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Physical Therapy Outcomes for Persons With Bilateral Vestibular Loss

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Objective: **The purpose of the study was to assess the efficacy of physical therapy for patients with bilateral vestibular loss.** ***Study Design:*** **Retrospective case series.** ***Methods:*** **Twenty-four patients with a diagnosis of bilateral vestibular loss were identified by a retrospective chart review. Thirteen of the 24 patients met the inclusion criteria of having a moderate or greater loss of vestibular function bilaterally as rated by an otoneurologist based on the patient's vestibular function tests. These patients were treated with a custom-designed physical therapy program for a mean of 4.6 visits over an average period of 3.8 months. Patients completed the Dizziness Handicap Inventory and the Activities-specific Balance Confidence Scale at initial evaluation and discharge. Patients were asked to perform the balance and gait tasks of the Dynamic Gait Index, Sensory Organization Test of computerized dynamic posturography, and the Timed "Up and Go" test at their first and last physical therapy sessions. The number of falls in the previous 4 weeks and the use of an assistive device at initial evaluation and discharge were reported. Composite score, an overall score of clinical outcome, was calculated to determine clinically significant changes in physical performance and subjective information.** ***Results:*** **On a population basis, statistically significant improvement was observed after physical therapy for each of the outcome measures including the composite score ($P < .05$). Clinically significant changes were demonstrated by 33% to 55% of the patients on the various outcome measures. No change was noted in the patients' risk of falling, their number of falls, and the use of assistive devices.** ***Conclusion:*** **Many patients with bilateral vestibular loss benefit from an individualized vestibular physical therapy exercise program based on improved physical function and reduced self-perceived levels of handicap.**
Key Words: **Balance, dizziness, falls, physical therapy.**
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INTRODUCTION

Bilateral vestibular loss (BVL) is a disabling condition first described by Dandy[1] in 1941. It is a condition that accounts for approximately 1% to 2% of all individuals undergoing electronystagmography studies[2–4] and results in significant functional disability and handicap.[5–7] The origins of BVL include ototoxicity, bilateral endolymphatic hydrops, autoimmune inner ear disease, bilateral vestibular neuritis, bilateral vestibular schwannoma, and idiopathic vestibular loss.[8–10] The symptoms and signs of BVL are well described and can include oscillopsia (jumping of the visual environment),[2,5,8,9,11,12] gait dysfunction (ataxia),[13] nausea,[8] lightheadedness,[9] episodic vertigo,[9,11,14] veering while walking,[15] tintitus,[8,10] an inability to read while walking, an inability to walk in the dark,[15] and decreased gait velocity,[16,17] Hearing loss may be associated with BVL.[4,9,10,18] Herdman et al.[19] reported that the percentage of falls in patients with BVL is significantly greater than in individuals with unilateral vestibular dysfunction.

The treatment of choice for individuals with BVL is vestibular rehabilitation.[14] Vestibular rehabilitation has been shown to be effective for numerous vestibular disorders,[20,21]but vestibular rehabilitation has been shown to be less efficacious with persons having BVL.[11] Telian et al.[11] reported that 3 patients had no improvement, 7 had mild improvement, and 1 had considerable subjective improvement. Fifty-one percent of persons with BVL reported improvement in a sample by Gillespie and Minor.[10] Krebs et al.[17] and Gillespie and Minor[10] both demonstrated improvements in gait speed and levels of activity. In a case report, Gill-Body et al.[16] established that an individual with BVL reported less dizziness, decreased double limb support during walking, and had an increased gait velocity after vestibular physical therapy.

Although vestibular physical therapy has helped persons with vestibular disorders, reported results may have

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varied because of the discrepancy in the severity of the disorder. Gillespie et al.[10] suggested that the benefits are less substantial in persons with BVL than in persons with other vestibular disorders because of multiple comorbidities, a slow progression of the loss, and severe loss of vestibular function. The purpose of the current retrospective study was to determine how effective physical therapy intervention was in improving balance, reducing the number of falls reported, reducing self-perceived disability, and improving gait in a case series of patients with confirmed BVL.

