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A systematic review of effectiveness of vestibular rehabilitation on improving balance in patients with different conditions

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ABSTRACT

Background: Numerous strategies and techniques are designed to treat disorders that cause body imbalance. These techniques, known as vestibular rehabilitation, focus on various exercises ranging from substitution, adaptation, habituation, and compensation. This systematic review aimed to assess the effectiveness of vestibular rehabilitation in improving balance among patients with different disorders.

Material and Methods: A search of research articles in 2021 was accomplished by exploring electronic databases such as Embase, PubMed, and Scopus. Following a systematic screening and searching of articles. Fourteen relevant articles were found that were included in the review. As per the eligibility criteria, all eligible research studies were randomized controlled trials (RCTs).

Results: All the included studies revealed the positive effect of vestibular rehabilitation in improving balance, and other symptoms (fatigue, vertigo, ankle sway, falls, and disequilibrium) among patients with different conditions, except one study did not find any difference between vestibular rehabilitation and standard of care. Furthermore, the reported studies indicated the benefits of the vestibular rehabilitation programs tailored to the patient's needs and requirements compared with a single program that may not fit everyone.

Conclusion: Vestibular rehabilitation protocols integrated with some technological techniques and home-based exercise programs can be considered safe and effective in improving balance among older adults suffering from different conditions affecting their balance. However, future studies with a relatively large sample size are required to assess the effectiveness of the same interventions in resource-poor settings before large-scale implementation.

Keywords: Efficacy, vestibular rehabilitation, balance, systematic review.

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INTRODUCTION

Vestibular dysfunction is found among approximately 18.5% of 40- 49 years older adults, in 49.4% of 60- 69 years olds, and in up to 84.8% of older people aged at least 80 years older[5]. Besides being relatively more common in advanced age, dizziness may be even more hazardous for elderly persons[6]. People with vestibular dysfunction usually present with vertigo or imbalance of the body (gaze disturbances and postural instability)[7, 8]. Activities that result in head movements and ambulation may trigger these symptoms. As a result, vestibular disorders are often said to trigger considerable distress, decrease independence in everyday actions, and disrupt body balance[9].

Numerous strategies and techniques, known as vestibular rehabilitation (VR), are designed to treat such disorders: they focus on exercises ranging from substitution, adaptation, habituation, and compensation[10]. VR is considered patient-centered physical therapy, encompassing various strategies to improve gaze stability, enhance postural stability, and promote somatosensory integration[11]. More precisely, VR can address imbalance symptoms, falls, vertigo, motion sensitivity, dizziness, and other symptoms such as anxiety and nausea[12, 13]. Furthermore, VR is considered an effective strategy among patients with peripheral vestibular hypofunction and improves balance (dynamic and static) among patients with diseases affecting central vestibular function[14]. However, despite the proven efficacy of VR in improving postural functions and balance, its use is not common in standard balance protocols. Furthermore, it appears to be neglected concerning its role in improving balance for various conditions[4].

In addition to epidemiological evidence based on observational studies, several randomized controlled trials (RCTs) have been conducted to assess the efficacy of VR in improving balance and other indirect symptoms. However, the evidence from those RCTs is not synthesized and reviewed systematically to aggregate findings regarding the effectiveness of VR in improving balance. Therefore, we conducted a systematic review of the published RCTs to assess the efficacy and effectiveness of VR in improving balance among patients with different disorders. The findings of this review may help clinicians and other experts in the field to choose appropriate protocols to treat vestibular disorders and improve associated symptoms and the equality of life.

MATERIAL AND METHODS

This review was designed systematically to assess the effectiveness of vestibular rehabilitation in improving balance by using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

Eligibility Criteria

A systematic and electronic search was undertaken in 2021 to assess vestibular rehabilitation's effectiveness in improving balance by including studies conducted in resource-rich and resource-constrained settings. To achieve the defined objective, we focused on studies that assessed the effect of VR among all age groups and genders and original research studies published in English in low- and high-income countries between 2010 to 2021. Conversely, any study that was not published in English was not included. Moreover, observational studies, qualitative literature, case reports, secondary data, reports, letters written to the editors, working papers, and conference abstracts were excluded.

