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Review Article

An update on vestibular physical therapy

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Abstract

Vestibular physical therapy is a specialized exercise based intervention for management of symptoms associated with vestibular dysfunction that manifests itself as dizziness and imbalance related to position or movement of the body. The aim of this review is to evaluate and summarize the efficacy of vestibular physical therapy for the treatment of vestibular disorders. A literature review was conducted to identify references related to vestibular disorders plus rehabilitation. Articles ranged from descriptions of vestibular dysfunction, its diagnosis, treatment, and rehabilitation in various populations. Case studies, case series with no controls, and controlled studies support the use of vestibular rehabilitation physical therapy for persons with peripheral vestibular disorders. There are emerging data that support vestibular rehabilitation physical therapy for persons with central vestibular disorders.

Keywords: dizziness; rehabilitation; vestibular

1. Introduction

Vestibular dysfunction is typically characterized by vertigo (i.e., an illusionary sense of motion) and imbalance owing to disturbances in gaze and postural stability.[1] Dizziness as a complaint is common among adults, especially in people older than 75 years of age.[2,3] Sloan et al[4] reported that in community living adults older than 60 years of age, the 1-year prevalence of having significant dizziness that prompted a medical evaluation, intervention with a medication, or that affected activities within the past year was 20%. In people older the age of 75, the 1-year prevalence of experiencing dizziness provoking a visit to the primary care physician was 7%. Data from 2001 through 2004 projected that 35% of adults older than 40 years of age in the United States have vestibular disorders.[5] Those with vestibular dysfunction also had a 12-fold increase in reported falls rates.[5] Unexplained falls in the emergency department have been related to vestibular complaints.[6] Vestibular disorders significantly decrease balance confidence and increase the likelihood of falls.[7] Treatment of vestibular deficits reduces the burden of fall related injuries and improves quality of life.[8−10]

2. Methods

We conducted a literature review, with "vestibular dysfunction" and "rehabilitation" as keywords using PUBMED, MEDLINE, and CINAHL databases. All articles that were published in the English language between 1984 and 2011 were reviewed. We also searched the reference lists in the publications that we obtained in an attempt to find relevant citations. For each study, we reviewed the methodology, results, discussion, and conclusion sections. We attempted to summarize the information from these publications with regard to symptoms and disorders among children, adults, and older persons living with vestibular disorders.

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3. Causes of vestibular dysfunction

The most common causes of peripheral vestibular disorders include benign paroxysmal positional vertigo (BPPV), vestibular neuronitis, and Ménière disease.[11] Benign paroxysmal positional vertigo is characterized by brief periods of vertigo triggered by a change in position of a person's head relative to gravity[12,13] and is an underestimated cause of dizziness or vertigo in older people frequently seen in the primary care setting.[14,15] Vestibular neuronitis is an acute peripheral vestibular dysfunction syndrome characterized by rapid onset of severe vertigo, nausea, vomiting, and gait instability that appears to be optimally managed with a combination of medication and vestibular rehabilitation.[16,17] Ménière disease is typically characterized by episodic vertigo, nausea, and often vomiting lasting for minutes to hours, fluctuating low frequency sensorineural hearing loss, tinnitus, and aural fullness.[18] All of the above conditions appear to respond favorably to vestibular rehabilitation.

Central vestibular disorders are less common, but they can have significant functional ramifications.[19] Central vestibular disorders often present with constant symptoms, an inability to ambulate, and nystagmus that is either not suppressed or may even increase in intensity with fixation on a target object.[16] Conversely, if a patient presents with nystagmus of peripheral origin and is asked to fixate on a target, their nystagmus typically diminishes in intensity, thus helping the practitioner to differentiate between central and peripheral nystagmus. The most common central vestibular disorder is migraine dizziness followed by multiple sclerosis and then other central vestibular disorders. The patient's history is the key factor in differentiating peripheral and central causes of vertigo.[20] Persons presenting to the emergency department with an inability to ambulate should always be carefully examined for central pathology.[16]

