



## From Crisis to Compensation-Early Physical Therapy to Address Symptoms Resulting From Vestibular Neuritis in 54-Year-Old Female: A Case Report

Bhupinder Singh\* and Ashley Van Artsdalen

Department of Physical Therapy, College of Health and Human Services, California State University, USA

### Abstract

**Background:** Vestibular neuritis typically affects the superior vestibular nerve resulting in unilateral peripheral Vestibular Dysfunction (PVD). It is also linked to an increased rate of Benign Paroxysmal Positional Vertigo (BPPV). Patients are typically prescribed medications to address the symptoms associated with acute vestibular crisis, but are not referred to physical therapy for treatment of lingering symptoms of PVD after the crisis has passed. Physical therapy has been shown to be safe and effective for reducing symptoms and improving function for patients suffering from chronic PVD, but early intervention has not been studied extensively.

**Objective:** The purpose of this case is contrast the effect of early physical therapy intervention for a patient with symptoms resulting from acute vestibular neuritis with the traditional course of care.

**Case Presentation:** The patient was a 54-year-old female who was referred to physical therapy by an emergency room physician following diagnosis of acute vestibular neuritis. At time of evaluation, she was unable to independently perform many activities of daily living (ADLs). Examination revealed BPPV, motion sensitivity, and vestibular-ocular reflex dysfunction. Interventions included patient education, canalith repositioning maneuvers, habituation/compensation program, and gradual return to functional activities.

**Outcomes:** At discharge, the patient had achieved all of her goals and reported no symptoms. In addition, the patient demonstrated no limitation with any ADLs.

**Discussion:** The outcomes suggest that, for this patient, the chosen intervention resulted in complete resolution of symptoms. The key to the patient's rapid success was early intervention and patient education. Due to the patient's compliance and motivation, she recovered completely in less than three months.

### Introduction

Vestibular neuritis typically affects the superior vestibular nerve resulting in unilateral dysfunction of the utricle and superior and horizontal semi-circular canals [1]. Vestibular neuritis has been linked to increased rates of benign paroxysmal positional vertigo (BPPV), indicating that the dysfunction of the utricle may result in otoconia displacement into the posterior semi-circular canal. BPPV has been reported to occur in 15%-20% of patients post vestibular neuritis versus the 3% prevalence in the general population. Treatment of secondary BPPV using canalith repositioning maneuvers (CRMs) has been shown to be somewhat less effective than treating idiopathic BPPV, generally requiring more treatment sessions and demonstrating increased recurrence rates [1].

Typically, patients who suffer from vestibular neuritis are prescribed medications during the acute phase to suppress the vestibular system, curb nausea, and reduce anxiety. These medications are typically taken consistently and for an extended period of time. After resolution of the active vestibular crisis, motion sensitivity and oscillopsia lingers for the majority of patients. In a study published researching the effect of medication, the authors found that at 12 months post onset of vestibular neuritis, complete peripheral vestibular recovery ranged from 36%-62.4% of patients depending on the medications prescribed indicated that many patients continue to suffer from symptoms regardless of medication [2]. The result of vestibular dysfunction can be debilitating and, if left untreated, function generally declines further. Certain vestibular dysfunction can resolve spontaneously over time, but the patient suffers from symptoms much longer than necessary if it

### OPEN ACCESS

#### \*Correspondence:

Bhupinder Singh, Department of Physical Therapy, College of Health and Human Services, California State University, Fresno 5315 N. Campus Drive M/S PT29 Fresno, Ca 93740-8019, USA, Tel: (559) 278-4356; Fax: (559) 278-3635;

E-mail: bhsingh@csufresno.edu

Received Date: 26 May 2017

Accepted Date: 02 Sep 2017

Published Date: 04 Sep 2017

#### Citation:

Singh B, Van Artsdalen A. From Crisis to Compensation-Early Physical Therapy to Address Symptoms Resulting From Vestibular Neuritis in 54-Year-Old Female: A Case Report. *Ann Clin Case Rep.* 2017; 2: 1431.

