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THE ROLE OF VESTIBULAR REHABILITATION ON BALANCE AND FALL FREQUENCY AMONG POST-STROKE PATIENTS: EVIDENCE FROM A SYSTEMATIC REVIEW

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ABSTRACT

Background: Individuals recovering from a stroke experience gait and posture instability, leading to imbalance and increased fall risk. These significantly affect independence and quality of life. Vestibular rehabilitation (VR) has emerged as a promising adjunct therapy, yet its role among post-stroke patients remains insufficiently clarified.

Objective: Systematically reviewing randomized controlled trials (RCTs) investigating the effects of vestibular rehabilitation on balance and fall frequency in post-stroke individuals.

Methods: A systematic search performed in PubMed, PEDro, Cochrane Library, EMBASE, Scopus, Web of Science, ScienceDirect, ClinicalTrials.gov, and WHO ICTRP registry for publications between January 2013 and May 2025. Only RCTs with adult stroke who received vestibular rehabilitation were included 8. Methodological appraisal was done with Physiotherapy Evidence Database (PEDro) and PRISMA 2020 statement guided reporting.

Results: Ninety records were identified after removing three duplicates, 87 records were screened, 20 full-text articles were assessed, eight RCTs were included (n = 306). Interventions involved gaze-stabilization, oculomotor, and combined vestibular exercise for durations of 3–8 weeks. Berg Balance Scale, Mini-BEST test, Functional Gait Assessment and Timed Up and Go, Dynamic Gait Index improved in most studies. Only one study noted fewer falls and reduced fall risk 3. PEDro scores 6–8, suggesting moderate-to-high quality.

Conclusion: Vestibular rehabilitation has significant benefits in enhancing balance and gait performance among post-stroke individuals. Evidence supports its integration into conventional stroke physiotherapy programs, with growing indications of its potential to reduce fall risk. However, the heterogeneity in intervention protocols, small sample sizes, and short follow-up restrict generalizability. Future studies should prioritize standardized VR protocols, larger multicentre trials, and consistent reporting of fall-related outcomes to enhance clinical applicability.

Keywords: vestibular rehabilitation, stroke, balance, gait, falls, systematic review.

INTRODUCTION:

Stroke continues to be among the major causes of long-term disability across the globe, commonly leading to motor, sensory, and cognitive impairments. Of these, balance dysfunction is a highly disabling outcome, and it accounts for a considerable proportion of mobility impairment and an increased risk of falls. Vestibular dysfunction, dizziness, and postural control impairment are common in post-stroke patients, and they may

compromise recovery and make them more dependent. Stroke patients are at high risk for falls throughout their lives at all stages, and balance and gait deficits play an important role in falls [16].
Standard rehabilitation protocols focus mainly on strength training and motor recovery. But growing evidence indicates that vestibular dysfunction is a factor in balance deficits after stroke, and that focused vestibular rehabilitation can improve outcomes over standard therapy. Vestibular rehabilitation therapy (VRT) includes exercises to enhance gaze stabilization, postural control, and neural adaptation via mechanisms of habituation, substitution, and adaptation. These mechanisms might enable central nervous system compensation for vestibular deficits and result in better balance and a decrease in the frequency of falls
In light of increasing popularity in VRT, the evidence for its effectiveness in post-stroke populations has remained mixed. While some studies document remarkable changes in balance and gait performance, others are characterised by limited or mixed findings. This difference highlights the importance of reviewing the current literature.

Thus, this systematic review is intended to consolidate the current evidence on the effectiveness of vestibular rehabilitation in enhancing balance and decreasing the frequency of falls in post-stroke patients. Knowledge about the efficacy of VRT can inform clinical practice and direct the development of more specific rehabilitation interventions for this group.

While many systematic reviews have examined the vestibular rehabilitation effects on balance and walking or muscle strength and walking in patients with stroke, little evidence has specifically addressed its impact on balance and fall rate. This is an important area to close, given that falls are one of the most disabling and avoidable complications after a stroke.
There is robust evidence supporting vestibular rehabilitation (VR) in peripheral vestibular disease, but limited evidence for its efficacy after central lesions like stroke. Early trials have demonstrated promising effects on postural control and dizziness improvement, though sample sizes are small and designs are heterogeneous.

A prior systematic review by Mitsutake et al. (2020) had indicated the possibility of vestibular or gaze-stabilization training programs enhancing gait and functional mobility after stroke, although the quality of evidence was graded as low [8]. Several new RCTs with better designs have since been released. A renewed synthesis is thus required to ascertain current evidence for the impact of VR on balance and outcomes of falls after stroke.
The present review thus sought to:
1. Search and consolidate RCTs that study vestibular rehabilitation in patients with stroke.
2. Consider its influence on balance and incidence of falls.
3. Evaluate methodological quality based on PEDro scale and report evidence based on PRISMA 2020.

METHODS

Study Design

The review was carried out according to PRISMA guidelines (Preferred Reporting Items for systematic review and meta-analysis). And registered in PROSPERO (ID: CRD420251171168).