Sources of information and searching modality

All published articles were searched, and a thorough search was finalized in 2021: Embase, PubMed, and Scopus as three important electronic databases were explored. An impartial and unbiased search was performed to review the study findings of relevant research articles. The main exposure per the objective of the systematic review was VR given to patients with vestibular disorders, and the main outcome of interest was balanced. Relevant Medical Subject Heading (MeSH) key terms were employed to access the relevant research studies. The search terms included "vestibular rehabilitation AND balance," "vestibular rehabilitation AND sitting balance AND RCTs," "vestibular rehabilitation AND improvement in balance," and "vestibular rehabilitation AND sitting balance AND vestibular disorders." In addition, the most prevalent concepts were employed, including vestibular rehabilitation and sitting balance vs. balance, to obtain pertinent research papers. This was followed by joining these common concepts using AND and OR. An example of a complete search strategy included: "vestibular rehabilitation AND sitting balance OR balance AND vestibular disorders." Moreover, truncation (*) with a comparable root word was utilized o find more appropriate articles. Search constraints and filters were used on the language (English), time of publication, and study design to incorporate appropriate studies while searching for the research articles.

Abstraction of data and assessment of the quality

The relevant research articles were imported into a reference manager software known as the EndnoteTM file, where all studies were reviewed. The EndnoteTM file was utilized to recognize and eliminate repeats or duplicates. The abstracts that did not unambiguously investigate the study aim were not further evaluated, followed by retrieving and reviewing the suitable full-texts of the research articles. A standard form was developed to evaluate the abstracts and summarize all the articles that met the inclusion criteria. Furthermore, the citations of all relevant full-text articles were also evaluated to eliminate losing any valuable studies. The summarized data comprised the research author, study reference, year of publication, total sample size, type of intervention, gender by intervention arm, and age group by intervention group.

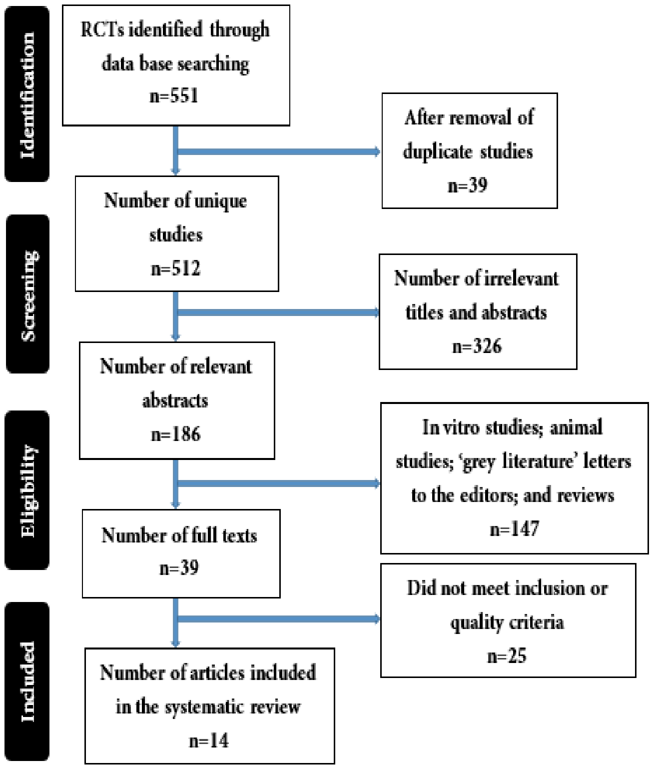
RESULTS

Findings of the search strategy

Initially, the selected research studies were reviewed by titles, followed by reviewing their abstracts. An evaluation of full-text articles followed this. The first search identified

551 RCTs in the databases after a filter was applied to the study design, and 39 duplicates were discarded. Of the remaining 512 exclusive research articles, 186 relevant abstracts were found and scrutinized. While we reviewed the abstracts, we found that 147 articles did not meet the inclusion criteria defined apriori, and 25 did not meet inclusion criteria after their full texts were scrutinized. Henceforth, 14 articles of full-text articles were reviewed and were incorporated into this systematic review (Figure 1).