ISSN: 2474-1655

Copyright © 2017 Bhupinder Singh. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Table 1:** Psychometric Properties of Tests and Measures.

Test	Reliability (interrater)	Validity (Criterion)	Sensitivity	Specificity	MCID	MDC
Head Thrust	NE	NE	35% [5]	95% [5]	N/A	N/A
Computerized DVA (NE for manual DVA)	NE	NE	94.5% [5]	95.2% [5]	NE	NE
DHI	NE	-0.64 [14] (correlated with ABC)	50% [15] (multiple sclerosis)	77% [15] (multiple sclerosis)	≥18 [8] (vestibular deficits)	17.18 [8] (vestibular deficits)
Dix-Hallpike	0.92 [16]		79.3% [17]	75% [17]	N/A	N/A
SOT	NE	NE	95% [10] (estimated)	NE	NE	>710
FGA	0.86 [18]	0.64 [18] (correlated with ABC)	100% [13] (community dwelling older adults)	72% [13] (community dwelling older adults)	>6 [19] (vestibular deficits)	4.2 [20] (stroke)

NE=Not established

**Table 2:** Goals.

<b>5 weeks</b>	Pt. will be independent with HEP
	SOT normal in all conditions
	Increase FGA by 40% (to 21/30) in order to improve ambulation in all conditions
	Decrease DHI score by 60% (to 32/100) to decrease activity limitation from dizziness to a moderate level (from severe)
<b>10 weeks</b>	Increase FGA by 90% (to 28/30) to allow for normal ambulation with all normal head/body motions
	Decrease DHI score by 90% (to 8/100) to decrease activity limitation from dizziness to a minimal level
	Decreased symptoms of dizziness to allow independence with all prior activities
	Independent with gait x 300 ft. with head turns for environment scanning with good path management to allow for safe ambulation in busy environments

is left untreated [3]. Though this is suggested, there is little research published about early intervention after acute vestibular neuritis.

Through a literature review, a single study was found by Strupp et al. [2] which addressed vestibular rehabilitation immediately following diagnosis of vestibular neuritis. The patients were all hospitalized and treatment was giving for seven days, followed by a detailed Home Exercise Program (HEP). The treatment group demonstrated significantly greater postural stability at a 30 day follow-up as compared with the control group. This being said, patients diagnosis with vestibular neuritis are now not generally hospitalized, and referral to vestibular rehab is not a standard procedure when the patients visit the emergency room or a primary care physician to receive treatment.

For patients with chronic peripheral vestibular dysfunction, physical therapy interventions including CRMs, Vestibular Ocular Reflex (VOR) retraining, vestibular spinal reflex (VSR) retraining, habituation, and adaptation/compensation have been reported to successfully reduce symptoms [4]. Prior to instructing the patient in any exercise, it is important to educate the patient on the expected results of rehabilitation. The patient must understand the mechanism of recovery in vestibular rehabilitation is error detection/error correction. This means the patient will have increased symptoms with the activities until the central nervous system adapts to the dysfunction. If the patient does not understand this progression, compliance with the home exercise program will decrease significantly [5].

According to Giray et al. [6] vestibular rehabilitation including adaptation, substitution, and balance activities results in significant improvement of symptoms, disability, balance, and postural stability in patients with chronic vestibular hypofunction [4,7]. Habituation and adaptations activities for vestibular recovery are also considered safe and effective forms of rehabilitation for patients with peripheral vestibular loss. Goals of vestibular rehabilitation often include reduction in symptoms, fear, and risk of falling. Improvements in

balance, VOR function, and gait (especially with head movements) are also expected [7].

The purpose of this case report is contrast the effect of early physical therapy intervention for a patient with symptoms resulting from acute vestibular neuritis with the traditional course of care.