4. Symptoms of vestibular dysfunction

Typically, patients with acute vestibular disorders complain of dizziness, vertigo, visual blurring, oscillopsia (a jumping of the visual field associated with movement of the head), and feelings of being off balance. Occasionally, some may complain of nausea. Making the diagnosis when the chief complaint of the patient is dizziness can be challenging with so many presenting complaints. Hoffman et al[21] suggest that most clinicians can confirm the diagnosis in persons complaining of dizziness 75% of the time based on the history and physical examination. Occasionally, cardiovascular, neurologic, and laboratory testing may be needed to confirm the patient's diagnosis based on the clinical evaluation findings.[21,22]

5. What is vestibular physical therapy?

Vestibular physical therapy is a program of exercises designed to either adapt the vestibuloocular reflex (VOR), i.e. change the gain of the VOR, habituate the person to movement, or to teach sensory substitution plus improve a person's balance/postural control.[23] In persons with peripheral vestibular disorders (exclusive of BPPV), vestibular rehabilitation generally attempts to "adapt" the error signal from the involved ear and change the gain through the use of specific eye/head movements.[24] Adaptation of the VOR through head movements has been demonstrated in both primates and humans.[25–27] Habituation is another concept that is used in the rehabilitation of the dizzy patient whereby a person practices a provoking maneuver repetitively in order to be better able to control their symptoms.[28] Physical therapists use VOR adaptation exercises as their first choice of vestibular exercises to attempt to decrease dizziness complaints. Sensory substitution is often used to augment loss of vestibular inputs. An example of sensory substitution is the use of Tai Chi to enhance distal sensation.[29] Older persons, with or without distal sensory problems, who practiced Tai Chi have demonstrated changes in distal sensation after a 6-month training program.[29] Most commonly, physical therapists use the canalith-repositioning maneuver to treat BPPV.[30]

Vestibular rehabilitation is effective and beneficial for many patients with disequilibrium and balance disorders. Relief of symptoms of vertigo, improved balance and postural control, decreased dizziness, and improvements of quality of life have all been reported after a course of vestibular rehabilitation. A recent Cochrane review reported that there was moderate to strong evidence, based on high quality trials, that vestibular rehabilitation for persons with peripheral vestibular dysfunction is safe and effective.[31] Yardley[32] recently suggested that vestibular rehabilitation in primary care settings is a safe and effective intervention for persons presenting with dizziness symptoms. Negative prognostic factors related to vestibular physical therapy are summarized in Table 1.

Objective and subjective improvement in participants with chronic peripheral and central vestibular disorders have been documented.[19,23,30,31] Vestibular rehabilitation is inexpensive and useful in primary care settings[32] and has recently been introduced into some emergency departments.[31]

6. Examination of the person with a vestibular disorder

A thorough dizziness and balance history is obtained prior to the start of the physical examination. Patients are asked to complete the Dizziness Handicap Inventory (DHI) or a verbal/visual analog scale (VAS) to determine how dizziness is affecting function.[33,34] Scores obtained from the analog scales

Table 1
Negative prognostic factors that may hinder recovery after a vestibular disorder.

History of migraines
Inability to move head or body
Distal sensory impairment
Visual dysfunction (strabismus, cataracts, macular degeneration, glaucoma)
Memory impairment
Fear of falling
Anxiety/psychiatric comorbidities

or the DHI can be compared at discharge to determine if the patients' dizziness perception has changed. The DHI is a reliable, standardized questionnaire that addresses the person's perceived handicap from dizziness. The DHI can be subdivided into three subscales: emotional, physical, and functional.[34] People with peripheral and central vestibular conditions have demonstrated change over time using the DHI [35,36] as well as with the VAS.[33,37]

The Activities-specific Balance Confidence (ABC) scale has been used to quantify balance confidence in older adults and persons with vestibular disorders.[38,39] The ABC scale is from 0%−100%, with 100% indicating optimal balance confidence. Persons are asked to rate their confidence while performing 16 different balance tasks, and a total score is generated. Scores of 67% or less have been related to increased fall risk in older people.[40] Alghwiri et al[41] recently compared many of the commonly used instruments that assess function in persons with vestibular disorders according to the International Classification of Function, Disability and Health.