Figure 1: Flow chart summarizing the identification and selection of papers for systematic review



Characteristics of the included research articles

Of the14 studies, all were single- or double-blinded randomized controlled trials (RCTs) as far as study design is concerned. The overall total sample size of all eligible RCTs ranged from 14 to 296. Almost 93% of the studies (n=13) had included both genders (males and females): the one exception did not report the gender of the study subjects. The average age of the study subjects was variable; however, the studies mainly included elderly adults (Table 1). Concerning the year, two studies were conducted in 2011, 2013, and 2018, three were conducted in 2016 and 2020, and one was conducted in 2017 and 2019, as shown in Table 1. In addition, four studies were conducted in Brazil, and three were undertaken in Italy, one in Germany, Spain, Turkey, the USA, Norway, and the United Kingdom (U.K.), indicating that 100% of the studies were conducted in high-income nations. The eligible research articles provided VR for various health conditions, including central vestibular dysfunction, canal paresis, multiple sclerosis, otolith disorder, posterior circulation stroke, removal of an acoustic neuroma, benign paroxysmal positional vertigo, microvascular compression syndrome, subacute stroke, postural instability, Parkinson's disease, and vertigo.

Summary of the main findings regarding the effectiveness of vestibular rehabilitation

Overall, each included study revealed the beneficial effect of VR on body balance among patients with different conditions. For example, Basta et al. conducted a trial in Germany on 105 patients. They found a substantial decrease in trunk and ankle sway along with improvement in the subjective symptom scores in the intervention arm[16]. In addition, the authors demonstrated that vibrotactile neurofeedback training reduces body sway in different balance disorders [16]. Similarly, another RCT conducted by Hebert et al. in the same year in the USA showed the efficacy of a 6-week VR program on fatigue and balance disability resulting from dizziness or disequilibrium[17]. In addition, the researchers revealed that among patients with multiple sclerosis, the body balance improved in participants randomized to the intervention arm, along with fatigue and disability due to dizziness or disequilibrium as opposed to two non-intervention groups [17].

Likewise, a study conducted by Marioni et al. in 2013 demonstrated consistent findings among 28 patients suffering from central vestibular dysfunction among older patients[18]. It was found that following rehabilitation, intervention arm scored significantly higher in the Dizziness Handicap Inventory for the emotional ($p = 0.01$) and functional ($p = 0.0016$) aspects and overall score ($p = 0.001$); only the score for the emotional aspect got better substantially in control arm ($p=0.038$) [18]. The intervention arm showed significant improvement in posturographic parameters, including reaction time, movement velocity, and endpoint excursion, while the non-intervention group had more restricted improvements[18]. In the same year, Balci et al. assessed the effectiveness of rehabilitation with two programs, namely, visual feedback posturography training or VR group, among 25 patients with posterior circulation stroke with imbalance complaints[19]. It was found that the balance and gait scores were significantly improved in both groups (rehabilitation and home exercise) ($p < 0.05$), however, there were no significant differences across the two groups ($p > 0.05$) [19].

In 2016, three different RCTs were conducted in Brazil and Turkey. First, Ricci et al. assessed Multimodal Cawthorne & Cooksey protocol for improving the balance among older adults with chronic dizziness [20]. The study findings demonstrated that the variations between two groups for Sensorial Romberg Eyes Closed (4.27 secs) and Unipedal Left Leg Eyes Open (4.08 secs) were substantial post-intervention; therefore, indicating the effectiveness of Multimodal Cawthorne & Cooksey protocol[20].