PATIENTS AND METHODS

Twenty-four patients with a diagnosis of BVL were identified through a retrospective chart review of patients seen for vestibular physical therapy from January 1997 to January 2001 at the Jordan Balance Center at the University of Pittsburgh Medical Center (Pittsburgh, PA). The University of Pittsburgh Institutional Review Board designated this study exempt. Thirteen of the patients met the inclusion criteria, which included completing a neurological or otological examination, or both, and vestibular function testing; a moderate or severe loss of vestibular function as rated by a neurologist based on the patient's vestibular function tests (electronystagmography and rotational chair, ocular motor, and positional testing), and completion of two or more physical therapy sessions. The criteria for deciding that a patient had moderate to severe vestibular loss included a review of the patient's history and physical examination plus review of the vestibular laboratory findings before the neurologist assigning them a score. The rating scale for each ear was as follows: 0 = absent, 1 = severe, 2 = moderate, 3 = mild, and 4 = normal vestibular function. Patients with scores of 2.5 or lower for each ear were included in the analysis. All patients included in the study had symmetrical vestibular loss. Table I includes a description of the patients included in the study. The mean age of the patients was 65 ± 18 (range, 41–90 y); there were six men and seven women who were treated for a mean period of 3.8 months with a mean duration of symptoms before intervention of 13.6 months. Individual characteristics and outcomes of each patient are included in Table II.

The patients were referred from five different physicians. Vestibular physical therapy was administered by one of three physical therapists skilled in the examination and treatment of patients with vestibular disorders. Each patient was treated with a customized treatment plan specifically designed based on the results of the physical therapy assessment. The treatments included one or more of the following elements: balance and gait training; activities to promote the use of varied sensory inputs for maintaining balance, especially somatosensation, general strengthening, and flexibility exercises; and activities to improve vestibular adaptation for those with remaining vestibular function. Patients with little to no vestibular function were taught to substitute vision and somatosensation for their lost vestibular function. For example, a patient might be instructed to fixate their gaze during ambulation to stabilize their walking and decrease veering to the side.

The patients were asked to complete the Dizziness Handicap Inventory (DHI), which is a 25-item scale, at each visit.[22] Scores on the DHI range from 0 to 100. Higher scores on the DHI indicate a greater level of handicap. There are three subscales included in the DHI: physical, emotional, and functional.

Patients also completed the Activities-specific Balance Confidence Scale (ABC) at each visit. The patients rated their level of confidence while performing 16 activities of daily living.[23] A score of 100% indicates that a person is completely confident that he or she will not lose their balance or become unsteady during the performance of the 16 activities. Scores of less than 50% indicate a low level of functioning[24] and often indicate that the person cannot leave their home without assistance. Scores of 80% and above are expected in community-living older adults.[24] The patients also were asked to report the number of falls they had experienced in the previous 4 weeks and their use of an assistive device at initial evaluation and at discharge.

During the physical therapy examination and subsequent visits, the patients were asked to perform the eight gait tasks that comprise the Dynamic Gait Index (DGI).[25] The eight tasks include walking, walking with head turns, pivoting, walking over

TABLE I.
Descriptive Group Demographics of Persons With Bilateral Vestibular Dysfunction (n = 13).

Gender	Males: 6
	Female: 7
Age (yr)	Range: 41–90
	Mean: 65 ± 18
Duration of symptoms prior to rehabilitation (mo)	Range: 0.5–72
	Mean: 13.6 ± 20.3
Reported oscillopsia	Yes: 10
	No: 3
No. of physical therapy visits	Range: 2–9
	Mean: 4.6 ± 2.3
Duration of physical therapy (mo)	Range: 1–9
	Mean: 3.8 ± 2.6
Clinical rating of bilateral vestibular loss	Absent to severe: 9
	Moderate: 4
No. of patients reporting falls	Initial evaluation: 6 (46%)
	Discharge: 4 (31%)
No. of patients using assistive device	Initial evaluation: 8 (62%)
	Discharge: 8 (62%)

TABLE II.
Descriptive Information, Pre- and Post-Physical Therapy Assessment Information for Each Person With Bilateral Vestibular Disease.

