THE EFFECTIVENESS OF VESTIBULAR REHABILITATION IN CENTRAL VERTIGO: A SYSTEMATIC REVIEW

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Abstract

Background: Patients with vestibular dysfunction complain of vertigo or dizziness, which may affect balance and quality of life and activities of daily living. Vestibular Rehabilitation Therapy (VRT) aims at teaching the brain to use other senses such as vision and somatosensory to compensate for vestibular damage or hypofunction to alleviate vertigo or dizziness. This therapy includes various exercises such as adaptation, habituation, sensory substitution, balance and gait training.

Methods: The following five electronic databases were searched from inception to November 2018: PEDro, PubMed, Scopus, Web of Science and Cochrane for relevant Randomized Controlled Trials (RCT). Further, manual search of bibliography and snowballing were done on eligible studies from the electronic search. Quality assessment of all eligible studies was done using the PEDro scale. The Primary outcomes were dizziness, vertigo and balance. Secondary outcomes were quality of life or any other functional outcomes.

Results: Three articles with 125 patients met our inclusion criteria. Dizziness Handicapped Inventory (DHI) was the main scale that measure dizziness in all included studies. Balance was measured by Posturography, Berg Balance Scale and other scales and tests. According to PEDro scale, two studies were of high quality and one of a moderate quality. All included studies showed significant differences between VRT group and control group in favor of VRT group in dizziness, vertigo and balance.

Conclusion: there is a limited evidence to support the effectiveness of VRT in treating patients suffering from central vertigo or dizziness. More high-quality clinical trials are needed to confirm this finding.

Keywords: Dizziness; Vestibular rehabilitation therapy; Vertigo.

Introduction

Patients with vestibular dysfunction complain of vertigo, dizziness, gaze instability and imbalance (1). **Vertigo** is one of the most common vestibular disorders in which patients develop a false impression that the surrounding environment is rotating around them. Further, patient may suffer from nausea or vomiting. This clinical entity may be caused by central or peripheral neurological diseases. (2). **It** adversely affects patient's quality of life and social habits (3) (4)**. Dizziness** is a sensation of disequilibrium or improper spatial orientation without any sensation of rotation that may cause imbalance and increase risk of falling (3).

There are many treatment approaches to alleviate vertigo and dizziness such as drugs (e.g. Benzodiazepines, antihistamines, and anticholinergic) which used to reduce the intensity of the attack with a limited prophylactic role (5)**.** Surgical removal of tumors in a case of posterior fossa tumor and Lavage in cerebellar hemorrhage (6)**.** Vestibular Rehabilitation Therapy (VRT) has gained popularity in treating vertigo and dizziness as it aims at teaching the brain to use other senses such as vision and somatosensory to compensate for vestibular damage or hypofunction (7**)**. This therapy includes various exercises such as adaptation, habituation, sensory substitution, balance and gait training (1). Although there is a moderate to strong evidence supporting VRT in peripheral vertigo or dizziness (4) (8), The effectiveness of VRT in treating central vertigo or dizziness is not well established yet. Therefore, the purpose of this study was to review and evaluate clinical trials that investigated VRT effectiveness in treating central vertigo and dizziness.

Subject, materials and methods

Subjects:

The protocol for this study was registered at Prospero (CRD4 2018071933).

Searching strategies

The following five electronic databases were searched from inception up to Nov 15, 2018: -*Scopus*, *PubMed, Cochrane and Web of science (WOS)* and PEDro. Searching was done using the following key words and Boolean operators: (Vertigo* OR "Spinning sens*" OR dizziness OR orthostasis OR lightheadedness OR light-headedness OR "light headedness") AND ("Vestibular rehabilitation" OR "Vestibular train*" OR "Vestibular physical therapy" OR "Vestibular physiotherapy" OR "Vestibular exercise*" OR "Balance train*" OR "Balance exercise*" OR "Postur* stability" OR "Postur* stabilization" OR "Virtual reality" OR "Habituat* exercise*" OR "Habituat* train*" OR "Gaze stabilization" OR "Adaptation exercise*" OR "Substitution exercise*" OR "Substitution train*") AND ("Millard Gubler syndrome" OR "Millard-Gubler syndrome" OR "Wallenberg* Syndrome" OR "Vieseaux-Wallenberg Syndrome" OR "Vieseaux Wallenberg Syndrome" OR "Dorsolateral Medullary Syndrome" OR "Lateral Bulbar Syndrome" OR "Brain stem infarction*" OR "Brainstem infarction*" OR "Claude Syndrome" OR "Weber Syndrome" OR "Benedict Syndrome" OR "Foville Syndrome" OR "Cerebellar hemorrhage" OR "Cerebellar heamorrhage" OR "Cerebellar infarction" OR "Nodular infarction" OR "Vertebral artery dissection" OR