## Case Presentation

### Patient history

Mrs. M., a 54-year-old female, was referred to physical therapy by an emergency room physician when she visited the emergency room ten days prior to the physical therapy evaluation with complaint of persistent vertigo, leading to diagnosis of vestibular neuritis. No clinical tests were performed to evaluate vestibular function. The patient was prescribed Reglan, Diazepam, and Meclizine to address symptoms of acute vestibular crisis and anxiety. She had not taken any medication for four days prior to beginning therapy. Her chief complaints at the time of the evaluation were motion sensitivity, imbalance, and oscillopsia. Mrs. M. had no history of similar symptoms. Her general health status was fair. She was overweight but had been active in aerobic exercise, successfully reducing her weight. The patient reported history of significant left knee dysfunction resulting from a prior ACL injury. She had history of multiple arthroscopic surgeries to address the dysfunction. She had no psychological medical history. Mrs. M. quit smoking three years prior to evaluation after smoking one pack per day for over thirty years. She indicated occasional drinking. She reported no significant family medical history.

Prior to vestibular neuritis, the patient was independent with all household and community activities. She was married and lived with her husband. Mrs. M. was a mother and grandmother and enjoyed visiting her family which required driving and flying frequently. She was a retired EMT, but remained active as a volunteer medical coordinator for community events such as concerts and festivals.

**Table 3:** Home Exercise Program.

Exercise	tx 1 eval	tx 2 (wk 1)	tx 3 (wk 2)	tx 4 (wk 2)	tx 5 (wk 3)	tx 6 (wk 3)	tx 7 (wk 4)	tx 8 (wk 5)	No tx (Wk 6)	tx 9 (wk 7)	tx 10 (wk 8) re-eval	tx 11 (wk 9)	tx 12 (wk 10) discharge
Gaze stabilization (yaw plane) 3 x 45-90 sec*			Firm surface, simple background, no pacing	Pacing 85 BPM, firm surface, simple background	Pacing 80 BPM, soft surface, simple background	Pacing 90 BPM, soft surface, complex background	Pacing 100 BPM, soft surface, complex background	Pacing 100 BPM, firm surface, narrow BOS, complex background	Pacing 110 BPM, firm surface, narrow BOS, complex background	Pacing 110 BPM, soft surface, narrow BOS, complex background	Hold	Hold	Hold
Gaze stabilization (pitch plane) 3 x 45-90 sec*			Firm surface, simple background, no pacing	Pacing 75 BPM, firm surface, simple background	Pacing 80 BPM, soft surface, complex background	Pacing 90 BPM, soft surface, complex background	Pacing 90 BPM, soft surface, complex background	Pacing 110 BPM, soft surface, complex background	Pacing 110 BPM, soft surface, complex background	Pacing 105 BPM, soft surface, narrow BOS, complex background	Hold	Hold	Hold
Brandt-Daroff 3 x 5		EO	EC	EC	EC	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
Log Roll 3 x 5		EC	EC	EC	EC	Hold	Hold	Hold	Hold	Hold	Hold	Hold	Hold
Standing head turns/head nods 5 x 5			EO, Firm surface (pt to progress to EC)	EO, soft surface	EC, soft surface	EC, soft surface	EC, soft surface	EC, soft surface	EC, soft surface	EC, firm surface, narrow BOS	Hold	Hold	Hold
Standing forward flexion 3 x 5					EO	EC	Hold	Hold	Hold	Hold	Hold	Hold	Hold
1/2 turns 3 x 5						EO	EO	pt to progress to EC when appropriate	EC	EC	EC	EC	EC
Ball bounces (Otolith stimulation) 3 x 30 sec								visual fixation, simple background	visual fixation, simple background	visual fixation, complex background	visual fixation, complex background	with cervical rotation, flexion, and extension	with cervical rotation, flexion, and extension
Ambulation with quick motions (otolith stimulation)												Stopping, turning	Stopping, turning

tx=treatment, EO=eyes open, EC=eyes closed, BOS=base of support

\*Pt self-progressed pace by 5 BPM when symptoms allowed (able to perform for >90 sec with symptom provocation <2/5)

At time of evaluation, Mrs. M. was unable to perform certain activities of daily living (ADLs) independently; she was limited with driving, ambulation, bending forward, rolling in bed, and functioning in visually complex environments secondary to her symptoms. Her husband was actively involved in her recovery and was able to provide transportation, as well as emotional support throughout the rehabilitation process.

