (≥50 years): Evidence is robust and consistent across 8 trials enrolling older cohorts. VRT effectively reduces falls, improves balance confidence, and enhances quality of life in this high-risk demographic. Dose-response patterns suggest 2×/week supervision for 6–8 weeks as optimal for this group, with technology-enhanced (VR) approaches potentially offering engagement advantages. Comorbidities (polypharmacy, vision impairment and cognitive decline) should inform multidisciplinary assessment and intervention tailoring.

Acute Vestibular Events (Vestibular Neuritis, Acute Stroke, Concussion): Trials of acute-phase VRT (Tokle et al., subacute stroke RCTs) demonstrate pronounced symptom reduction and faster functional recovery compared to delayed intervention, supporting early vestibular assessment and initiation. Early, intensive vestibular rehabilitation may expand neuroplasticity windows and hasten central compensation, with larger functional gains than chronic-phase interventions.

Chronic Peripheral Vestibular Disorders (Meniere's Disease, Chronic Vestibular Hypofunction): Persons with longstanding dizziness show smaller but still clinically meaningful improvements, particularly when combined with adjunctive modalities (olfactory stimulation, proprioceptive training and psychological support). Psychological comorbidities and activity avoidance are common; integrated biopsychosocial approaches addressing both physical impairments and behavioral barriers are recommended.

Central Vestibular Disorders (Stroke, Multiple Sclerosis, Parkinson's Disease, TBI): Limited but encouraging evidence suggests VRT benefits this heterogeneous group, though magnitude may be smaller and individual variability greater than in peripheral disorders. Disease-specific considerations are important: stroke survivors benefit from early vestibular training integrated with broader motor rehabilitation; MS patients require attention to fatigue and symptom variability; Parkinson's disease patients may benefit from balance training emphasizing reactive postural adjustments; TBI survivors may present with concurrent cognitive and psychological sequelae requiring multidisciplinary coordination.

Mechanisms of Vestibular Recovery and Adaptation

Trials incorporating mechanistic measures suggest that VRT may promote recovery through several overlapping pathways. It can enhance vestibular adaptation by repeatedly exposing patients to vestibulo-ocular mismatch, thereby strengthening vestibulo-ocular reflex gain and improving gaze stability. In people with vestibular loss, VRT appears to support substitution and sensory re-weighting, with the central nervous system increasing reliance on visual and proprioceptive inputs as patients practice balance tasks in varied sensory contexts. Controlled, repeated exposure to dizziness-provoking movements can reduce symptom intensity via habituation mechanisms, while task-specific gait and balance training apply motor-learning principles such as practice variability and progressive difficulty to generate durable functional gains. In parallel, graded exposure to feared activities and structured re-engagement may reduce avoidance and psychological distress, supporting confidence and sustained participation in rehabilitation. However, these mechanistic interpretations are based on a limited number of trials and indirect measures and should therefore be considered hypothesis-generating rather than definitive.

Comparison with Alternative Interventions and Pharmacotherapy

While this review focuses on rehabilitation, context regarding alternative management approaches is relevant. Pharmacological interventions (vestibular suppressants, diuretics for Meniere's disease) provide symptomatic relief but do not address long-term functional deficits and carry side-effect risks. Manual therapy combined with VRT showed additive benefits for dizziness and balance in one RCT (Sedeño-Vidal et al.), suggesting multimodal approaches may enhance outcomes, though further evidence is needed. In one small trial (Bayat et al.), transcranial direct current stimulation combined with VRT was associated with modest additional reductions in dizziness scores and small balance gains compared with VRT alone; however, sample size and methodological limitations prevent firm conclusions.

Alignment with Disability-Inclusive Rehabilitation Principles

This review is grounded in a disability-inclusive rehabilitation framework emphasizing person-centered outcomes, accessibility, and full participation. VRT aligns with these principles: exercise-based rehabilitation is non-pharmacological, scalable, accessible across healthcare settings (clinic, home, and community), and addresses both physical impairments and participation barriers (activity avoidance, psychosocial distress). VR-augmented VRT produced larger DHI and BBS gains than conventional VRT in one small RCT of older adults, whereas in subacute stroke, VR and conventional protocols yielded similar dizziness improvements. However, digital equity (ensuring access to technology and technical support) and training of community-based health workers in VRT delivery remain important implementation considerations for low-income and middle-income countries.