"Brainstem tumor*" OR "Brainstem neoplasm" OR "Pontine tumor*" OR "Pontine neoplasm" OR "Midbrain tumor*" OR "Midbrain neoplasm" OR "Mesencephalic Neoplasm" OR "Mesencephalic tumor" OR "Medullary neoplasm" OR "Medullary tumor*" OR "Acoustic neuroma*" OR "Acoustic Schwannoma*" OR "Vestibular Schwannoma*" OR "Acoustic Neurilemmoma*" OR "Acoustic Neurinoma*" OR "Angle tumor*" OR "Vestibular Glioma*" OR "Vestibular Meningioma*" OR "Cerebellar neoplasm" OR "Primary cholesteatoma*" OR Metastasis OR Metastatic OR "Multiple sclerosis" OR MS OR "Disseminated sclerosis" OR "Post concussi* syndrome" OR "Post-concussi* syndrome" OR "Vestibular migraine" OR "Arnold chiari malformation" OR "Arnold-chiari malformation" OR "Atlanto axial dislocation" OR "Atlanto-axial dislocation" OR "Atlantooccipital fusion" OR "Atlas occipitalization" OR "Atlas assimilation" OR Platybasia* OR "Basilar impression" OR "Basilar invagination" OR Parkinsonism OR Parkinson*) NOT (surger* OR drug* OR medicine OR pharmaceutical* OR electrotherap* OR pediatric* OR paediatric* OR child* OR peripheral vestibular disorder*).

Electronic search was followed by manual search of eligible literature and snowballing using WOS, Scopus and google scholar. Records retrieved were screened by two independent reviewers first by title, then by abstract finally by full text according to the following inclusion criteria:

Randomized controlled trials (RCTs)

- Studies that enrolled adults; female and male with central vertigo or dizziness.
- Studies that investigated the effectiveness of VRT compared to placebo or any other conservative treatment.
- Studies that evaluated any of the following outcomes: dizziness, vertigo, balance, gait, quality of life, visual acuity, risk of falling or any other functional outcome.

Articles were ***excluded*** if they were non-randomized controlled trials, case series, case report, or observational studies. Also, articles were excluded if they were not published in the English language.

Data extraction

Eligible studies for the inclusion criteria were read in details and the following items were extracted; sample size, patient's demographic characteristics, randomization method, setting, blindness, baseline comparison, intervention type, treatment duration, comparator or control, primary and secondary outcomes, results and conclusion **(Appendix 1).**

Outcomes

The primary outcome for this review was dizziness and vertigo severity. Secondary outcomes were balance, gait, risk of fall or any other functional outcomes that may affected by vestibular dysfunction.

Quality assessment

Quality assessment of eligible studies were done by two independent reviewers using the ***PEDro scale***. This scale consists of eleven criteria that assesses study's inclusion criteria, random allocation, concealment, baseline comparison, blindness of subjects, therapist and assessors, the number of patients included in key outcome measurements, the employment of "intention to treat", reporting between groups results of at least one key outcome, and expressing

the variability for at least one key outcome. PEDro score ranges between 0 and 10 with higher score represents higher study quality (9). Any disagreement was resolved by consensus, discussion, or consulting a third reviewer.