Mrs. M.'s personal goals were to return to all prior activities without symptoms, including: an exercise program, volunteer activities in visually complex environment, and frequent traveling.

**Systems review**

Mrs. M.'s blood pressure was slightly elevated, but all other vital signs were within normal limits at rest (BP =144/72 mmHg, HR=78 BPM, RR= 16, O<sub>2sat</sub> = 99%). She reported no diagnosis of hypertension or cardiac disease.

The patient had no integumentary impairments. Scar formation, skin color, and skin integrity were normal, and she had no evidence of edema. Mrs. M.'s musculoskeletal system was generally unimpaired. Her gross range of motion and strength were within functional limits. She had history of left knee dysfunction, but reported only stair climbing and extended periods of standing caused discomfort. She stated she used the rail to climb stairs secondary to knee instability.

Her height was 1.73 m (5'8") and her weight was 113.4 kg (250 lbs.). The patient presented with no cognitive deficits, though she had extreme anxiety with movement secondary to fear of falling. Mrs. M. had neurological involvement secondary to her disease process. Her balance and locomotion were impaired by symptoms of motion sensitivity and imbalance. An in-depth evaluation of balance and gait was performed.

**Clinical impression #1:** The patient's rehab potential was good due to recent onset of symptoms. Her anxiety was also acute, beginning only with symptom onset. She was highly motivated to return to her normal activities.

To determine extent of dysfunction and plan interventions, full oculomotor exam, BPPV screen, impairment based balance testing, and functional testing were performed [5].

**Patient examination**

The psychometric properties of the tests and measures utilized are recorded in Table 1. Oculomotor exam revealed normal smooth pursuits and vergence indicating no central involvement. Self-paced vestibular-ocular reflex testing (VORx1, which indicates a gain of one between head and eye movements) resulted in patient report of increased dizziness and loss of visual focus. Head thrust and Dynamic Visual Acuity (DVA) tests, described by Gill-Body [5], were both

**Table 4:** Changes in Tests and Measures after 7 Weeks and 10 Weeks of Treatment.

Test	Eval	Re-eval	Discharge
DHI	80/100	30/100	4/100
Head Thrust	(+) Left with corrective saccades	NT	(-)
DVA	(+) with 8 lines lost	NT	(+) with 3 lines lost
Romberg	(+) with EC	NT	(-)
SOT	Difficulty in condition #2	No deficit	NT
FGA	15/30	25/30	28/30

EC=eyes closed  
NT=Not tested

positive suggesting vestibular hypofunction [5]. Subjective symptoms of dizziness were evaluated with the Dizziness Handicap Inventory (DHI). With the patient's score of 80/100, she was severely impaired by her symptoms [8]. Benign paroxysmal positional vertigo (BPPV) screen revealed positive right Dix-Hallpike with up-beating, right, torsional nystagmus, indicating right posterior canalithiasis [9]. Balance was screened with Romberg test which was positive eyes closed with right posterior loss of balance. To evaluate balance system impairment, the patient's sensory organization was tested using the NeuroCom<sup>®</sup> Balance Manager<sup>™</sup> computerized sensory organization test (SOT). Mrs. M. presented with somatosensory pattern indicated by difficulty in condition #2. No other impairments were noted with this test, although she reported extreme anxiety throughout testing. It was observed that the patient had large limits of stability, allowing her to remain standing though she demonstrated significant sway through tests conditions #5 and #6 which tax the vestibular system. Her composite score was within the normal range for her age [10].