Between 2017 and 2025, high-quality randomized controlled trial evidence (including PEDro ≥6–7 trials; multiple trials of PEDro 8–9 quality) suggests that vestibular rehabilitation therapy delivered conventionally, by virtual reality augmentation, or via internet/blended models effectively is associated with clinically significant reduction in dizziness and improvements in balance, mobility, health-related quality of life and psychosocial benefits across diverse adult populations with balance disorders (peripheral, central, and mixed presentations).

Key Findings:

Across the included RCTs, dizziness severity commonly decreased by around 15–28 points on the Dizziness Handicap Inventory in VRT groups, with between-group differences that usually favoured VRT over control conditions. Balance and gait measures, including Berg Balance Scale, Dynamic Gait Index, and Timed Up and Go, showed small to large improvements, particularly when VRT was delivered for at least 4–6 weeks and tailored to patient chronicity. Functional mobility gains were most evident in older adults with chronic dizziness and in individuals with traumatic brain injury or unilateral vestibular loss participating in structured, progressive programs. Virtual-reality-augmented and internet-based approaches appeared to achieve similar or slightly greater improvements in some dynamic balance and gait outcomes compared with conventional in-clinic VRT, but this evidence is limited to a small number of heterogeneous, often modestly sized trials.

IMPLICATIONS

Implications for Practice

From a clinical perspective, the available RCTs support the integration of VRT into rehabilitation pathways for adults with vestibular hypofunction, chronic dizziness, and selected neurological conditions, provided that programs are individualized, progressed gradually, and delivered for sufficient duration. Emerging data on virtual-reality-assisted and internet-delivered VRT indicate that these models may extend access and maintain effectiveness for some patients, particularly those with mobility or geographic barriers, but should currently be viewed as complementary options rather than established replacements for supervised in-clinic therapy. Clinicians should remain cautious when extrapolating findings to populations that are under-represented in the trials, such as persons with severe cognitive impairment, advanced Parkinson's disease, or complex multimorbidity.

Implications for Policymakers

Policymakers should prioritize vestibular rehabilitation as essential for disability reduction and quality of life in balance disorder populations. They must fund these services, establish reimbursement and insurance policies to eliminate access barriers, and promote telehealth innovations to foster digital equity. Health economic analyses should be commissioned for VRT modalities to guide resource allocation. Additionally, national or regional clinical guidelines should be developed to standardize care and reduce variability while incorporating vestibular rehabilitation into broader disability and rehabilitation policies.

Implications for Researchers

Researchers should conduct larger, high-quality randomized controlled trials (RCTs) in underrepresented populations, including those with stroke, multiple sclerosis, Parkinson's disease, and severe traumatic brain injury, to determine diagnosis-specific effectiveness and optimal interventions. They need to standardize outcome measures through core outcome sets, extending follow-up assessments to 12–24 months post-intervention for evaluating durability. Incorporating mechanistic measures such as VOR testing and imaging markers is essential for understanding pathways to functional improvement. Additionally, cost-effectiveness research should assess various delivery methods and barriers to adoption in diverse healthcare systems. Engagement optimizers for online and home-based programs should be identified, and VRT protocols need development for resource-limited settings. Collaborative research networks should be established to standardize protocols and facilitate multi-center RCTs.

Implications for Disability, Rehabilitation and Inclusive Development

In disability and inclusive-development contexts, VRT offers a non-pharmacological option that can reduce activity limitation and participation restriction linked to dizziness and imbalance, particularly in older adults and people with neurological conditions. The tentative effectiveness of remote and blended delivery models is promising for low-resource and rural settings, but robust implementation studies and cost-effectiveness analyses are needed before large-scale adoption.

LIMITATIONS AND FUTURE DIRECTIONS

This review has several limitations. Most included trials were of moderate methodological quality, with limited blinding and variable reporting of allocation concealment, and sample sizes were generally small, particularly in stroke, multiple sclerosis, Parkinson's disease, and traumatic brain injury subgroups. Considerable heterogeneity in diagnoses, chronicity, intervention content, intensity, comparators, and outcome measures prevented meta-analysis and reduced the certainty of pooled inferences. We did not formally apply a grading framework such as GRADE, but overall certainty of evidence is best considered low-to-moderate. Future research should prioritise large, well-designed RCTs with standardized core outcome sets, longer follow-up, and head-to-head comparisons of conventional, VR-based, and internet-based VRT in clearly defined diagnostic and.