Results

Search results

Electronic and manual search yielded 2643 articles. After duplicate removal, screening by title, abstract, 78 articles were eligible for full text reading. Based on our eligibility criteria, three articles were included in this study, Snowballing using Scopus and WOS added no more articles for the review **(Figure 1).**

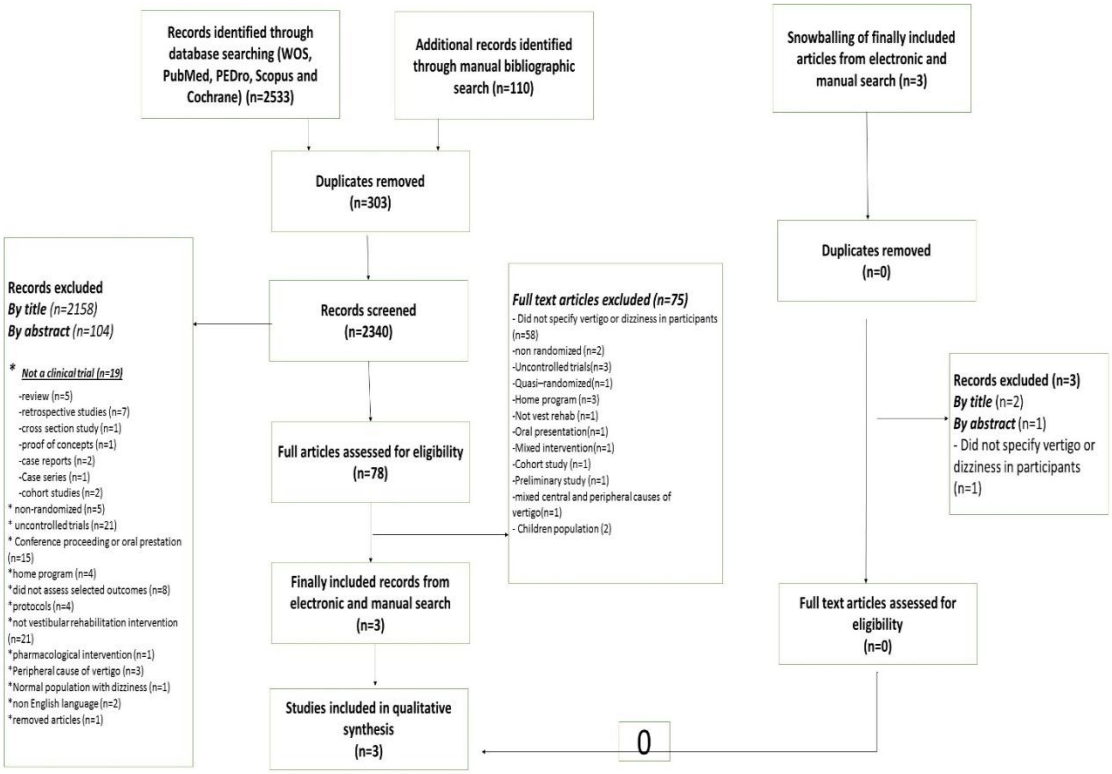

Figure 1; PRISMA Flow Chart

Sample characteristics

The three eligible studies were RCTs that enrolled male and female patients with an age ranged between 16 and 60 years old. The sample size ranged from 20 to 65. Patients were randomized to VRT group or control group receiving routine medical care only. Causes of central vertigo or dizziness included traumatic brain injury (TBI) or multiple sclerosis (MS).

Baseline assessment in all reviewed studies included complete neurological, ontological and vestibular assessment to exclude other causes of vertigo or dizziness. Further, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), Vestibulo Ocular Reflex (VOR) and dynamic visual acuity was used to confirm the diagnosis.

Intervention

Various forms of VRT were used including substitution, adaptation, habituation, gaze stabilization and balance training. Balance was done from sitting, standing and standing. Besides, dynamic balance exercises were used. Vestibular Rehabilitation Therapy (VRT) was performed by specialized therapist and was given with an adjunct home-based program (10) (11) (12).

Control group received standard medical care (12) and didn't receive any treatment in another two studies (10) (12), In all included studies control group didn't receive any VRT in the study duration (10) (11) (12).

Outcomes

Primary outcomes

The primary outcome in all included studies was changes in dizziness score as measured by the Dizziness Handicapped Inventory (DHI) (10) (11) (12). In addition, primary outcomes included balance as measured by Posturography, Activities-Specific Balance Confidence (ABC), Romberg test, Tandem Romberg Test, Foam Romberg Test, Five Times Sit-to-Stand Test (FTSTS), Timed Up and Go Test (TUG), Six-Meter Walk Test (6WT), Dynamic Gait Index (DGI), Functional Gait Assessment (FGA) and Berg Balance Scale (BBS) (Ozgen et al., 2016).