Asking a patient about whether he or she has recently fallen helps the physical therapist develop an appropriate plan of care. Falls can be catastrophic in consequence for older adults and many falls are associated with vestibular dysfunction.[5,7,42,43] The clinician needs to adjust their behavior in the clinic if the patient has reported recent falls by guarding more closely during challenging balance tasks.

Physical therapists perform objective and subjective testing to determine functional deficits in persons with dizziness. Measures of static and dynamic balance plus gait are recorded, as are subjective measures of dizziness, nausea, vertigo, and perceived handicap and balance. Examples of static and dynamic balance testing include standing in the Romberg position, semi-tandem standing, tandem Romberg position, and single leg stance. The length of time that a patient can maintain the position and/or the amount of sway is recorded in order to determine if the patient is improving.[44] All of the above positions can be manipulated by changing the surface support (solid versus standing on a compliant surface), eyes open versus closed, and also with head/body movements while attempting to maintain the position without a fall, step, increased sway, or excessive arm movements.[23]

Static and dynamic balance test positions can also be used by the physical therapist to identify the optimal exercise prescription in order to improve a patient's postural control under the various conditions described above. The modified Clinical Test of Sensory Integration and Balance (CTSIB) consists of four of the above conditions (eyes open/closed on a firm and compliant surface) and is used to quantify changes in postural sway over time.[44,45] Patients are timed using a stopwatch in the four stance positions, usually for up to 30 seconds. Computerized dynamic posturography is used in tertiary care centers to systematically record postural control and has been used to demonstrate change over time in persons with vestibular disorders.[46,47] During the different test conditions, the walls and floor may move to test the person's ability to use visual, somatosensory and vestibular inputs for postural control.

Gait measures are commonly used to determine if there are any functional deficits in the person with dizziness/balance disorders include gait speed,[48] the Timed Up and Go (TUG) test,[49] the Dynamic Gait Index (DGI),[50] and the Functional Gait Assessment (FGA).[51] Change over time is recorded to determine if the patient is improving. Other than gait speed, all of the instruments record the ability of the patient to turn while walking. The DGI and FGA emphasize head movements during gait plus higher-level gait activities such as walking backward, turning, going up and down stairs, and walking with eyes closed. Scores are recorded (either ordinal or ratio data) and compared over time.

The physical therapists examination also includes an assessment of strength, range of motion, cranial nerve function, sensation, and eye function. Saccades, VOR cancellation, vergence, the head thrust test, gaze-evoked nystagmus, and smooth pursuits are evaluated for accuracy and normalcy. The ability to move the head and visualize a target has been called dynamic visual acuity and is a functional test of the VOR. The clinical and instrumented versions of the dynamic visual acuity test have been used to demonstrate improvements in VOR function over time.[52]

7. Goals of vestibular physical therapy

The goal of the physical therapy treatment plan is designed to address those patients presenting complaints and symptoms. Patients complain of feeling dizzy, being off balance, or even of experiencing nausea with their vestibular disorder.[16,23,53] Falls are also associated with vestibular dysfunction.[5,7,43,54] The physical therapist's goals often include (1) decreasing dizziness, (2) increasing balance confidence, (3) decreasing the risk of falling, (4) improving the function of the VOR, (5) improving gait, especially with head movements, as patients have a tendency to move "en bloc" as a unit with little rotation of the trunk or head to minimize the sensation of dizziness, (6) switching the persons dependence on one sensory modality so that they can switch between somatosensation, remaining vestibular function, and vision, (7) enhancing walking mobility and endurance, and (8) decreasing anxiety that may be a result of the sensory mismatch that is occurring with the abnormal or absent vestibular input.