Subject No.	Age (y)	Gender	Cause of Bilateral Vestibular Loss	Duration of Symptoms (mos)	Duration of Physical Therapy (mos)	No. of Visits	Severity of Lesion (each ear)	Oscillopsia	Assistive Device IE	Assistive Device D/C	DHI Begin/End	ABC Begin/End	DGI Begin/End	Timed "Up & Go" (sec) Begin/End	SOT Begin/End	Composite Score Begin/End
1	75	M	Ototoxicity	3	8	8	2.5	Yes	Cane	None	52/46	60/60	14/19	12.7/11.5	* /58	55/64
2	71	F	Ototoxicity	12	1	2	1	Yes	Wheeled walker	Wheeled walker	86/90	0/3	1/*	*	*	6/*
3	57	F	Ototoxicity	3	9	5	1.5	Yes	Wheeled walker	Wheeled walker	74/42	43/46	13/19	20.0/10.6	*	41/61
4	50	F	Ototoxicity	36	4	5	1	Yes	None	None	72/38	89/86	20/21	7.1 /*	41/49	67/78
5	41	F	Ototoxicity	9	2	3	2	Yes	None	None	22/18	64/89	15/21	10.8 /*	24/44	68/86
6	90	M	Unknown	22	4	5	2.5	No	None	None	30/32	16/38	16/16	19.6/13.3	47/75	51/58
7	72	M	Unknown	.5	4	7	.5	Yes	Cane	Cane	68/44	52/55	11/20	14.0/11.2	28/44	43/65
8	46	F	Ototoxicity	1.5	7	9	1	Yes	Cane	Cane	100/92	0/13	13/16	14.9/13.8	32/47	18/29
9	86	M	Unknown	3	3	4	1	No	Walker	Walker	32/*	*	11/12	66.0/60.2	*	*
10	78	F	Unknown	3	3	3	2.5	No	Walker	Cane	26/22	17/46	*	*	*	*
11	89	F	Unknown	72	2	2	1.5	Yes	Cane	Cane	56/32	47/24	7/12	21.7/20.8	34/42	40/47
12	45	M	Ototoxicity	1.5	2	2	1.5	Yes	None	Cane	76/72	30/43	11/14	11.5/10.6	29/39	33/43
13	46	M	Ototoxicity	10	5	5	1	Yes	None	None	66/72	.9/30	9/15	15.4/11.5	45/42	24/40

*Missing data.
PT = physical therapy; IE = initial evaluation; D/C = discharge; DHI = Dizziness Handicap Inventory; ABC = Activities-specific Balance Confidence Scale; DGI = Dynamic Gait Index; SOT = Sensory Organization Test of Computerized Dynamic Posturography.
Severity of lesion score: 0 = absent, 1 = severe, 2 = moderate, 3 = mild, 4 = normal.

objects, walking around objects, and going up and down stairs. The maximum DGI score is 24, and scores of 19 or less indicate increased risk of falling in older adults.[26] A score of 19 or less also has been shown to be related to self-reported number of falls in persons with vestibular disorders, regardless of age.[27]

Patients were also asked to perform the Timed "Up and Go" test at each visit. The therapist recorded the speed at which the patient could stand up, walk 3 m, turn around, walk back, and sit down.[28] Times of 13.5 seconds or greater have been related to increased risk of falling in older adults.[26]

Eight of the patients completed the six conditions of the Sensory Organization Test (SOT) of the computerized dynamic posturography. The SOT comprises six sensory conditions consisting of a fixed or movable platform with eyes open and the visual surround stable, eyes closed, or eyes open with the visual surround sway-referenced.[29]

A composite score (CS), which was previously developed in an effort to provide the clinician with an overall score of outcome disability,[30] was calculated. The CS combines three measures, two subjective measures and one gait rating scored by the physical therapist. The equation incorporates the ABC, DHI, and DGI and is as follows:

$$100 \times [ABC + (100 - DHI) + (DGI \times 4)]/296$$

The maximum point value is 100. The following levels of disability were defined based on clinical experience: greater than 91, no impairment; 81 to 91, minimal impairment; 41 to 81, moderate impairment, and less than 40, severe impairment. Strong correlation between the CS and the disability score of Telian et al.[31] has been previously demonstrated.[30]

Data Analysis

Scores on the DHI, ABC, DGI, and SOT and the CS were compared before and after therapy using the Wilcoxon matched-pairs, signed rank test to determine whether statistically significant differences were seen following physical therapy. Scores before and after therapy on the Timed "Up and Go" test were compared using paired Student *t* tests. Differences in the number of falls and the use of an assistive device between the initial and discharge visits were evaluated using the Wilcoxon matched-pairs, signed rank test. Spearman's correlation coefficients (r) were used to determine whether there was a relationship between the severity of the bilateral vestibular lesion and the outcome following vestibular rehabilitation on the assessment measures. Spearman's correlation coefficients were also used to determine whether initial performance on any of the assessment measures predicted greater improvement at discharge.