Secondary outcomes

Secondary outcomes included Functional capacity and quality of life (QoL) measured by Six-Minute Walking Test (6MWT), Beck Depression Inventory (BDI), Expanded Disability Status Scale (EDSS) and Multiple Sclerosis Quality of Life Scale (Ozgen et al., 2016). Further; Mobility was measured by High Level Mobility Assessment Tools for traumatic brain injuries (TBI), Self-reported post-concussion symptoms was measured by Rivermead post-concussion symptoms questionnaire, Psychological distress was analyzed by Hospital Anxiety and Depression Scale. Balance was assessed by Balance Error scoring System (11).

Effect of intervention

The included studies enrolled homogenous sample as evident by the lack of significant differences between intervention and control groups at baseline. For VRT effectiveness, results suggested that there was improvement in the VR group compared to the control group following treatment (10) (11) (12). **Jafarzadeh et al., 2018** found that there are no significant differences between the two groups in dizziness by DHI score at the first and second weeks of treatment, yet, significant differences were observed at the third and fourth weeks. In the study done by **Kleffelgaard et al., 2018** found that there were a statistically significant differences in primary and secondary outcomes: dizziness related disability, vertigo, balance and post-concussion symptoms and depression in the intervention group other than control group at the first follow up period about 2.7 ± 0.8 after base line assessment. But there were no significant differences between groups in the second follow up period about 4.4 ± 1.0 months after base line assessment. In study of **Ozgen et al., 2016** there was a significant difference between intervention and control group in all balance parameters except for the tandem Romberg with eye closed and foam standing with eye open tests.

Only three studies were found eligible for this review, two were of a high quality scored (scored 8 out of 10) (10) (11) and one of a good quality (scored 4 out of 10) (12). A study done by **Jafarzadeh et al., 2018** was the only study which has no allocation concealment, no blinding even the assessor, no intention to treat and the outcomes measured from less than of 85% from patients initially allocated to group **(Table 1).** Blindness of subjects and therapists was not applicable due to nature of treatment between intervention and control group which may be a source of bias **(Figure 2).**