Exercises are prescribed that address VOR adaptation, habituation, sensory substitution, gait and posture, strengthening, flexibility, and endurance to maximize functioning. Customized exercise programs have been shown to be more effective than providing a patient with a generic exercise program.[47,55] It is thought that compliance is enhanced with customization and with follow-up visits with a physical therapist[56]; however, Cohen and Yardley[32,57,58] have shown that patients can also improve with a home exercise program.

8. Physical therapist interventions

There are three theories in the literature related to how people adapt to vestibular insult; these include VOR adaptation, substitution, and habituation. Vestibuloocular adaptation

is most commonly used in the rehabilitation of persons with vestibular disorders. Often eye/head coordination exercises are provided for patients with vestibular disorders to change the gain of the VOR. Active movement has been shown to be more effective than passive head movements. Patients are often asked to maintain gaze during active head motion (Fig. 1) and perform the exercises in the pitch and yaw planes.[23,59] The eye/head exercises involve moving the head while focusing on a stationary target and keeping the target's image clear on the retina. The VOR adaptation type of exercise produces retinal slip and assists in re-equilibrating VOR function after vestibular insult.[16] Generally, exercises are progressed from sitting to standing and then to ambulation. Also, the backgrounds are adjusted as the patient improves from simple backgrounds to more complex and visually stimulating backgrounds such as checkerboard patterns, stripes, or backgrounds with movement in their central or peripheral visual fields.[23] Surface supports are also adjusted based on the patient's abilities, such as standing on a solid surface, grass, a foam pad, or even standing in sand.

Patients with bilateral vestibular loss use saccades to assist with compensation after vestibular damage since VOR function is severely damaged or absent.[60] The saccadic eye system can assist with higher speed functional eye movements in persons with bilateral vestibular loss. Patients are trained to perform saccadic eye exercises whereby they are asked to shift their gaze quickly between targets both up/down and right/left. The exercises are progressed from sitting to standing and then to gait. Patients with bilateral vestibular loss often require an assistive device during ambulation such as a cane or walker because of the increased prevalence of falls in persons with bilateral loss.[54] Documented changes have been demonstrated in postural control after an individualized course of vestibular physical therapy.[61] Generally, most patients are seen for intervention one to two times per week for 6−8 weeks for persons with peripheral vestibular disorders.[58] Persons with central or combined peripheral and central vestibular disorders have a longer time course of recovery to see clinically meaningful changes.[23]

Fig. 1. Patient standing and performing the vestibuloocular reflex adaptation exercise in the yaw plane. The objective is to clearly see the target while the patient moves his or her head as quickly as possible.

Head movement is incorporated into gait, as many persons with vestibular disorders will walk with little head/trunk rotation. Early mobilization after vestibular injury may prevent some of the abnormal compensatory behaviors seen after vestibular disorders such as neck stiffness and fear of falling. Almost every patient, as part of their exercise prescription, is asked to begin a walking program to further mobilize the patient and ensure that they are actively participating in their community.

Occasionally, patients are provided habituation exercises. Habituation exercises are movement experiences whereby the person is exposed to the provoking stimuli and is desensitized by repetition of the provocative movements.[62]

Most patients with vestibular disorders also have associated balance dysfunction. A thorough exercise program usually includes higher-level balance activities that are practiced both in the clinic and at home. Simple exercises such as standing in the Romberg position are begun to prevent the patient from falling. The standing and walking exercises are often progressed by changing the base of support, moving the upper extremities or head, and changing the speed at which activities are performed from slow to faster as the patient improves. Safety is always emphasized, especially in the home program. Gradually, the exercises are advanced over a series of visits.

Pavlou et al[10] have suggested the use of provocative visually projected scenes to assist in the recovery of the VOR in persons with vestibular disorders. Others previously have used optokinetic stimuli to assist with recovery of the VOR.[28,63] Virtual reality has also been used recently to stimulate recovery in persons postvestibular insult.[25−27] Visual stimuli appear to assist in adapting the VOR gain and improving the patient's functional capabilities.