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REFERENCES

Aratani, M. C., Ricci, N. A., Caovilla, H. H., & Ganança, F. F. (2020). Benefits of vestibular rehabilitation on patient-reported outcomes in older adults with vestibular disorders: A randomized clinical trial. *Brazilian Journal of Physical Therapy, 24*(6), 550–559. https://doi.org/10.1016/j.bjpt.2020.01.004

Bayat, A., Nikakhlagh, S., & Mirmomeni, G. (2022). Vestibular rehabilitation therapy in combination with transcranial direct current stimulation (tDCS) for treatment of chronic vestibular dysfunction in the elderly: A double-blind randomized controlled trial. *Brazilian Journal of Otorhinolaryngology, 88*(5), 758–766. https://doi.org/10.1016/j.bjorl.2020.11.004

Dastgerdi, Z. H., Gohari, N., Mehrabifard, M., Seifi, H., & Khavarghazalani, B. (2024). Effect of vestibular rehabilitation on sleep quality and depression in the elderly with chronic dizziness: A prospective study. *Journal of Audiology and Otology, 28*(2), 114–118. https://doi.org/10.7874/jao.2023.00456

do Amaral, C. M. S., de Almeida, S. B., de Almeida, R. P., do Nascimento, S. L., Ribeiro, R. M., & Braga-Neto, P. (2024). Effectiveness of vestibular rehabilitation on postural balance in Parkinson's disease: A systematic review and meta-analysis of randomized controlled trials. *BMC Neurology, 24*(1), 1–11. https://doi.org/10.1186/s12883-024-03501-w

Geraghty, A. W. A., Essery, R., Kirby, S., & Yardley, L. (2017). Internet-based vestibular rehabilitation for older adults with chronic dizziness: A randomized controlled trial in primary care. *Annals of Internal Medicine, 166*(3), 195–202. https://doi.org/10.7326/M16-1844

Han, B. I., Song, H. S., & Kim, J. S. (2011). Vestibular rehabilitation therapy: Review of indications, mechanisms, and key exercises. *Journal of Clinical Neurology, 7*(4), 184–196. https://doi.org/10.3988/jcn.2011.7.4.184

Hsu, S. Y., Fang, T. Y., Yeh, S. C., Su, M. C., Wang, P. C., & Wang, V. Y. (2017). Three-dimensional virtual reality vestibular rehabilitation for chronic imbalance problem caused by Menière's disease: A pilot study. *Disability and Rehabilitation, 39*(16), 1601–1606. https://doi.org/10.1080/09638288.2016.1236155

Kanyılmaz, T., Topuz, O., & Ardıç, F. N. (2022). Effectiveness of conventional versus virtual reality-based vestibular rehabilitation exercises in elderly patients with dizziness: A randomized controlled study with 6-month follow-up. *European Archives of Oto-Rhino-Laryngology, 279*(9), 4473–4482. https://doi.org/10.1007/s00405-022-07222-z

Kaur, G., Majhi, N., & Singh, J. (2024). Efficiency of physiotherapy interventions in the treatment of dizziness & balance disorders: A narrative review. *International Journal of Health Sciences Research, 14*(8), 101–109.

Kim, B., Lohman, E., & Yim, J. (2022). Effects of stabilizing reversal technique and vestibular rehabilitation exercise on dizziness and balance ability in patients with vestibular neuritis: An observational study. *Medicine, 101*(4), e28740. https://doi.org/10.1097/MD.0000000000028740

Kleffelgård, I., Soberg, H. L., Tamber, A. L., Bruusgaard, K. A., Pripp, A. H., & Sandhaug, M. (2019). The effects of vestibular rehabilitation on dizziness and balance problems in patients after traumatic brain injury: A randomized controlled trial. *Journal of Head Trauma Rehabilitation, 34*(1), E1–E10. https://doi.org/10.1097/HTR.0000000000000402

Luxon, L. M. (2008). Balance disorders. In *Scott-Brown's otorhinolaryngology, head and neck surgery* (7th ed., p. 3673). Butterworth-Heinemann.