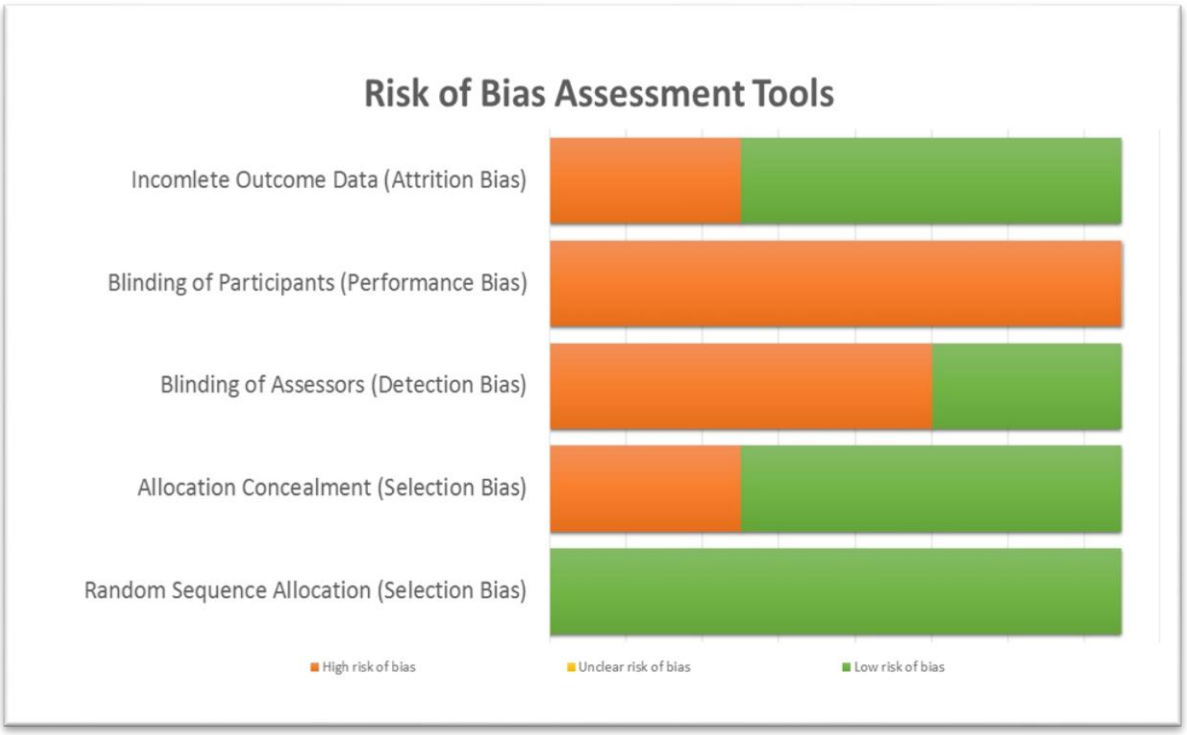

Figure 2: Risk of Bias Assessment

Discussion

This study aimed at investigating the strength of evidence that support VRT effectiveness in treating central -vertigo or dizziness**. Results showed promising effect from high quality study in favor of VRT, yet due to scarcity of literatures, no solid conclusion could be drawn.**

To authors knowledge, this is the first study that systematically reviewed and assessed the quality of evidence drawn from RCTs regarding VRT effectiveness in central vertigo. A few systematic reviews have investigated the effectiveness of VRT in treating peripheral vertigo and dizziness. ***Ricci et al., 2010*** recommended the using VRT in normal middle and old age population who complains of vertigo or dizziness. ***Cochrane review of McDonnell* & Hillier, 2015** found that VRT has moderate to strong evidence to patients with unilateral peripheral hypofunction. **Hunt et al., 2012** recommended using modifications of Epley's maneuver for posterior canal Benign Paroxysmal Positional Vertigo.

Included studies did not provide adequate level of blindness for the therapist and patients due to differences in treatment methods which made blindness not applicable for these types of studies and may be considered as a source of bias.

Studies limitations

Some deficits in our included articles were found such as: small sample size which may affect external validity of the results, two of three included studies have the same cause of dizziness which is TBI which may also affect external validity of results to another causes of dizziness, lack of follow up period with exception to study of Kleffelgaard et al., 2018 The primary outcome of all included studies was Dizziness severity measured by DHI which is subjective method to determine the effect of intervention. In addition to using different methods of VRT in each study (Ozgen et al., 2016; Kleffelgaard

et al., 2018; Jafarzadeh et al., 2018). One study has no exclusion criteria which may include participants have psychological or other co morbidities (Kleffelgaard et al., 2018).

Limitations;

The current study was limited to articles published in English language only which may exclude relevant articles in another languages. Results were not homogenous, so meta-analysis was not applicable. We included articles that have participants above 16 years old. Further RCTs with large sample size, longer follow up periods, with an objective assessment at base line and after treatment duration with a definite exclusion criterion are needed to confirm the effectiveness of VRT in central vertigo or dizziness.

Conclusion

According to the results. VRT is an effective method for central vertigo or dizziness and must take apart in treatment plan when dealing with these patients.

Reference

1- **Macias, J. D., Massingale, S., & Gerkin, R. D. (2005).** Efficacy of vestibular rehabilitation therapy in reducing falls. Otolaryngology—Head and Neck Surgery, 133(3), 323-325.

2- **Chang, A. K., & Olshaker, J. S. (2014).** Dizziness and vertigo, In: Rosen's Emergency Medicine: Concepts and Clinical Practice, Edited by Marx, et al., 8th ed. Elsevier Health Sciences. Philadelphia, USA, P 161-169.

3- **Strupp, M., Dieterich, M., & Brandt, T. (2013).** The treatment and natural course of peripheral and central vertigo. Dtsch ArzteblInt, 110 (29-30), 505-16.

4- **McDonnell, M. N., & Hillier, S. L. (2015).** Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. Cochrane Database of Systematic Reviews 2015, Issue Art. No: CD005397.