The use of vibrotactile feedback has been used recently to enhance postural control during gait in persons with vestibular disorders (Fig. 2).[64,65] Trunk stimuli from the vibrotactors appear to enhance postural control during stance and gait in persons with vestibular disorders.[53,64]

Patients presenting with BPPV are treated with the canalith repositioning maneuver[30] and often are provided balance exercises afterwards if they are older; this is because older adults continue to experience postural control abnormalities after repositioning.[42] Benign paroxysmal positional vertigo continues to be an under-recognized phenomena that is associated with an increased risk of falling and impaired quality of

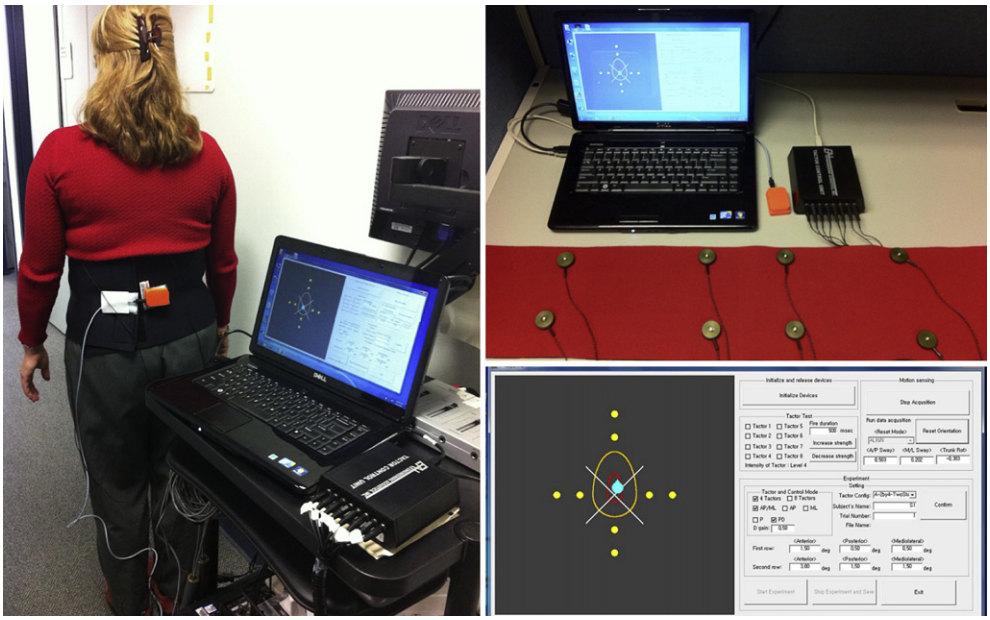

Fig. 2. Use of a vibrotactile device to enhance postural control in persons with vestibular disorders. The device consists of a waistband and tactors that vibrate to "warn" the patient that he or she has exceeded the preset limits of stability. Eight tactors are placed around the waist. (Technology developed by Kathleen Sienko, PhD, University of Michigan, Ann Arbor, MI, USA.)

life.[66] The typical presentation includes vertigo or dizziness associated with a change of head position with symptoms lasting under one minute.[30] The BPPV treatment maneuvers are highly effective in improving quality of life, decreasing falls, and decreasing vertigo associated with a change of head position.[9,66,67] In a recent systematic review, the resolution rates of BPPV were between 22 and 37 times better in persons who received the canalith repositioning maneuver compared to a sham intervention.[12]

9. Efficacy of vestibular physical therapy

Vestibular physical therapy has been in use since the 1940s when it was first introduced by Cooksey and Cawthorne,[68,69] but it has only gained mainstream attention over the last 15−20 years. Norre and colleagues[62,70] promoted vestibular rehabilitation in the 1980s, and vestibular rehabilitation is now considered the standard of care for persons with peripheral vestibular dysfunction based on a recent Cochrane review.[71]