Inclusion criteria

1. Patients with any form of stroke (ischemic or hemorrhagic), any phase (acute, sub-acute, chronic).
2. Adults age group >18 years
3. Stroke patient with balance impairment, postural instability, or vestibular dysfunction
4. Vestibular rehabilitation is the main treatment of any other adjunctive intervention
5. Vestibular rehabilitation exercises consisted of gaze stabilization, habituation, postural control or balance retraining,
6. Comparison with any kind of intervention or no interventions, or usual care.
7. Outcome measurements: Berg balance scale, postural assessment scale of stroke or equivalent, frequency of fall, risk of fall, postural sway or gait stability measures of fall risk
8. Randomized controlled trials.
9. Language – English language studies
10. A systematic search was done in major databases, which are PubMed, Scopus, Web of Science, and Science Direct, published from 2013 to 2025.

Exclusion criteria

1. Non-randomized studies, study designs or quasi-experimental designs, case reports, case series, observation studies, reviews, conference abstracts or unpublished theses.
2. Studies in non-stroke patients with balance impairment. Balance impairment unrelated to stroke.
3. Non-vestibular rehabilitation as a treatment
4. Outcome measures not measuring balance and fall risk or frequency as an outcome measure.
5. Articles written in languages other than English
6. Articles published beyond the year 2013 – 2025
7. Not accessible in full-text articles.

INFORMATION SOURCES AND SEARCH STRATEGY

Databases searched: PubMed, PEDro, Cochrane Library, EMBASE, Scopus, Web of Science, Science Direct, Trial registries: ClinicalTrials.gov and WHO ICTRP.

Search conducted using the keywords "Vestibular rehabilitation" OR "gaze stabilization" OR "oculomotor training "AND stroke OR "cerebrovascular accident" OR "post-stroke" AND balance OR falls AND randomized controlled trial

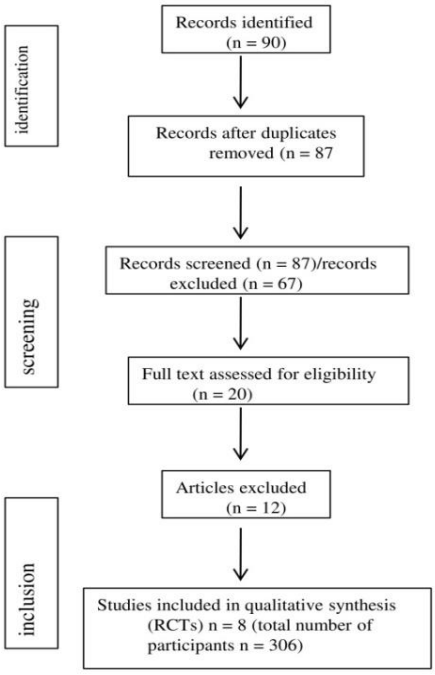
STUDY SELECTION

All references were transferred into Rayyan for the removal of duplicates and screening. Titles and abstracts were screened independently by two reviewers; discrepancies were resolved through discussion.

Study Selection

Ninety studies were retrieved; after screening and eligibility review, eight RCTs met the inclusion criteria (n = 306).

PRISMA 2020 guidelines flow chart



DATA EXTRACTION

A uniform sheet documented study features, interventions, comparators, duration, outcomes, and key results.

Quality Assessment

Methodological quality was evaluated with the PEDro scale (0–10). Scores ≥ 8 = high, 5–7 = moderate, ≤ 4 = low quality.

Data Synthesis

Due to heterogeneity in types of interventions and outcome measures, data were synthesized narratively.

Ethical Considerations

All trials included had institutional ethical approval. No new patient data were obtained.

Table 1. Summary of Included Randomized Controlled Trials

Author (Year)	Country	Sample (n)	Intervention Type	Control group treatment	Duration	Key Outcomes	Main Findings
Saleem et al., 2019 [1]	India	30(15 + 15)	VR vs Dual Task	Dual task training	4 w, 45 mins, 3 times in a week	Mini-BEST, WGS	VR > Dual Task ($p<0.05$) for balance and gait.
Zhao et al., 2022 [2]	China	40	Gaze Stabilization + Physiotherapy	Conventional Physiotherapy	4 w, 5 days a week	BBS, TUG, COP	Improved gait and balance ($p<0.05$).
Correia et al., 2020 [3]	Portugal	68	Home occulomotor exercises	Control	3 w	BBS, TUG, falls	Reduced falls (0 vs 4); BBS improves.
Sana et al., 2023 [4]	Pakistan	34	VR vs Virtual Reality	—	8 w, 3 sessions per week	DHI, DGI, TUG	Both improved; VR was better for dizziness; VR < VR-Reality for gait.
Dai et al., 2013 [5]	China	48	VR + caregiver	Conventional rehab	4 w	ADL, BBS	Significant improvement in balance and ADL.
Tramontano et al., 2018 [6]	Italy	25	Custom VR	Concventional rehab	4 w, 2 times a week,	10MWT, stride	Improved gait speed and stability.
Balci et al., 2013 [7]	Turkey	25	VR vs Posturography vs Home Ex	Home Ex	6 w	BBS, TUG, DGI	All groups improved; no sig. difference.
Varshini et al., 2025 [14]	India	36	VR vs Core stability exercises	Core stability exercises	8 weeks, 2 sessions per day for twice a week	SCP, PASS	Reduce pushing, and enhance ADL

BBS – Berg Balance Scale, TUG – Time Up and Go test, DGI – Dynamic Gait Index, ADL –Activities of Daily living, Mini-BEST – Mini Balance Evaluation Systems Test, FGA – Functional Gait Assessment, COP – Center of Pressure, PASS – Postural Assessment Scale for Stroke, SCP – Scale for Contraversive Pushing, DHI – Dizziness Handicap Inventory.