5- **Boomsaad, Z. E., Telian, S. A., & Patil, P. G. (2017).** Treatment of intractable vertigo. Youmans and Winn Neurological Surgery. 7th ed. Philadelphia, PA: Elsevier.

6- **Pulec, J. L. (1995).** Surgical treatment of vertigo. Acta Oto Laryngologica, 115(sup519), 21-25.

7- **Hall, C. D., Herdman, S. J., Whitney, S. L., Cass, S. P., Clendaniel, R. A., Fife, T. D., et al. & Woodhouse, S. N. (2016).** Vestibular rehabilitation for peripheral vestibular hypofunction: an evidence-based clinical practice guideline: from the American physical therapy association neurology section. Journal of Neurologic Physical Therapy, 40 (2), 124.

8- **Hunt, W. T., Zimmermann, E. F., & Hilton, M. P. (2012).** Modifications of the Epley (canalith repositioning) manoeuvre for posterior canal benign paroxysmal positional vertigo (BPPV). Cochrane Database of Systematic Reviews, (4).

9- **Verhagen, A. P., de Vet, H. C., de Bie, R. A., Kessels, A. G., Boers, M., & Knipschild, P. G. (1998)**. Balneotherapy and quality assessment: interobserver reliability of the Maastricht criteria list and the

need for blinded quality assessment. Journal of clinical epidemiology, 51(4), 335-341.

10- **Ozgen, G., Karapolat, H., Akkoc, Y., & Yuceyar, N. (2016)**. Is customized vestibular rehabilitation effective in patients with multiple sclerosis? A randomized controlled trial. European journal of physical and rehabilitation medicine, 52(4), 466-478.

11- **Kleffelgaard, I., Soberg, H. L., Tamber, A. L., Bruusgaard, K. A., Pripp, A. H., Sandhaug, M., & Langhammer, B. (2018).** The effects of vestibular rehabilitation on dizziness and balance problems in patients after traumatic brain injury: a randomized controlled trial. Clinical rehabilitation, 0269215518791274.

12- **Jafarzadeh, S., Pourbakht, A., Bahrami, E., Jalaie, S., & Bayat, A. (2018)**. Effect of early vestibular rehabilitation on vertigo and unsteadiness in patients with acute and sub-acute head trauma. Iranian journal of otorhinolaryngology, 30(97), 85.

13- **Ricci, N. A., Aratani, M. C., Doná, F., Macedo, C., Caovilla, H. H., & Ganança, F. F. (2010).** A systematic review about the effects of the vestibular rehabilitation in middle-age and older adults. *Brazilian Journal of Physical Therapy*, *14*(5), 361-371.

Table 1: **Quality Assessment according to PEDro Scale**

	Jafarzadeh et al.,	**Kleffelgaard et al.,**	**Ozgen et al.,**
Eligibility criteria were specified	Yes	Yes	Yes
Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Yes	Yes	Yes
Allocation was concealed	No	Yes	Yes
The groups were similar at baseline regarding the most important prognostic indicators	Yes	Yes	Yes
There was blinding of all subjects	No	No	No
There was blinding of all therapists who administered the therapy	No	No	No
There was blinding of all assessors who measured at least one key outcome	No	Yes	Yes
Measures of at least one key outcome were obtained from more than 85%of the subjects initially allocated to groups	No	Yes	Yes
All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by intention to treat	No	Yes	Yes
The results of between-group statistical comparisons are reported for at least one key outcome	Yes	Yes	Yes
The study provides both point measures and measures of variability for at least one key outcome	Yes	Yes	Yes
Total	4	8	8

