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Physical Therapy Principles in Rehabilitation

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Abstract

The use of vestibular rehabilitation for persons with balance and vestibular disorders is used to improve function and decrease dizziness symptoms. Principles of a vestibular rehabilitation program are described including common exercises and outcome measures used to report change. A review of negative and positive predictive factors related to recovery is also provided.

Keywords

vestibular rehabilitation; exercise

Historical background

The use of exercises to treat dizziness and balance dysfunction is not novel. Cawthorne (Cawthorne, 1944) and Cooksey (Cooksey, 1946), as early as the 1950's, used group exercises to improve function and decrease dizziness in persons living with dizziness. The exercises were provided in a group setting and consisted of eye and head movements progressing to trunk movements and even climbing ladders and playing games. More recent evidence suggests that the exercises that Cawthorne and Cooksey described continue to be effective in decreasing dizziness and improving functional independence (Corna et al., 2003). Norre and Telian and Shepard expanded on the principles of Cawthorne and Cooksey and today vestibular rehabilitation, as it has come to be known, is a well established and accepted intervention for persons with balance and vestibular disorders.

The Rehabilitation Team

Physical and occupational therapists as well as some audiologists perform vestibular rehabilitation and are ideally suited based on their training in restoring functional activities, balance, strengthening, and preventing falls. It is imperative that the people administering

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the rehabilitation program have experience and an interest in treating persons with vestibular disorders for optimal results. Although not proven, it appears that the results of vestibular rehabilitation may vary depending on the experience of the treating therapist.

The primary referral sources for vestibular rehabilitation are usually primary care physicians, otolaryngologists, and neurologists. When patients are referred by a primary care physician, the treating therapist may use their professional judgment as to whether additional testing or a referral to another medical team specialist is advised. Ideally, the vestibular rehabilitation team at a specialized center should consist of an otolaryngologist, neurologist, audiologist, psychiatrist, and either a physical or occupational therapist who are all interested in the treatment of the person with dizziness. The neurologist or otolaryngologist will often interpret the vestibular function tests and the audiologist will perform the audiometric testing. A referral to a psychiatrist may be necessary if the patient has significant anxiety, panic attacks, or depression associated with their vestibular disorder.

Prior to referring a person for rehabilitation, it is advised that the physician develop a working relationship with the therapist. Persons with dizziness often present with a complex array of signs and symptoms that must be interpreted correctly in order to best assist the person in their functional recovery. People with dizziness can get worse if they are prescribed exercise that is too advanced or are not appropriate for their condition. In addition, vestibular rehabilitation exercises often work best when combined with pharmacotherapy. Making patients dizziness worse can result in patients not returning for further therapy, thus causing them to have greater functional impairment.

Theories of why rehabilitation improves function

Over the past 65 years, exercises for persons with vestibular and balance disorders have evolved but there continue to be many unanswered questions about why exercise decreases dizziness and motion sensitivity. The concept of habituation has been proposed as the rationale for why persons improve after exercise. Norre and colleagues (Norre and Beckers, 1988, Norre, 1984) have proposed habituation as one possible mechanism by which dizziness may be decreased. They suggest that by repeating a movement, one can retrain the brain to manage the offending stimuli. Nudo et al. (Nudo, 2003) have provided some preliminary evidence that in persons post-brain injury, remodeling occurs when the cerebral cortex is “shaped” by the motor experiences that the person receives after the insult. The motor experiences (exercises) that are provided appear to alter the person’s recovery (Nudo, 2003).

Adaptation of the vestibulo-ocular reflex (VOR) has been proposed as another method of recovery. With acute injury, the gain of the VOR is usually reduced, resulting in eye movement velocity that is less than head movement velocity. Consequently, as a person moves their head, the image of what a person is stabilizing their vision upon slips across the retina and causes blurred vision. This retinal slip, i.e. movement of the visual image across the retina, causes an error signal resulting in a change in the gain of the VOR. (Miles and Braitman, 1980). Therefore, active head movements are essential for VOR adaptation. Exercises that may induce retinal slip include having patients move their head while trying

to stabilize gaze on a stationary object (e.g. VORx1 exercise, see below). Graham and Dutia (Graham and Dutia, 2001) have suggested that in response to exercises promoting retinal slip, there are adaptive changes in commissural gain in addition to changes in the regulation of the gamma-aminobutyric acid (GABA) system in the vestibular nucleus that may be an explanation of vestibular plasticity.