Because the SOT indicated a somatosensory deficit, sensation of the lower extremities was assessed. Literature has demonstrated that peripheral neuropathy is suggested with the presence of two or more signs of deficit. If two signs are diminished, the sensitivity is 94.1% and the specificity is 84.4% for neuropathy [11]. The patient's light touch with localization was intact throughout the lower extremity dermatome pattern. Vibration was tested using a Rydel Seiffer graduated tuning fork on the great toe and medial malleolus. The patient reported feeling the vibration until a value of 7.5 at each location bilaterally. The normal value for lower extremities for her age group is greater than 4.0 indicating the patient's vibration sense is intact [12]. With both of these intact, somatosensory impairment was not indicated. Mrs. M.'s score of 15/30 on the Functional Gait Assessment (FGA) put her at increased risk for falling (fall risk < 22/30) [13]. The patient had difficulty and symptom provocation during ambulation with head motion and turning. She presented with decreased velocity of ambulation with head movements, backward ambulation, and ambulation with eyes closed. Observation of Mrs. M. revealed increased lumbar lordosis secondary to anterior pelvic tilt during stance. The patient's center of gravity (COG) alignment was appropriate, indicated by SOT results.

**Evaluation:** Tests and measures indicated the patient suffers from right posterior canalithiasis (BPPV), motion sensitivity, and increased anxiety post vestibular neuritis; which were consistent with initial impressions based on history. The patient's problem list included fall risk, BPPV, VOR dysfunction, and motion sensitivity which limited ADLs including the following: driving, household chores (i.e. bending forward to unload dishes or laundry), ambulation, volunteer community involvement, and exercise program (Table 1).

## Physical therapy diagnosis

The patient was diagnosed as having impaired motor function and sensory integrity associated with peripheral nerve injury (Practice pattern 5F), which includes peripheral vestibular disorders such as labyrinthitis and paroxysmal positional vertigo [21]. The most appropriate ICD-9 code is 386.1 (other and unspecified peripheral vertigo), but others include 781.3 (lack of coordination) and 780.4 (dizziness and giddiness).

**Goals:** Goals divided into short term (5 week) and long term (10 week), are outlined in Table 2.

## Prognosis

The patient's rehab potential was good due to recent onset of motion sensitivity. Her anxiety was also acute, beginning only when her symptoms began. She was highly motivated to return to her former activities and had support from her husband.

**Plan of care:** The plan of care for Mrs. M. included canalith repositioning maneuvers (CRMs), VOR and VSR retraining, habituation activities for motion sensitivity, and gait activities. The CRMs were to address mechanical dysfunction of the vestibular systems resulting from BPPV [22]. Habituation, VOR, and VSR exercises provided the appropriate stimulus of error detection/error correction to promote central nervous system reorganization [5].

The patient was treated twice per week for three weeks, followed by once per week for seven weeks with re-evaluation on the tenth visit. The first three weeks included completion of the initial evaluation, CRMs as indicated, and considerable patient education. The patient was educated in symptom recognition, symptom provocation, and symptom management. She was taught to rate her symptoms on a scale of zero to five, and to discontinue any activity when symptoms of 3/5 were provoked. The last seven weeks of treatment were primarily to provide the patient with the appropriate progression for her home exercise program.

**Intervention:** The detailed home exercise program progression is provided in Table 3.

## BPPV

Treatment began with CRM to address right posterior canal BPPV. The Epley maneuver was successful in treating the condition with resolution of nystagmus and complaint of vertigo with second Dix-Hallpike [22]. The patient continued to complain of a light-headed and floating feeling upon return to upright, which is consistent with motion sensitivity [23]. The patient's BPPV resolved completely after the first treatment and did not reoccur throughout the course of her treatment.

## Motion sensitivity: Habituation program

The patient was progressively introduced to a habituation home exercise program. Habituation exercises included Brandt-Daroffs, log rolls, standing head turns/head nods, standing forward flexion, and ½ turns. These activities were chosen based on results of a motion sensitivity screen, derived from the motion sensitivity quotient test. These were also based on literature which demonstrates successful reduction of symptoms using similar activities [5,23,24].