RESULTS

Assessment scores before and after therapy for each patient are listed in Table II. Statistically significant differences for the group were identified after physical therapy on the DHI, ABC, DGI, Timed "Up and Go" measures and the CS, and on the physical and emotional subscales of the DHI (Table III). Patients did not demonstrate statistically significant differences in the functional subscale of the DHI following vestibular physical therapy. The reported number of falls and the use of an assistive device were not different before and after physical therapy.

As an alternative method of assessing outcome, criteria developed by Wrisley et al. (unpublished data) were used to determine clinically significant changes in outcome measures. Table IV identifies the percentage of individuals who exhibited clinically significant changes af-

TABLE III.
Mean Assessment Measure Values at Initial Evaluation, Discharge, and the Mean Amount of Change Post- versus Pre-therapy.

	DHI (n = 12)	DHI Emotional Subscale (n = 12)	DHI Physical Subscale (n = 12)	DHI Functional Subscale (n = 12)	ABC (n = 12)	DGI (n = 11)	Timed Up & Go (sec) (n = 9)	SOT (n = 8)	Composite Score (n = 10)
Initial PT visit	61	21	17	24	35	13	21.8	35	44.0
Discharge visit	50	17	13	21	44	17	18.2	48	57.0
Mean change	11	4	4	2	10	4	3.6	13	13
P value	.027	.026	.019	.227	.040	.005	.007	.017	.005

DHI = Dizziness Handicap Inventory; ABC = Activities-specific Balance Confidence Scale; DGI = Dynamic Gait Index; SOT = Sensory Organization Test of Computerized Dynamic Posturography; CS = composite score.

ter versus before therapy. All patients demonstrated clinically significant changes in at least one of the assessment measures. However, when analyzed as a group, only 33% to 55% of the patients demonstrated clinically significant changes on any individual assessment item.

The bilateral vestibular severity score was moderately but significantly correlated with the DHI emotional subscale score at discharge ($r = -0.72$, $P < .05$). Patients with more severe vestibular loss perceived greater handicap (higher scores) on the emotional subscale of the DHI. The severity score also demonstrated a moderate but not significant correlation with the overall DHI total score at discharge ($r = -0.53$, $P = .09$), the DHI physical subscale score at discharge ($r = -0.54$, $P = .09$), and the change in CS from initial evaluation to discharge ($r = -0.61$, $P = .08$). These values most likely did not achieve significance because of the small number of patients in our study.

Using previously reported criteria for determining which older adults are at increased risk of falling, the majority of our patients continued to demonstrate an increased risk of falling.[25,26] Shumway-Cooket et al.[32] defined scores of 19 or less on the DGI as indicating an increased risk for falling in community-dwelling older adults. Seventy-three percent (8 of 11) of our patients demonstrated scores of 19 or less on the DGI at discharge. Scores of 13.5 seconds or greater on the Timed "Up and Go" test have been defined as indicating an increased risk of falling in community-dwelling older adults.[26] Sixty-seven percent (6 of 9) of our patients continued to demonstrate scores of greater than 13.5 seconds on the Timed "Up and Go" test at discharge.

DISCUSSION

Our results indicate that, although patients with BVL improve following vestibular physical therapy, they continue to demonstrate significant physical impairments, to perceive significant disability, and to be at increased risk of falling. These results agree with previous studies which indicated that patients with BVL demonstrated improvements in subjective and objective measures of balance following vestibular rehabilitation, although their improvement is generally less than that of patients with other vestibular disorders.

Our patient population demonstrated changes in the total DHI score, the emotional subscale, and the physical subscale over the course of rehabilitation, yet their functional scores did not significantly change. Other authors have reported an overall change in DHI total score after physical therapy intervention.[16,17,33] The functional subscale includes items such as the ability to walk in the dark, interference with job or household responsibilities, interference with social activities, and restriction of travel because of the problems. It is unlikely that, in a group of persons with severe BVL, these items would change, because of persistent oscillopsia and impaired use of sensory information for orientation.[7]

The ABC score is a self-report measure that provides information about how confident persons are about their balance. The mean score of the group changed an average of 10% points over the course of rehabilitation, yet the mean score at discharge was only 44%. Scores of less than 50% correspond with homebound elderly adults.[24] The

TABLE IV.
Number and Percentage of Patients in Each Group Who Improved by a Clinically Significant Amount on Each Assessment Measure.