RESULTS

Study Selection

Ninety studies were found; eight RCTs qualified on inclusion after screening and review for eligibility (n = 306).

Effects of Vestibular Rehabilitation

Across the trials, balance outcomes were significantly improved in 8 of 8 trials. Gains were noted on the BBS, Mini-BEST, and FGA, usually exceeding the minimal clinically important differences. Frequency or risk of falls decreased in 3 trials, especially those that had oculomotor or dual-task home-based components.

Table 2. PEDro Quality Appraisal

Study	Randomization	Concealment	Blinding	ITT	Score /10	Quality
Saleem et al., 2019 [1]	✓	✗	✗	✓	7	Moderate
Zhao et al., 2022 [2]	✓	✓	✗	✓	8	High
Correia et al., 2020 [3]	✓	✓	✗	✓	8	High
Sana et al., 2023 [4]	✓	✗	✗	✓	6	Moderate
Dai et al., 2013 [5]	✓	✗	✗	✓	6	Moderate
Tramontano et al.,2018 [6]	✓	✓	✗	✓	7	Moderate
Balci et al., 2013 [7]	✓	✗	✗	✓	6	Moderate
Varshini et al., 2025 [14]	✓	✗	✗	✓	7	Moderate

Quality Summary

PEDro scores 6–8 represent moderate-to-high quality. The majority of studies had no participant blinding because of exercise-based designs, but outcome measures were standardized and low levels of attrition.

DISCUSSION

This systematic review of eight RCTs investigating vestibular rehabilitation for post-stroke balance and fall outcomes found that most showed significant improvement in balance and functional mobility compared to usual care or control interventions. These results are in keeping with previous evidence that VR is able to activate central adaptation processes, which improve sensory integration and stability following neurological damage. The following researchers explained this in the following way: repeated repetition of gaze-stabilization and head-movement exercises facilitates recalibration of the vestibulo-ocular and vestibulospinal reflexes, improving sensory integration and postural control (Herdman & Clendaniel, 2014) [9] (Cullen, 2019) [10]. Functional imaging research proves reorganization in the cortex and cerebellum during vestibular compensation to indicate support for neuroplastic processes supporting functional recovery (**McGarvie LA, MacDougall HG**, 2020), [11] (Popp et al., 2017) [12]. Enhanced confidence and less dizziness also facilitate increased mobility, indirectly lowering fall risk (Hall et al., 2016) [13].

Comparison with Previous Literature

Mitsutake et al. (2020) had modest but encouraging results for VR after stroke; the current review contributes six more recent RCTs appearing in 2018 or later, corroborating evidence that VR improves balance [8]. Zhao et al. (2022) and Correia et al. (2021) showed that gaze-stabilization and home oculomotor programs are associated with measurable functional improvements [2, 3]. Although Balci et al. (2013) reported comparable improvement across interventions, benefit was still provided by home-based programs, even pointing to the flexibility of VR protocols [7].

Clinical Implications

VR incorporation into stroke rehabilitation can:

- Enhance static and dynamic balance through multisensory retraining.
- Reduce risk of falling through increased postural control and confidence.
- Facilitate independent walking through enhanced gaze-stabilization.

The intensity and complexity of VR should be adjusted to the neurological status and cognitive ability of each patient. Training sessions between 30–45 minutes, 3–5 times a week for 4–6 weeks seem practical and effective.

Limitations of the Evidence

Most studies had small numbers and brief follow-up periods. Protocol heterogeneity (type of exercise, dosage, outcome measures) restricted the meta-analysis. Blinding was frequently not possible, with possible inflation of the effect estimates. Only one study assessed fall frequency directly [3], and long-term feasibility is unclear.

Future Directions

Future research needs to:

1. Perform large multicenter RCTs with standardized VR protocols.
2. Have long-term follow-up (≥6 months) for fall incidence.
3. Investigate neural mechanisms through imaging or neurophysiological markers.
4. Investigate technology-augmented VR (virtual reality, telerehabilitation) to enhance accessibility.

CONCLUSION

Vestibular rehabilitation is an effective and safe addition to standard physiotherapy for enhancing balance and functional mobility in stroke patients. Moderate-to-high-quality RCTs repeatedly demonstrate beneficial effects on balance and gait outcomes, and some document decreased risk of falls. The overall evidence supports adding vestibular-specific exercises to broad stroke-rehabilitation protocols despite methodological heterogeneity. More high-quality trials are needed to establish optimal dosage and long-term effects.

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