Ball bounces on 65 cm exercise ball were included after an otolith screen of both horizontal and vertical acceleration revealed dysfunction [25]. It has been demonstrated that patients who have involvement of both the semicircular canals and the otolith respond

to vestibular rehab as effectively as those with only canal involvement [26].

All of these exercises were progressed based on symptom limitations. The patient began each exercise with eyes open, and when symptom provocation decreased to less than 1/5, the exercise was progressed to eyes closed. The activity was then performed until symptoms were no longer provoked. Standing head turns/head nods were progressed from standing on a firm surface to a soft surface, which further stimulated the vestibular system. The symptom limited progression was performed to determine when this was appropriate.

The patient was limited to only three habituation exercises at a time. A new exercise was introduced after a current exercise was discontinued. The home exercise program was titrated this way to prevent overstimulation of the vestibular system which results in slowed progression, or even regression.

### VOR retraining

VOR dysfunction was identified from oculomotor examination. To train this system, the patient was treated with progressive gaze stabilization (VOR x1) activities in both pitch and yaw plane [5,27,28]. By performing these exercises in standing, VSR retraining was also incorporated.

The exercise was progressed based on the same parameters as the habituation program. The patient was to increase the pace of the exercise by five beats per minute when she was able to perform 90 seconds of the activity with symptoms of less than 1/5. The activity was progressed from standing on a firm surface to standing on a soft surface when the patient's postural stability during the activity had improved. This was determined by observation and the patient's subjective report of stability.

### Functional activity

After significant reduction in symptom provocation through the habituation and VOR retraining program, the patient was introduced to functional activity training including ambulation with head turns/head nods (environment scanning), ambulation with eyes closed (mimicking dark environments), ambulation with quick starts and stops, and ambulation with half-turns. These activities stimulated both the semicircular canals and the otolith. They were chosen based on symptom provocation and the initial FGA results. The patient was to self-monitor symptoms during these activities and discontinue if symptoms reached 3/5.

The patient was also instructed to re-initiate her gym program within symptom limitations [5]. She was to self-monitor symptoms and discontinue any activity that provoked symptoms of motion sensitivity of 3/5. Her gym program included water aerobics, stationary bike, treadmill, rowing machine, and resistance training machines. These activities all stimulate the vestibular system significantly with altered surfaces and quick horizontal and vertical acceleration. The patient performed these activities at a community gym, which also incorporated a visually complex environment. When the visual system is taxed, and not able to be utilized to provide balance feedback, the vestibular system input is more heavily weighted. For a patient with motion sensitivity, this leads to increased symptom provocation.

These activities were incorporated into the patient's home exercise program after she had demonstrated the ability to perform self-limitation of activities and had demonstrated significant reduction in symptom provocation with more simple tasks.

### Outcomes

Outcomes are shown in Table 4. At discharge, the patient reported no symptoms of dizziness, oscillopsia, or vertigo. She did not present with fall risk or motion sensitivity, and had no anxiety with movement. The patient achieved all of her goals by discharge. She increased her FGA score to 28/30 which indicated no fall risk and was normal for her age. Her DHI score decreased from 80/100, severe handicap, to 4/100 which indicated no handicap related to dizziness. Mrs. M.'s DVA remained positive with three lines lost, normal is less than three lost. She had significant improvement on the test, but reported her contact lenses were shifting during the test at discharge resulting in less clarity during head movements. At initial evaluation, she wore glasses.

### Discussion

The outcomes suggest that, for this patient, early intervention including: BPPV treatment, VOR/VSR retraining, habituation, and gradual return to functional activities resulted in complete resolution of the patient's symptoms. This is consistent with findings from previous studies focusing on chronic PVD which indicate significant improvement in patients' symptoms and quality of life with vestibular rehabilitation [4,6,7,24]. The combination of the habituation activities, progressing from lower level, full support activities to higher level activities with less support or on compliant surfaces, provided stimulus to re-integrate signals from the vestibular system into the central nervous system [24]. BPPV treatment was successful without typical post-repositioning precautions provided. According to Tusa and Herdman [3], studies indicate there is no evidence to support the efficacy of remaining upright for 48 hours after the repositioning maneuvers.