	DHI	ABC	DGI	Timed "Up and Go" (sec)	CS
Clinically significant change	>18	>10	>4	>3	>15
No. of patients	4/12 (33%)	6/12 (50%)	6/11 (55%)	4/9 (44%)	4/10 (40%)

DHI = Dizziness Handicap Inventory; ABC = Activities-specific Balance Confidence Scale; DGI = Dynamic Gait Index; CS = composite score.

ABC scores indicate that these persons continued to be impaired and were not confident with their balance.

The DGI includes several items that are difficult for persons with BVL to perform, especially the walking with head turns in yaw and pitch. Other authors have documented changes in gait after physical therapy intervention[11,16,17] but have used gait speed as their criteria for improvement. An average change of four points on the DGI in the current study indicates a significant improvement in gait function. More than half of our subjects improved by four points or more on the DGI, yet their mean score was only 17. Scores of 19 or less indicate high risk for falling.[34] The average score of 17 indicates that, although our patients with bilateral vestibular disorders made significant improvements, their gait continued to be impaired.

Krebs et al.[17] documented an 8% increase in gait speed after rehabilitation in persons with bilateral vestibular disease. Our patients demonstrated a 17% change in their time to perform the Timed "Up and Go" test (stand from a chair, walk 3 m, turn, return, and sit down). Gait speed and the Timed "Up and Go" test have previously been shown to correlate ($r = -0.61$).[28]

Falls have been reported in persons with bilateral vestibular disorders.[10,19] Thirty-four percent of patients of Gillespie and Minor[10] and 51% of patients of Herdman et al.[19] with bilateral vestibular disorders reported falls. Forty-six percent of the patients in our study reported falling initially, and 31% reported falling at discharge. Sixty-three percent of our patients continued to be at risk for falling based on their DGI scores, and 67% were at risk for falling based on their Timed "Up and Go" test score.

Eight of 13 patients used an assistive device at the start of physical therapy, and they continued to use an assistive device at discharge. Devices ranged from a wheeled walker to straight canes. The use of an assistive device also has been previously related to falls in older adults,[34] as has decreased gait velocity.[35] The use of a walking stick or cane has been shown to significantly decrease postural sway in patients with peripheral vestibular disorders.[36] Our data further support the idea that persons with BVL should be educated about their increased risk of falling, about the proper use of an assistive device, and about fall prevention, because no difference was found between the number of falls reported at initial evaluation and discharge from physical therapy.

The symptom of oscillopsia has been related to severe BVL.[11,37] Seventy-seven percent of the patients in our study reported oscillopsia. Oscillopsia may persist following bilateral loss because of reduced gain of the vestibulo-ocular reflex and the inability of the cervico-ocular reflex to compensate gaze stabilization during high-amplitude or high-velocity head movements.[9,38,39]

An interesting finding in our study is that all of our patients had some improvement in their CS, which is a combination of three of the tools (DHI, ABC, and DGI). This supports the results of Gillespie and Minor,[10] who noted that 51% of their patients with BVL improved with vestibular physical therapy. Their criteria for improvement was based on gait velocity, the timed Romberg test, and dynamic visual acuity scores. Patients had to report a decrease in subjective symptoms and also an improvement of two of the three above-mentioned criteria.

Improvements in dynamic posturography scores following vestibular rehabilitation of patients with BVL have been reported by other authors,[10,16] yet neither of the studies demonstrated large improvements. Our patients had a mean change of 13 on the total SOT result, indicating a change, but the patients with bilateral vestibular disorders as a group continued to be well below normal for their age with a mean result at discharge of only 48.

CONCLUSION

Patients with bilateral vestibular loss improve in their perception of dizziness and imbalance, as well as in outcome measures of gait and balance, following physical therapy. However, despite physical therapy, a majority of the patients in our study continued to be at risk for falling and remained physically impaired. Patients with bilateral vestibular loss should be referred for physical therapy intervention to maximize their balance abilities and for education in reducing their fall risk.

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