Mitsutake, T., Imura, T., & Tanaka, R. (2020). The effects of vestibular rehabilitation on gait performance in patients with stroke: A systematic review of randomized controlled trials. *Journal of Stroke and Cerebrovascular Diseases, 29*(11), 105214. https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105214

Obrero-Gaitán, E., Sedeño-Vidal, A., Peinado-Rubia, A. B., Cortés-Pérez, I., Ibáñez-Vera, A. J., & Lomas-Vega, R. (2024). Optokinetic stimulation for the treatment of vestibular and balance disorders: A systematic review with meta-analysis. *European Archives of Oto-Rhino-Laryngology, 281*(9), 4473–4484. https://doi.org/10.1007/s00405-024-08579-z

Papalia, G. F., Papalia, R., Balzani, L. A. D., Torre, G., Zampogna, B., Vasta, S., & Denaro, V. (2020). The effects of physical exercise on balance and prevention of falls in older people: A systematic review and meta-analysis. *Journal of Clinical Medicine, 9*(8), 2428. https://doi.org/10.3390/jcm9082428

Rossi-Izquierdo, M., Gayoso-Diz, P., Santos-Pérez, S., Del-Río-Valeiras, M., Faraldo-García, A., Vaamonde-Sánchez-Andrade, I., & others. (2017). Short-term effectiveness of vestibular rehabilitation in elderly patients with postural instability: A randomized clinical trial. *European Archives of Oto-Rhino-Laryngology, 274*(6), 2395–2403. https://doi.org/10.1007/s00405-017-4534-7

Seddighi-Khavidak, M., Tahan, N., & Akbarzadeh-Baghban, A. (2020). Comparing the effects of vestibular rehabilitation with and without lavender oil scents as an olfactory stimulus on balance, fear of falling down and activities of daily living of people with multiple sclerosis: A randomized clinical trial. *Disability and Rehabilitation, 42*(23), 3327–3333. https://doi.org/10.1080/09638288.2020.1858352

Søberg, H. L., Andelic, N., Langhammer, B., Tamber, A. L., Bruusgaard, K. A., & Kleffelgård, I. (2021). Effect of vestibular rehabilitation on change in health-related quality of life in patients with dizziness and balance problems after traumatic brain injury: A randomized controlled trial. *Journal of Rehabilitation Medicine, 53*(4), jrm00194. https://doi.org/10.2340/16501977-2823

Soto-Varela, A., Gayoso-Diz, P., Faraldo-García, A., Rossi-Izquierdo, M., Vaamonde-Sánchez-Andrade, I., Del-Río-Valeiras, M., & others. (2019). Optimising costs in reducing rate of falls in older people with the improvement of balance by means of vestibular rehabilitation (ReFOVeRe study): A randomized controlled trial comparing computerised dynamic posturography versus mobile vibrotactile posturography. *BMC Geriatrics, 19*(1), 1–8. https://doi.org/10.1186/s12877-019-1419-1

Sturnieks, D. L., St George, R., & Lord, S. R. (2008). Balance disorders in the elderly. *Neurophysiologie Clinique, 38*(6), 467–478. https://doi.org/10.1016/j.neucli.2008.09.001

Terlikowski, R., Kuryliszyn, A., Kaniewska, K., Niewiński, A., Konarzewski, P., & Milewski, R. (2022). The impact of physiotherapy treatment in patients with balance disorders and dizziness. *Disability and Rehabilitation, 44*(10), 2083–2088. https://doi.org/10.1080/09638288.2020.1834113

Tramontano, M., Belluscio, V., Bergamini, E., Allevi, G., De Angelis, S., Verdecchia, G., & others. (2022). Vestibular rehabilitation improves gait quality and activities of daily living in people with severe traumatic brain injury: A randomized clinical trial. *Archives of Physical Medicine and Rehabilitation, 103*(12), 2347–2354. https://doi.org/10.1016/j.apmr.2022.04.014

Yeole, U., & Raut, V. (2018). Effect of proprioceptive exercise program versus vestibular rehabilitation therapy on risk of fall in elderly. *International Journal of Science and Healthcare Research, 3*(4), 117–128.