The key to this patient's success was early intervention and patient education on symptom limitation and reduction of vestibular taxing activities to keep symptoms within acceptable limits. She was required to self-monitor and alter her normal activities to prevent symptom provocation above acceptable limits.

The patient was able to resume all ADLs, volunteer activities, and full work-out program in ten weeks. She no longer had difficulty with ambulation in complex environments or with head movements. She was able to return to social drinking without anxiety about becoming lightheaded. All of these things were very important to the patient as she wanted to maintain an active, social lifestyle.

It is interesting to note, in week five, the patient's progression slowed because she complained of increased symptom provocation throughout the week. During that week, the weather suddenly changed from sunny and warm to overcast and rainy. There is no literature to describe the effect of acute weather changes on vestibular function. Articles have been published describing self-reported triggers for migraine associated vertigo in which weather changes have been implicated [29,30]. These articles are not experimental in design, and they are not specific to the pathology described in this case, but they are the only literature available supporting the claim. Many online communities which are dedicated to patients suffering from vestibular disorders (i.e. blogs, support groups, social networks) also suggest that weather changes lead to increased symptom provocation, but as previously stated, this has not been formally studied. The effect of acute changes in weather and barometric pressure would be an interesting area of further research, especially because subjective complaints implicate these changes as a major trigger for symptom

provocation.

Though there were set-backs throughout the treatment including the weather changes and the missed treatment day in week six, her recovery followed the expected timeline. She was able to return to all activities in less than three months and no longer experienced anxiety about movement. Due to her compliance with the program and motivation to recover, she completed her rehabilitation and was satisfied with the experience and results.