Sensory substitution has also been suggested as a method of recovery. If the vestibular system is not functioning optimally, the use of the visual and somatosensory systems are enhanced to assist in postural control. Exercises are provided to re-weight the sensory adaptive mechanisms in order to prioritize visual and somatosensation [Peterka?, Jeka, Allison, Horak]. Postural sway may also be stabilized using visual fixation, (Jahn et al., 2002). Jahn et al. proposed that ocular motor efference copy signals are critical for the control of posture. Persons with vestibular disorders often fixate on objects while walking to feel more stable. One of the goals of vestibular rehabilitation is to allow free head movement without dizziness, especially during gait. While visual fixation will result in stabilizing postural sway,, it does not appear to assist in the functional recovery of the VOR.

Principles of Vestibular Rehabilitation

There is evidence that suggests that an individualized exercise program is better than a generic exercise program (Shepard and Telian, 1995). In persons with peripheral vestibular disorders, a generic exercise program that included isometric exercise was not effective at improving balance when compared to a program of vestibular exercises (Horak et al., 1992, Black and Pesznecker, 2003). Krebs et al (Krebs et al., 1993) suggest that persons with peripheral vestibular disorders who received vestibular rehabilitation demonstrated greater improvement after a 6 week intervention program compared with those who performed a strengthening program. Patients who continued to perform their exercises at 1 year had better outcomes than those who were not compliant with their exercises. In an earlier study by Krebs et al (Krebs et al., 1993), they suggested that persons with bilateral vestibular loss improved more with a customized exercise program than with a generalized strengthening program. Patients may benefit from the addition of cognitive-behavioral therapy in addition to vestibular rehabilitation (Johansson et al., 2001).

In our clinic, the vestibular rehabilitation treatment sessions are highly structured. During the initial evaluation, medical records from the referring physician and any diagnostic testing are reviewed, as are self report of patient impairments and disability. A detailed history considering the initial onset and course of the illness is taken, complete with reports of symptom severity during activity. Then examination of eye movements and gaze stability performance is assessed, followed by screeneing for presence of Benign Paroxysmal Positional Vertigo (BPPV). Finally, a comprehensive evaluation of standing and walking balance is performed. Patient goals of the intervention can then be determined. Based on the findings from the examination, a home exercise program (HEP) that addresses the patient’s impairments and functional limitations developed and explained to the patient. If time permits, the therapist initiates treatment.

During follow-up visits, an assessment of the patient's symptoms and compliance with the HEP since the last clinic visit is performed. The therapist then leads the patient through an exercise program, frequently asking about the severity of symptoms, as well as determining if any of the exercises can be progressed. Finally, the therapist may decide to update the HEP based on the patient's performance.

Exercise prescription (mode, intensity of symptoms, frequency, and duration)

It is helpful to classify persons into one of 3 groups based on their complaints: those with dizziness complaints, those with balance problems, and those with both. Each category of patients discussed above is treated differently based on their presenting complaints.

The most common exercises provided for persons with complaints of dizziness are gaze stabilization or VOR adaptation exercises for persons with peripheral vestibular hypofunction. Active eye and head movements are performed in a lighted room while the patient focuses on a target appear to recalibrate the VOR through the concept of retinal slip. The exercises appear to be task specific. The distance from the target, speed and frequency of head movement, plane of head movement, base of support, and posture of the subject will affect the ultimate outcome of the exercise prescription. All of the above factors are manipulated in order to optimize functional recovery.

Standing and walking balance exercises are incorporated for patients who have deficits in postural control. Some patients may be over-reliant on one sensory system (vision, vestiublar or somatosensation). Clinicians will manipulate the visual, somatosensory, or vestibular sensory systems in order to reduce influence of the one dominant sensory system. Changes in the size of the base of support, modifications in the surface compliance (level vs. foam), and control of the amount of light (eyes open, in dimmed light, and eyes closed) are incorporated to progress balance activities. See Table 1 for an example of how to progress balance exercises. Standing balance and gait activities are usually incorporated simultaneously, if walking can be performed safely with or without an assistive device. Head movements, walking on uneven surfaces and changes of directions are manipulated to provide the person with a rich variety of experiences to draw upon so that they are able to successfully navigate novel environments.

Various forms of habituation exercises are used for persons who become dizzy with visually complex environments. Optokinetic environments such as what is stimulated by a disco ball (Pavlou), in virtual environments (Sparto, whitney refs), and with head movements when viewing a complex pattern are also used as therapeutic techniques to decrease dizziness. The concept of repeating a provocative movement many times was popularized by Norre and DeWeerdt. This form of habitation therapy is used in audiology with tinnitus reduction programs.