Appendix 1: Date Extraction table of Included Studies

	Effect of Early Vestibular Rehabilitation on Vertigo and Unsteadiness in Patients with Acute and Sub-Acute Head Trauma	**Is customized vestibular rehabilitation effective in patients with multiple sclerosis? A randomized controlled trial**	**The effects of vestibular rehabilitation on dizziness and balance problems in patients after traumatic brain injury: a randomized controlled trial**
Authors	Jafarzadeh et al.,	Ozgen et al.,	Kleffelgaard et al.,
Objectives	evaluation of the effect of early vestibular rehabilitation on patients with acute and sub-acute head trauma using DHI	investigate the effects of customized vestibular rehabilitation (VR) on balance, functional capacity, quality of life, and depression in patients with MS.	To investigate the effects of group-based vestibular rehabilitation in patients with traumatic brain injury
Methods			
Randomization	Done	computer-generated minimization method	a computer-generated list of random numbers
Study duration	4 weeks	8 weeks	8 weeks
Allocation concealment	No	Yes	Yes
Blinding	No	Assessors	Assessor
Setting	vestibular rehabilitation center	Neurology, Physical Medicine, and Rehabilitation clinics at the University of Ege, Izmir, Turkey	outpatient clinic of the Department of Physical Medicine and Rehabilitation at Oslo University Hospital
Baseline assessment	complete neurologic and otologic evaluations and hospital discharge and had normal computed tomography (CT) scans and an absence of physical abnormalities including benign paroxysmal positional vertigo, rupture of the round window membrane, perilymphatic fistula and endolymphatic hydrops. Patients showed no remarkable pathology (e.g., fractures, wounds, intracranial pathology or neurological deficits).	All participants underwent 17 outcome measurement sessions during a four-week nonintervention baseline phase	clinical assessments of the vestibular system at baseline consisted of tests of the oculomotor system (smooth pursuit, saccadic eye movements) and the vestibulo-ocular reflex (head-thrust test, clinical test for dynamic visual acuity). Benign paroxysmal positional vertigo was tested with the Dix-Hallpike and Roll test.
Participants			
No of participants	20	40	65
Inclusion criteria	- Age from 18:60 years old - vertigo and unsteadiness due to head trauma	- diagnosis of MS and disability according to ICF - impairments in ADL activities due to balance problems and dizziness	patients with traumatic brain injury, aged 16– 60 years who reported mild, moderate, or severe feelings of dizziness on the Rivermead Post-Concussion Symptoms

	- Glasgow coma score higher than 9 - lack of cognitive, cervical, visual and neck problems in the neurologic and otologic evaluations - abnormal results in cVEMP or Dynamic Posturography indicating a vestibular abnormality		Questionnaire (dizziness score ⩾ 2) and/or had a positive Romberg's test.
Exclusion criteria		- Documented MS-related relapse within six months prior to the study - Change in MS-specific disease modification medication within three months prior to the study - Advanced visual or hearing defects - Orthopedic or other neurological disease that would prevent exercising - Participation in a vestibular or endurance exercise program within eight weeks prior to the study	- severe psychological disease - substance abuse reported in their medical record - Insufficient command of Norwegian and/or cognitive dysfunction - fractures, or other comorbidities affecting mobility and independent gait, and scores <15 points on the Dizziness Handicap Inventory.
Procedures	Vestibular assessment of the patients was performed at the beginning of the program, including a case history, bedside examination, assessment of spontaneous nystagmus, horizontal and vertical gaze and saccade, Romberg's test, Dix–Hallpike maneuver, cVEMP (Labat, Italy) and Dynamic Posturography (Equitest, USA). to determine the site of the lesion of the vestibular disorder and to confirm inclusion criteria Persian version of the DHI was used to measure the physical, emotional and functional outcomes of head trauma and the progress	Considering each patient's history, physical examination and diagnostic tests, an exercise program was developed by the physical medicine and rehabilitation specialist, who had five years of experience in balance disorders. The program was given to the patient after a discussion with the physiotherapist, who had Three Years of experience specializing in vestibular and balance rehabilitation. The following topics were discussed with the patient during the training component: MS, balance disturbances often seen in MS and vestibular balance system functions, and the rationale for and contraindications of performing the exercises	