In 2017 Geraghty et al. assessed the effectiveness of internet-based VR intervention. This automated internet-centered plan encompassed VR exercises and recommended cognitive behavioral management approaches among patients with chronic dizziness [21]. Authors found that the intervention arm had reduced the degree of dizziness at 12 weeks (mean difference, 2.75 points; 95% CI, 1.39-4.12; P <.001) and at 24 weeks (difference in mean, 2.26 points; 95% CI, 0.39-4.12; P = 0.02) [21]. An RCT followed this by Tramontano et al. in 2018, where authors assessed a VR program plus ten days of prednisolone, general information, and counseling(Tramontano et al.,2018). A statistically significant difference was observed in the VR group for the primary outcome (perceived dizziness) at 3 (p = 0.007) and 12 months (p = 0.001) (Tramontano et al., 2018). Another RCT by Rodrigues et al. in 2019 illustrated similar findings while assessing the effectiveness of maneuvers and VR exercises among patients with benign paroxysmal positional vertigo[22]. The participants in the intervention arm had a decreased degree of dizziness at the end of follow-up (p < 0.05) and a reduced rate of recurrences (p = 0.038) when compared with the control arm[22].

Recently, in 2020, three studies were undertaken evaluating the effectiveness of 1) VR, an exercise-based plan (exercises for the stability of gaze and posture) [23], 2) customized VR training[24], and 3) VR protocols, respectively[25]. Tramontano et al. found that patients with multiple sclerosis showed meaningful progress in the gait and balance in the treatment group compared to patients in the other group with no intervention[23]. Similarly, Tokle et al., 2020 found that higher values of walking speed and stride length were noticed in the intervention than in the control group. However, no significant difference was observed in trunk stability[24]. Lastly, Aratani et al., 2020 found contradictory results with the above two studies. More precisely, the authors found no significant difference in the Dizziness Handicap Inventory post-intervention (difference in mean: -0.7; 95% CI: -9.2, 7.8) and follow-up of three months (difference in mean: -1.6; 95% CI: -9.5, 6.2). Also, no effect of the intervention was found on the secondary outcomes [25].

DISCUSSION

This systematic review was conducted to assess the effectiveness of vestibular rehabilitation in improving balance in patients with different conditions. The review's findings demonstrated an overall positive effect of VR improving balance and other parameters such as fatigue, ankle sway, dizziness, vestibular symptoms, and disequilibrium. Of 14 studies included in this review, 13 found a positive effect, and only one RCT did not find any difference between VR and standard of care. The potential reason for insignificant findings of a single study could be the limited sample size and lack of power to detect the difference caused by the intervention. Generally, the findings suggest that VR is considered safe and efficacious in improving balance and other symptoms, for example, reduction of falls, fatigue, and dizziness among elderly with vestibular dysfunction or other conditions. In addition, the studies reported the benefits of the VR programs tailored to the patient's needs and requirements rather than a single program that may not fit everyone.

Furthermore, one of the potential benefits of VR is its duration of implementation as it does not require to be implemented for a lengthy time, and patients can benefit from the therapy after being exposed to it for a few weeks. Some studies highlighted the importance of balancing training with new technologies using video feedback, which also showed a positive effect[1]. This suggests two implications for the clinical practice: balance network tends to be more malleable than previously considered, and balance training is more useful when incorporated with real-time visual feedback. However, the underlying potential mechanism by which the central nervous system processes the augmented sensory information is not precise [2, 3]. The findings of the current systematic review are consistent with similar reviews that mainly focused on neurological disorders[4]. Also, the previously conducted systematic review included observational studies and RCTs rather than only focusing on RCTs, which are considered the gold standard in the hierarchy of study designs.

Strengths and limitations

This systematic review is one of a kind that attempted to assess the effectiveness of vestibular rehabilitation in improving balance among elderly with different conditions. This reveals the degree to which VR is safe and effective after it is integrated into rehabilitation protocols. Including participants with diverse conditions emphasizes the usefulness of VR not only for a single disorder but for multiple conditions that affect the body balance and, consequently, the quality of life. This contributes to the clinical practice where clinicians may hesitate to use VR for some conditions due to lack of evidence. The feasibility of VR and its implementation in a shorter time could be beneficial in improving the balance and other symptoms among the elderly. This review was based on the PRISMA guidelines to minimize the potential biases, and we defined the eligibility criteria apriori to avoid selection or publication bias. All studies included were RCTs, well-known for checking for potential known and unknown confounders. They are helpful, therefore, for obtaining unbiased estimates.