The length of time seen and number of visits needed to improve function is largely unknown. Furthermore, because most of the recovery probably occurs due to the performance of the HEP, because of the greater volume compared with the in-clinic exercise

performance, it is also unknown what frequency and duration of home exercises is optimal. The range of visits can range from 2–3 times a week to once every 2–3 weeks. The duration of the interventions can last from as little as 1 to 2 weeks to several months. Most persons with vestibular disorders are seen for visits lasting between 45 minutes and one hour. Patient symptoms dictate how long the exercise sessions. Persons who become highly symptomatic with exercise need modifications made to the program such as shorter bouts of exercise throughout the day, different exercises, less complex visual backgrounds, or slower speed of head movements.([Gill-Body and Krebs, 1994]) Progression is usually gauged based on the patient's perception of their dizziness. Typically one does not want the patient to be dizzy longer than 20 minutes following the exercises. During and immediately following the exercises, patients may experience an increase in dizziness, nausea, or imbalance after completing the exercise program. The therapist and the patient may consider agreeing upon a subjective maximum dizziness rating that the patient is to tolerate during the exercise.

Equipment

Vestibular rehabilitation can be performed with minimal equipment, although infrared goggles are necessary to definitively diagnose and treat BPPV. Typical low cost equipment used includes eye charts, high density foam, balance boards, disco balls, and targets that can be fixed to a wall with Velcro. Higher cost items that are used in vestibular rehabilitation programs include moving posture platforms, virtual reality devices, and mechanical devices that can be used to objectively quantify, record, and manage BPPV as the subject is positioned in a 360 degree of motion chair (www.vesticon.com).

Outcome measures

There are at least nine self-report scales that are used as outcome measures in vestibular rehabilitation. Eight were recently compared to determine if they incorporated activity and participation items included in the International Classification of Function from the World Health Organization.(Alia- paper one). The eight self-report measures included the (1) Activities-specific Balance Confidence Scale (ABC), (2) the Dizziness Handicap Inventory (DHI), (3) the UCLA- Dizziness Questionnaire, (4) the Activities of Daily Living Questionnaire (ADLQ), (5) the Vestibular Disorders Activities of Daily Living Scale (VADL), (6) the Prototype Questionnaire, (7) the Vertigo Handicap Questionnaire (VHQ), and (8) the Vestibular Rehabilitation Benefit Questionnaire. The ninth commonly used self report measure is the visual or verbal analog scale. Visual analog scales have been reported to be reliable in persons with vestibular hypofunction (Hall/herdman). All of the above scales have been used to quantify effectiveness of rehabilitation outcomes. Self report is a powerful measure with persons with dizziness. Generally, it is accepted that if a person feels better and is participating more in life events, then the person has improved. Out of the eight scales reported above, the top four that included activities and participation items included the VADL, the ADLQ, the ABC, and the DHI. (Alia's paper) All of the self report measures are all capable of recording change over time in persons with balance and vestibular disorders.

The DHI is the most established of the self-report measures. There is a shortened version of the DHI and 3 subscales. Higher (worse) scores on the DHI have been related to increased fall risk in persons with balance and vestibular disorders. Changes of 18 or more are considered to be clinically significant.

The ABC scale was developed for older adults to determine their fear of falling. The ABC scale has been validated in persons with vestibular disorders. High scores are better and scores in community living older adults of 67 or less have been related to increased fall risk.

It is also common to use performance measures to quantify changes in function over time with rehabilitation as an indicator of success. One of the most powerful measures of change in older adults is recording casual gait speed. Gait speed is often recorded over a 3–4 m path with a stop watch. Changes of 0.1 m/s are considered to be a clinically significant change in function (Perera paper). Slowing of gait speed has been related to increased morbidity in older adults.

The Timed Up and Go (TUG) is often used as a performance outcome in persons with vestibular disorders. (Gill-body, whitney, krebs) The TUG is a recording of the time that it takes to stand from a chair with armrests, walk 3 meters, turn and return to sitting. Scores of greater than 11.1 s have been related to reported falls in persons with vestibular disorders.

The Dynamic Gait Index (DGI) is a measure of how well persons can ambulate under different conditions including walking, walking with head turns, walking around and over objects, going up and down steps, and waking and turning quickly. Each items is scored on a 0–3 basis with a total point value of 24. Scores of 19 or less have been suggestive of increased risk of falling in older persons. The Functional Gait Assessment was an attempt to better define the scoring of the DGI and to include different items to decrease ceiling effects of the DGI. A fall risk cut-off was recently established at 23 out of 30 total points. (Wrisley 2010).