	during and after 4 weeks of vestibular rehabilitation		
Demographics	age, sex and duration of symptoms	Age, sex, gender, BMI, Marital status, education, employment, MS type, EDSS, medical treatment, comorbidities diseases	personal factors, cause of injury and severity of injury were recorded from the patients' medical records. Personal factors included age at the time of the injury, married/cohabiting, level of education, preinjury employment studies and preinjury comorbidities. Severity of injury included the Glasgow Coma Scale score, loss of consciousness, post-traumatic amnesia and the presence of intracranial abnormality on MRI or CT.
Interventions			
Intervention group	received the usual medical therapy (Betaserc 8 mg pills; at least three pills per day) + vestibular rehabilitation (daily training for 4 weeks including gaze stability, adaptation and some substitution exercise. These exercises were selected for each patient based on their function and vestibular assessment test results. exercises were performed by therapists with specialized training in the assessment and treatment of vestibular disorders.	Adaptation exercises Substitution exercises Balance exercises Sitting balance Standing balance Standing dynamic balance exercises Habituation exercises Ambulation exercises Considering each patient's history, physical examination and diagnostic tests exercises done by the physical medicine and rehabilitation specialist had five years of experience in balance disorders after a discussion with the physiotherapist, who had Three Years of experience specializing in vestibular and balance rehabilitation for each type of exercise, a universal set of nine modifiers was used to describe other characteristics of the exercise 1) the posture in which the exercise was performed 2) the type of support surface 3) the size of the base of support 4) the positioning of the trunk 5) the positioning of the arms 6) the direction of the patient's head movements 7) the direction of whole-body movements 8) visual input	group-based vestibular rehabilitation intervention twice weekly for eight weeks. Attending all 16 sessions was considered 100% adherence to the intervention consisted of guidance, individually tailored exercises, a home exercise program, and an exercise diary. comprised Brandt–Daroff exercises for benign paroxysmal positional vertigo, habituation exercises for motion sensitivity and central post-traumatic vertigo, gaze-stabilization exercises (adaptation and substitution) for symptoms exhibited during eye–head coordination and reduced vestibulo–ocular reflex, and exercises for reduced balance focusing on improving sensory integration. The home exercise program included two to five individually modified exercises and general physical activity like walking, biking, and skiing.

		9) any other special circumstances, such as target distance (near or far) when performing the VOR exercise home program was designed to take approximately 15-20 minutes, twice a day	
Control group	received the usual medical therapy (Betaserc 8 mg pills; at least three pills per day)	not received any intervention in the 1st 8 weeks then received vestibular rehabilitation	did not receive any rehabilitation intervention in place of the group-based vestibular rehabilitation intervention,
Outcomes			
Primary outcome	**The Persian version of the DHI (25 item score 0:100)** **measures the effect of vertigo and unsteadiness on different physical, emotional and functional aspects of a patient's life, quality of life and treatment progress** every week	• ***symptoms*** - Visual Analog Scale (VAS). - Dizziness Handicap Inventory (DHI) - Activities-Specific Balance Confidence (ABC) - Romberg tests - Tandem Romberg Test - Foam Romberg Test • ***Balance*** - Static posturography - Five Times Sit-to-Stand Test (FTSTS) - Timed Up and Go Test (TUG) - Six-Meter Walk Test (6WT) - Dynamic Gait Index (DGI). - Functional Gait Assessment (FGA). - Berg Balance Scale (BBS)	Dizziness related disability measured by Dizziness Handicapped Inventory
Secondary outcome		***functional capacity, disability, and physiological quality of life*** - Six-Minute Walking Test (6MWT) - Beck Depression Inventory (BDI) - Expanded Disability Status Scale (EDSS) - Multiple Sclerosis Quality of Life Scale–54	mobility measured with the High-Level Mobility Assessment Tool for traumatic brain injury frequency and severity of dizziness symptoms was measured with the Vertigo Symptom Scale–Short Form. Self-reported post-concussion symptoms were measured with the Rivermead Post-concussion Symptoms Questionnaire Psychological distress was assessed with the Hospital Anxiety and

			Depression Scale. Balance was assessed with the Balance Error Scoring System
Results			
	No significant difference between the two groups in the total score and subtests at the beginning of the program	There were significant changes in the exercise group compared to the control group in most of the evaluated parameters at the termination of the study (except for tandem Romberg [eyes closed] and foam standing [eyes open] ($P<0.05$). No significant differences in any of the parameters were observed in the control group ($P>0.05$)	a statistically significant between intervention group rather than control group mean difference was found in the respective primary and secondary outcome measures in favor of the intervention group second post-intervention follow-up, the between-group differences were no longer statistically significant
Mean	44.2	Exercise group 42.5 Control group 39.5	Intervention group 37.6 Control 41.2
SD	12.6	12.3	13.6