One potential limitation, however, is the exclusion of those articles for which no abstracts were found, and those studies may well be significant in contributing to the evidence. Secondly, we did not perform a quantitative synthesis of the literature by conducting a meta-analysis, which may be vital for public health professionals and policymakers to make informed decisions. Although most of the included studies showed positive effects of VR heterogeneity across studies due to differences in sample size, follow-up time, and duration of intervention should be considered while interpreting the study's findings. Furthermore, almost all the included studies were from high-income countries, limiting our ability to generalize the findings to resource-constrained settings.

Conclusion and implications for future

Vestibular rehabilitation protocols integrated with some technological techniques and some home-based exercise programs can be considered safe and effective in improving balance among elderly suffering from different conditions affecting their balance. However, future studies with a relatively large sample size are required to estimate the exact duration for which such interventions can be given to patients. Also, these interventions must be explored in the pediatric population with vestibular dysfunction. Finally, there may be costs involved in staff training and the use of technology. Therefore, the cost-effectiveness of such interventions needs to be studied before proposing them, especially in resource-constrained settings worldwide.

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Tables and Figures

Table 1: Characteristics of included studies in the systematic review

Study	Year	Country	Sample Size	Health condition	Age	Gender
(Basta et al., 2011)	2011	Germany	105	canal paresis, otolith disorder, removal of an acoustic neuroma, microvascular compression syndrome, Parkinson's disease, and presbyvertigo	Intervention/control: age 60.6 ± 13.3/61.3 ± 9.2).	Intervention/control: gender 42.8%/42.9% female, 57.2%/57.1% male.
(Hebert et al., 2011)	2011	USA	38	Multiple sclerosis	Intervention: 46.8 (10.5) Control 1: 42.6 (10.4) Control 2: 50.2 (9.2)	Intervention: F=9 and M=3 Control 1: F=11 and M=2 Control 2: F=11 and M=2
(Marioni et al., 2013)	2013	Italy	28	central vestibular dysfunction in elderly patients	Intervention: 73.9 ± 8.0 years Control arm: 74.4 ± 7.3 years	Intervention: F=8 and M=6 Control: F=6 and M=8
(Balci et al., 2013)	2013	Turkey	25	Patients with posterior circulation stroke with imbalance complaints	Mean age for rehabilitation group: 61.0 ± 10.1 years. For the control group: 65.6 ± 9.3 years	F=18 M=7
(Ricci et al., 2016)	2016	Brazil	82	Elderly people with chronic dizziness resulting from vestibular disorders	At least 65 years	Intervention: F=27 and M=13 Control: F=32 and M=10
(Ribeiro et al., 2017)	2016	Brazil	14	Benign Paroxysmal Positional Vertigo	Intervention group age: 69 range between 65–78 years Control group age: 73 range between 65–76 years	Intervention: F=6 and M=1 Control: F=5 and M=2
(Ozgen et al., 2016)	2016	Turkey	40	Multiple sclerosis	Intervention: 42.5 [22-60], Control arm: 39.5 [24-56]	Intervention: F=16 and M=4 Control: F=12 and M=8
(Geraghty et al., 2017)	2017	UK	296	Elderly with Chronic Dizziness	Median age: 67 years	F=195 M=101
(Tramontano et al., 2018)	2018	Italy	25	Subacute stroke	64.1±12.1 years	M=12 F=13
(Rossi-Izquierdo et al., 2018)	2018	Spain	139	Postural instability	Intervention 1: 76.98±7.16 Intervention 2: 74.34±5.77 Intervention 3: 76.83±6.62 Control arm 76.82±5.74	N.R.
(Rodrigues et al., 2019)	2019	Brazil	32	Benign paroxysmal positional vertigo	57.13 ± 15.05	M=7 F=25
(Tramontano et al., 2020)	2020	Italy	20	Multiple sclerosis	Intervention: 51.9 ± 3.83 Control arm: 51.6 ± 10.91	Intervention: F=6 and M=2 Control: F=5 and M=3
(Tokle et al., 2020)	2020	Norway	61	Vestibular neuritis	18-70 years	Intervention: F=11 and M=20 Control: F=7 and M=23
(Aratani et al., 2020)	2020	Brazil	82	Elderly with chronic dizziness	Intervention: 74.4 ± 6.8 Control arm: 74.1 ± 5.9	Intervention: F=27 and M= 13 Control: F=32 and M=10