## References

- Balatsouras DG, Koukoutsis G, Ganelis P, Economou NC, Moukos A, Aspris A, et al. Benign paroxysmal positional vertigo secondary to vestibular neuritis. *Eur Arch Otorhinolaryngol*. 2013; 1-6.
- Strupp M, Thurtell MJ, Shaikh AG, Brandt T, Zee DS, Leigh RJ. Pharmacotherapy of vestibular and ocular motor disorders, including nystagmus. *J Neurol*. 2011; 258: 1207-1222.
- Tusa R, Herdman S. Bppv: Controlled trials, contraindications, post-manoeuvre instructions, complications, imbalance. *Audiological Medicine*. 2005; 3: 57-57.
- Brodovsky JR, Vnenchak MJ. Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. *Physical Therapy*. 2013; 93: 293-298.
- Gill-Body KM. Current concepts in the management of patients with vestibular dysfunction. *APTA Continuing Education*. 2001; 23: 40-58.
- Giray M, Kirazli Y, Kirazli T, Karapolat H, Celebisoy N, Bilgen C. Short-term effects of vestibular rehabilitation in patients with chronic unilateral vestibular dysfunction: A randomized controlled study. *Arch Phys Med Rehabil*. 2009; 90: 1325-1331.
- Alghadir AH, Iqbal ZA, Whitney SL. An update on vestibular physical therapy. *J Chin Med Assoc*. 2013; 76: 1-8.
- Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. *Arch Otolaryngol Head Neck Surg*. 1990; 116: 424-427.
- Janet Ody Helminski DSZ, Imke Janssen, Timothy Carl Hain. Effectiveness of particle repositioning maneuvers in the treatment of benign paroxysmal positional vertigo: A systematic review. *Physi Ther*. 2010; 90: 663-678.
- Thompson M. Balance manager systems: Clinical interpretation guide.
- Richardson JK1. The clinical identification of peripheral neuropathy among older persons. *Arch Phys Med Rehabil*. 2002;83(11):1553-8.
- Martina ISJ, van Koningsveld R, Schmitz PIM, van der Meche FGA, van Doorn PA. Measuring vibration threshold with a graduated tuning fork in normal aging and in patients with polyneuropathy. *Journal of Neurology, Neurosurgery, and Psychiatry*. 1998; 65: 743-747.
- Wisley DM, Kumar NA. Functional gait assessment: Concurrent, discriminative, and predictive validity in community-dwelling older adults. *Phys Ther*. 2010; 90: 761-773.
- Whitney SL, Hudak MT, Marchetti GF. The activities-specific balance confidence scale and the dizziness handicap inventory: A comparison. *J Vestib Res*. 1999; 9: 253-259.
- Cattaneo D, Regola A, Meotti M. Validity of six balance disorders scales in persons with multiple sclerosis. *Disabil Rehabil*. 2006; 28:789-795.
- Burston A, Mossman S, Weatherall M. Are there diurnal variations in the results of the Dix-Hallpike manoeuvre? *J Clin Neurosci*. 2012;19:415-417.
- Halker RB, Barrs DM, Wellik KE, Wingerchuk DM, Demaerschalk BM. Establishing a diagnosis of benign paroxysmal positional vertigo through the dix-hallpike and side-lying maneuvers: A critically appraised topic. *Neurologist*. 2008; 14: 201-204.
- Wisley DM, Marchetti GF, Kuharsky DK, Whitney SL. Reliability, internal consistency, and validity of data obtained with the functional gait assessment. *Phys Ther*. 2004; 84: 906-918.
- Pavlou M, Bronstein AM, Davies RA. Randomized trial of supervised versus unsupervised optokinetic exercise in persons with peripheral vestibular disorders. *Neurorehabil Neural Repair*. 2013; 27: 208-218.
- Lin JH, Hsu MJ, Hsu HW, Wu HC, Hsieh CL. Psychometric comparisons of 3 functional ambulation measures for patients with stroke. *Stroke*. 2010; 41: 2021-2025.
- Pattern 5F: Impaired peripheral nerve integrity and muscle performance associated with peripheral nerve injury *Guide to physical therapist practice* 2003.
- Helminski JO, Zee DS, Janssen I, Hain TC. Effectiveness of particle repositioning maneuvers in the treatment of benign paroxysmal positional vertigo: A systematic review. *Physi Ther*. 2010; 90: 663-678.
- Akin FW, Davenport MJ. Validity and reliability of the Motion Sensitivity Test. *J Rehabil Res Dev*. 2003; 40: 415-421.
- Clendaniel RA. The effects of habituation and gaze stability exercises in the treatment of unilateral vestibular hypofunction: A preliminary results. *J Neurol Phys Ther*. 2010; 34: 111-116.
- Lempert T, Gianna CC, Gresty MA, Bronstein AM. Effect of otolith dysfunction. Impairment of visual acuity during linear head motion in labyrinthine defective subjects. *Brain: A Journal of Neurology*. 1997; 120: 1005-1013.
- Murray KJ, Hill K, Phillips B, Waterston J. Does otolith organ dysfunction influence outcomes after a customized program of vestibular rehabilitation? *Journal of Neurologic Physical Therapy*. 2010; 34: 70-75.
- Rine RM, Schubert MC, Balkany TJ. Visual-vestibular habituation and balance training for motion sickness. *Physi Ther*. 1999; 79: 949-957.
- Schubert MC, Migliaccio AA, Clendaniel RA, Allak A, Carey JP. Mechanism of dynamic visual acuity recovery with vestibular rehabilitation. *Arch Phys Med Rehabil*. 2008; 89: 500-507.
- Cha YH, Baloh RW. Migraine associated vertigo. *Journal of Clinical Neurology*. 2007; 3: 121-126.
- Cohen JM, Bigal ME, Newman LC. Migraine and vestibular symptoms—identifying clinical features that predict “vestibular migraine”. *Headache: Headache*. 2011; 51: 1393-1397.