Vestibular exercises improve balance, decrease risk of falling, decrease dizziness, and improve quality of life.[10,12,36,37,52,59,61,63,71−73] Persons postoperatively after neurectomy, vestibular schwannoma removal, labyrinthectomy or after gentamicin injection appear to compensate faster after vestibular rehabilitation.[74−76] El Kashlan et al[36] have suggested that aggressive vestibular rehabilitation exercises should be provided for patients who may be at risk for having persistent imbalance after surgery. After a vestibular insult, most patients can effectively utilize central compensatory mechanisms for recovery. Early mobilization may decrease the change of patients developing fear of falling and anxiety from their dizziness symptoms. Cass et al[77] reported that 60% of patients who participated in a vestibular exercise program following surgery showed objective improvement of balance function, with 25% of the patients improving to normal balance scores on the sensory organization test of computerized dynamic posturography.

Vestibular exercises improve vestibulospinal compensation in patients with acute peripheral vestibular disorders.[59] Vestibular adaptation exercises result in improved postural stability and in a diminished perception of disequilibrium in both the chronic and acute stages.[73] Many patients with bilateral vestibular loss benefit from an individualized exercise program by improving physical function and reducing self-perceived levels of handicap.[78] Other studies have also shown significant improvements in symptoms, disability, balance, postural stability and quality of life in persons with chronic unilateral vestibular hypofunction after a customized exercise program.[79,80] Vestibular physical therapy enhances the recovery of the VOR and promotes vestibular compensation. Due to the fluctuating nature of Ménière disease, vestibular physical therapy has a limited role in its treatment.[18,77]

Traumatic head injury frequently results in vestibular dysfunction with resultant symptoms of vertigo and imbalance. Persons with head injuries can experience unilateral or bilateral hypofunction, central vestibular signs and symptoms and also unilateral or bilateral BPPV.[81,82] Vestibular signs and symptoms can be successfully treated with exercise, although the specific exercises used will depend on the patient's complaints.[83] Recent evidence suggests that vestibular rehabilitation in young and older persons post concussion may speed recovery.[84]

Patients with acute or chronic cerebellar lesions may be able to learn to improve their postural stability following vestibular physical therapy,[85] although Brown et al[78] reported

that of all central vestibular disorders, persons with cerebellar disorders improved the least after vestibular rehabilitation. Persons with vertigo related to relapsing-remitting multiple scleroses who participated in a vestibular exercise program improved their balance and noted less dizziness.[86,87]

There is a strong relationship between vestibular and anxiety disorders[88] Vestibular physical therapy positively influences the emotional component of persons with chronic vestibular disorders without pharmacological or psychotherapy treatments.[89] Early vestibular physical therapy may also prevent panic disorders caused by hyperventilation syndrome[90] and has been shown to improve balance in persons with panic disorders.[37]

Older adults appear to respond favorably to vestibular physical therapy, with changes noted in balance and dizziness.[91] Age does not appear to affect vestibular physical therapy outcomes.[91] Decline in vestibular function with increasing age, which may be related to deterioration in the peripheral or central vestibular systems, may be partly responsible for the high incidence of falls in the elderly.[5,92,93] Vestibular physical therapy plays an important preventive role in reducing falls in at risk elderly patients, with beneficial effects noted.[94,95] Age does not significantly influence the beneficial effects of VOR for persons with vestibular disorder.[91] One report suggests that there is a possibility that adaptive plastic mechanisms which normally assist in the recalibration of the VOR after vestibular injury might deteriorate with aging.[96] Children also appear to benefit from vestibular physical therapy.[97−100] Children with sensorineural hearing loss, post concussion, and those post cochlear implant may benefit from vestibular rehabilitation if they have evidence of vestibular dysfunction.[98−100]

In conclusion, vestibular rehabilitation therapy has become a mainstay in the management of patients with dizziness and balance disorders. Numerous case studies, case series with observational and controlled trials support the use of vestibular rehabilitation for patients with peripheral vestibular disorders. There is emerging evidence supporting the use of vestibular rehabilitation for patients with central vestibular disorders.

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