Table 2: Type of intervention and key findings for the effect of vestibular rehabilitation on the balance and other symptoms

Year	Intervention	Intervention groups	Duration of maximum Follow-up	Outcomes	Key findings	Summary
2011	Vibrotactile neurofeedback training	Intervention: The training was performed using the Vertiguard training device Control: Similar protocol with a sham device	3 months	Trunk and ankle sway, dizziness handicap inventory, and vestibular symptom score	Significant reduction in trunk and ankle sway as well as in the subjective symptom scores were observed in the intervention arm	Vibrotactile neurofeedback training is highly effective in reducing body sway in different balance disorders
2011	VR	experimental group, an exercise control group (underwent bicycle endurance and stretching exercises), or a wait-listed control group (usual medical care)	14 weeks	Fatigue and balance Disability due to dizziness or disequilibrium	Intervention arm demosntrated more improvements in fatigue, balance, and disability due to dizziness or disequilibrium compared with the two control groups	A 6-week VR program revealed both statistically significant and clinically meaingful change in fatigue, impaired balance, and disability due to dizziness or disequilibrium in patients suffering from Multiple Sclerosis.
2013	posturography-assisted VR protocol (30 min a week) combined with a home-based exercise program	Intervention: posturography-assisted VR protocol (30 min a week) combined with a home-based exercise program. Control: Home-based exercise program alone	6 weeks	Dizziness Handicap Inventory score	Following rehabilitation, intervention arm scored significantly higher in the Dizziness Handicap Inventory for the functional ($p = 0.0016$) and emotional ($p = 0.01$) aspects and overall total score ($p = 0.001$); only the emotional aspect improved significantly in control group ($p = 0.038$). The intervention arm showed significant improvement in posturographic parameters in the motor tests (reaction time, movement velocity, and endpoint excursion), while the control group had more restricted improvements.	program of posturography-assisted VR, and home-based exercises are more effective in improving the outcomes than home-based exercise alone
2013	Rehabilitation with two programs: Visual feedback posturography training or VR group	Rehabilitation (Visual feedback posturography training or VR group) or home exercise group for the control group	6 weeks	Balance and gait score	The balance and gait scores were significantly improved in both groups (rehabilitation and home exercise) ($p < 0.05$), however, there were no significant differences between the two groups in terms of post-treatment values ($p > 0.05$).	Rehabilitation intervention programs were equivalently effective to have better recovery in acute central vestibulopathy
2016	Multimodal Cawthorne & Cooksey protocol	Intervention arm: This was submitted to a Multimodal Cawthorne & Cooksey protocol The control arm: It treated according to the Conventional Cawthorne & Cooksey protocol	3 months	**Primary outcome:** Body balance control **Secondary outcomes**: Mobility, lower extremity strength, postural control, and disability, and Handgrip strength	The between-group differences for Sensorial Romberg Eyes Closed (4.27 secs) and Unipedal Left Leg Eyes Open (4.08 secs) were significant after the intervention, therefore, indicating the effectiveness of Multimodal Cawthorne & Cooksey protocol	Both protocols, implemented in intervention and control arms, showed improvement on older's balance control. On specific static balance tests, multimodal protocol revealed better performance
2016	Balance VR Therapy that was consisted of 50 min per session, two times a week, and Canalith Repositioning Maneuver as needed, for 13 weeks	Intervention arm: Balance VR Therapy Control arm: Canalith Repositioning Maneuver	13 weeks	Standing and dynamic balance, dizziness symptoms, and quality of life	No between-group differences were found in dizziness, quality of life, and standing balance at the end of 13 weeks. Significant differences were noticed in dynamic balance measures across two groups ($p < 0.05$	The group members who were in VRT showed good results in dynamic balance than those who were in the control arm, which shows the positive effect of VRT on dynamic balance
2016	VR	Intervention: Customized VR Control: usual medical care	4 weeks	balance, functional capacity, quality of life, and depression	Significant recoveries were found among participants randomized to the intervention group for all outcomes ($P<0.05$).	Customized VR is considered effective for improving balance, functional capacity, and quality of life