The modified Clinical Test of Sensory Integration and Balance (mCTSIB) is used to determine standing balance deficits. One stands on a solid surface with eyes open and closed, feet together and then assumes the same stance and eyes conditions while standing on a compliant foam surface. Scores are generally the time that the person can maintain the position. Persons who lose their balance while standing on the foam surface with eyes open are often considered to be surface dependent. Changes have been noted in the mCTISB over the course of rehabilitation.

Motion sensitivity

Motion induced symptoms can be particularly problematic for persons with vestibular disorders. With significant “space and motion” sensitivity (Jacob et al., 1993), “visual vertigo”,(Bronstein) or chronic subjective dizziness (Staab) patients may become very symptomatic in visually complex environments and cannot function. Persons with visually induced symptoms seem to be aided by medication and then can better tolerate their adaptive exercise program. Those with suspected migraine symptoms also appear to demonstrate better rehab outcomes when treated with medication plus physical therapy interventions.

(Wrisley 2000?; Jacobson? I can find this reference) Therapists attempt to quantify the motion sensitivity with verbal or visual analog scales that often range from 0–10 or 1–100.

Negative and Positive factors related to recovery

The degree to which people improve depends on their diagnosis, medication use or non-use, predisposing co-morbidities, motivation, and family support plus other factors outlined in Table 2. Persons with peripheral and central vestibular disorders can be helped with vestibular rehabilitation (Table 3). Generally, persons with peripheral diagnoses are considered to obtain better treatment outcomes than those with central vestibular disorders. (Whitney and Rossi). However, those with severe bilateral peripheral loss provide challenges to rehabilitation. Persons with both peripheral and central vestibular disorders have the poorest prognosis.(Whitney/Rossi and the Brown paper) Not all people, regardless of diagnosis, are helped with vestibular rehabilitation (Krebs et al., 2003) as the prognostic factors that affect outcome are not well understood.

Certain medications such as vestibular suppressants and anti-histamines may slow the adaptation process (Peppard, 1986), making recovery more difficult. Medications are not advised for benign paroxysmal positional vertigo (REF). However, in cases of vestibular neuritis, early steroid use has been associated with greater caloric function one year later in a randomized controlled trial. (Strupp, 2004) It is, therefore, important to carefully consider ordering medication for a person with dizziness. Advanced age is not an indicator for a poor prognosis. (Herdman, Whitney, and Cohen papers) Good cognition, motivation, a willingness to make themselves dizzy with the exercises, good psychologic support systems, and adequate somatosensation and vision are all positive factors that will affect recovery.

Conclusion

There are many principles to consider in designing a rehabilitation program for persons with vestibular dysfunction. The type of exercise, dose, diagnosis, co-morbidities, and appropriate outcome measures must all be considered to match the needs of the individual. Exercise programs must be regulated and dosed based on the response of the patient. No one exercise program is effective for all persons with vestibular disorders.

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Table 1

An example of a method to progress a balance exercise.

Standing with feet apart, eyes open
Standing with feet touching, eyes open
Standing with one foot ahead by a half-foot length, eyes open
Standing with the feet touching in a straight line, eyes open
The entire process could be repeated with eyes closed, with head movements in the pitch or yaw plane, with upper extremity movement, or on a compliant surface to make the balance exercise more difficult.

Table 2

Factors that complicate rehabilitation outcomes in persons with vestibular disorders.

A co morbid psychiatric disorder (anxiety, agoraphobia, major depressive disorder)
A history of migraine
Fear of falling and/or a history of falling
Lack of social support at home
Memory or cognitive deficits
Multiple medical co morbidities (coronary artery disease, orthopedic dysfunction, chronic obstructive pulmonary disease, diabetes, renal dysfunction)
Multiple medications
Multiple vestibular diagnoses: central *and* peripheral vestibular pathology, anxiety *and* migraine, BPPV *and* Menieres, or Menieres *and* migraine
Sensory co-morbidities, especially distal sensory loss or visual dysfunction

Table 3

Peripheral and central vestibular diagnoses that have demonstrated changes after vestibular physiotherapy.

Peripheral	Central
Benign Paroxysmal Positional Vertigo	Multiple sclerosis
Bilateral vestibular loss	Cerebellar ataxia or other cerebellar disorders
Labyrinthitis	
Meniere's disease	Mal de Debarquement
Neuronitis	Migraine related dizziness
Vestibulopathy	Panic disorder and agoraphobia with dizziness
	Post concussive disorder
	Stroke
	Traumatic brain injury