2017	Internet-based VR intervention: Automated Internet-based program that encompassed VR exercises and recommended cognitive behavioral management strategies	Intervention: Internet-based VR intervention Control: usual primary care	6 months	Dizziness	The intervention arm had reduced degree of dizziness at 3 months (difference, 2.75 points; 95% CI, 1.39-4.12; P <.001) and at 6 months (difference, 2.26 points; 95% CI, 0.39-4.12; P = .02, respectively). Dizziness-related disability was also reduced in the intervention group at 3 months (difference, 6.15 points; 95% CI, 2.81-9.49; P <.001) and 6 months (difference, 5.58 points; 95% CI, 1.19-10.0; P = .01).	Internet-based VR decreases dizziness and dizziness-related disability among the elderly without ant additional clinical support, therefore, this intervention can be implemented easily in communities.
2018	VR program plus 10 days of prednisolone, general information, and counseling	Intervention arm: VR program Control arm: standard care	12 months	Perceived dizziness during head motion. Walking speed, standing balance	A statistically significant difference was observed for the VR group for the primary outcome (perceived dizziness) at 3 (p = 0.007) and 12 months (p = 0.001). However, there were no statistically significant differences observed for secondary outcomes (standing balance and walking speed)	A VR program along with standard care commenced early after diagnosis of acute vestibular neuritis decreases the perception of dizziness and enhances functions of daily life more effectively than standard care alone.
2018	VR program	computerized dynamic posturography (CDP) training, optokinetic stimulus, exercises at home or control group	12 months	Balance and frequency of falls	The mean number of falls significantly reduced from 10.96 (before intervention) to 3.03 (endline) in the intervention arm (p < 0.001). In the control arm, the mean number of falls changed from 3.36 to 2.61 at the end of study (p = 0.166).	A VR program is effective in improving balance among elderly patients with postural disability
2019	Maneuvers and VR exercises	Intervention: Maneuvers and VR exercises Control group: Only the maneuver technique	6 months	Dizziness Handicap Inventory score and visual analog scale	The participants in the intervention arm had a lower level of dizziness at the end of follow-up (p < 0.05) and a reduced rate of recurrences (p = 0.038) when compared with the control arm.	VR exercises were found effective in improving the symptoms of benign paroxysmal positional vertigo with a relatively lower incidence of recurrences
2020	VR, an exercise-based program (gaze stability and postural stability exercises). cerebellar intermittent theta burst stimulation (c-iTBS), a high-frequency rTMS protocol	Intervention arm: cerebellar intermittent theta burst stimulation (c-iTBS), a high-frequency rTMS protocol before VR Control arm: sham iTBS before VR	2 weeks	Gait and balance	Patients suffering from Multiple sclerosis showed a significant improvement in the gait and balance in the intervention arm as compared to patients in the control arm.	Combined c-iTBS and VR improve gait and balance abilities more than standard VR treatment among patients of multiple sclerosis having a greater disability.
2020	Customized VR training	Intervention arm: Customized VR training Control arm: Standard of care	4 weeks	Gait stability	Higher values of walking speed and stride length were noticed in the intervention than in the control group. However, no significant difference was observed for trunk stability	VR may be considered as a part of a rehabilitation program for stroke patients to bring improvement in their gait and dynamic balance.
2020	VR protocols	multimodal protocols versus Cawthorne & Cooksey protocol.	3 months	**Primary outcome:** Dizziness Handicap Inventory score **Secondry outcomes:** Visual Analogue Scale, the Vestibular Disorders Activities of Daily Living Scale, the Geriatric Depression Scale, and the Activities-specific Balance Confidence Scale	There was no significant difference on Dizziness Handicap Inventory at post-treatment (Mean Difference (MD): -0.7; 95% CI: -9.2, 7.8) and at three-month follow-up (MD: -1.6; 95% CI: -9.5, 6.2). No effect of intervenntion was found on the secondary outcomes	Multimodal exercises did not contribute or add to the conventional protocols.

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