ORIGINAL ARTICLE

Short-Term Effects of Vestibular Rehabilitation in Patients With Chronic Unilateral Vestibular Dysfunction: A Randomized Controlled Study

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ABSTRACT. Giray M, Kirazli Y, Karapolat H, Celebisoy N, Bilgen C, Kirazli T. Short-term effects of vestibular rehabilitation in patients with chronic unilateral vestibular dysfunction: a randomized controlled study. Arch Phys Med Rehabil 20092009;90:1325-31.

Objective: To evaluate the short-term effects of vestibular rehabilitation on symptom, disability, balance, and postural stability in patients with chronic unilateral vestibular dysfunction.

Design: Randomized controlled trial.

Setting: Department of Physical Medicine and Rehabilitation, University Hospital.

Participants: Patients (N=42) with chronic vestibular dysfunction were divided into either a rehabilitation group (group 1) or a control group (group 2).

Interventions: Patients in group 1 were treated with a customized exercise program for 4 weeks, while the patients in the control group did not receive any treatment.

Main Outcome Measures: Subjects were assessed before and after the rehabilitation program with respect to symptoms (visual analog scale [VAS]), disability (Dizziness Handicap Inventory [DHI]), balance (Berg Balance Scale [BBS]), and postural stability (modified Clinical Test for Sensory Interaction on Balance [mCTSIB]).

Results: Significant improvements in all parameters (VAS, DHI, BBS, mCTSIB) were observed in group 1 ($P<.05$). When the 2 groups were compared, there were significant improvements in postexercise VAS, DHI (emotional, functional, physical, total), BBS, and mCTSIB (standing on a firm surface with eyes open, standing on a foam surface with eyes open, standing on a foam surface with eyes closed, mCTSIB mean) in favor of group 1 ($P<.05$). No significant improvements were seen in any parameters in the control group ($P>.05$).

Conclusions: Significant improvements were seen in symptom, disability, balance, and postural stability in chronic unilateral vestibular dysfunction after an exercise program. Customized exercise programs are beneficial in treatment of chronic unilateral vestibular dysfunction.

Key Word: Rehabilitation.

PEOPLE WITH DYSFUNCTION within the vestibular system frequently report the occurrence of symptoms such as disorientation, lightheadedness, disequilibrium, and visual blurring.[1] These impairments lead to significant restrictions in activity and participation in the affected person.[1,2] In many cases of chronic vestibular dysfunction, pharmacologic or surgical interventions are found to offer only limited improvement.[1,3] As yet, no treatment has been proven fully effective for unilateral peripheral vestibular disease.[1] Consequently, vestibular rehabilitation is receiving increased interest for the treatment of patients with vestibular disorders and has become one of the main treatments for these patients.[4] Vestibular rehabilitation has taken on many forms over the years, ranging from group exercise to customized exercise programs.[4]

Customized vestibular rehabilitation exercise programs can be adapted to suit the specific needs of the patient and have become the primary modality of treatment for patients with vestibular dysfunctions.[4] Only a limited number of studies have employed customized vestibular rehabilitation for unilateral peripheral vestibular disease.[2,5] The objective of the present study was to examine the effects of customized vestibular rehabilitation on symptom (unsteadiness), disability, balance, and postural stability in patients with decompensated vestibular disorder in a randomized study.

METHODS

All patients were reviewed by a panel of consultant physicians from the Departments of Ear Nose and Throat, Neurology, and Physical Medicine and Rehabilitation, and the Dizziness Council, who met once a week to discuss all patients with vertigo, dizziness, and balance problems. All patients considered suitable for vestibular rehabilitation were included in the study. As a result, 45 patients diagnosed by a neuro-otologist or neurologist between February 2006 and September 2007 with chronic decompensated unilateral vestibular deficit, secondary to peripheral vestibular dysfunction, using neurologic and otologic examinations and vestibular function tests (electronystagmography, bithermal caloric test, ocular motor testing, positional testing) participated in the study. Unilateral vestibular hypofunction was diagnosed based on the criterion of greater than 25% reduced vestibular response on the caloric test.

List of Abbreviations

BBS	Berg Balance Scale
DHI	Dizziness Handicap Inventory
EC	eyes closed
EO	eyes open
mCTSIB	modified Clinical Test of Sensory Interaction of Balance
VAS	visual analog scale
VOR	vestibulo-ocular reflex

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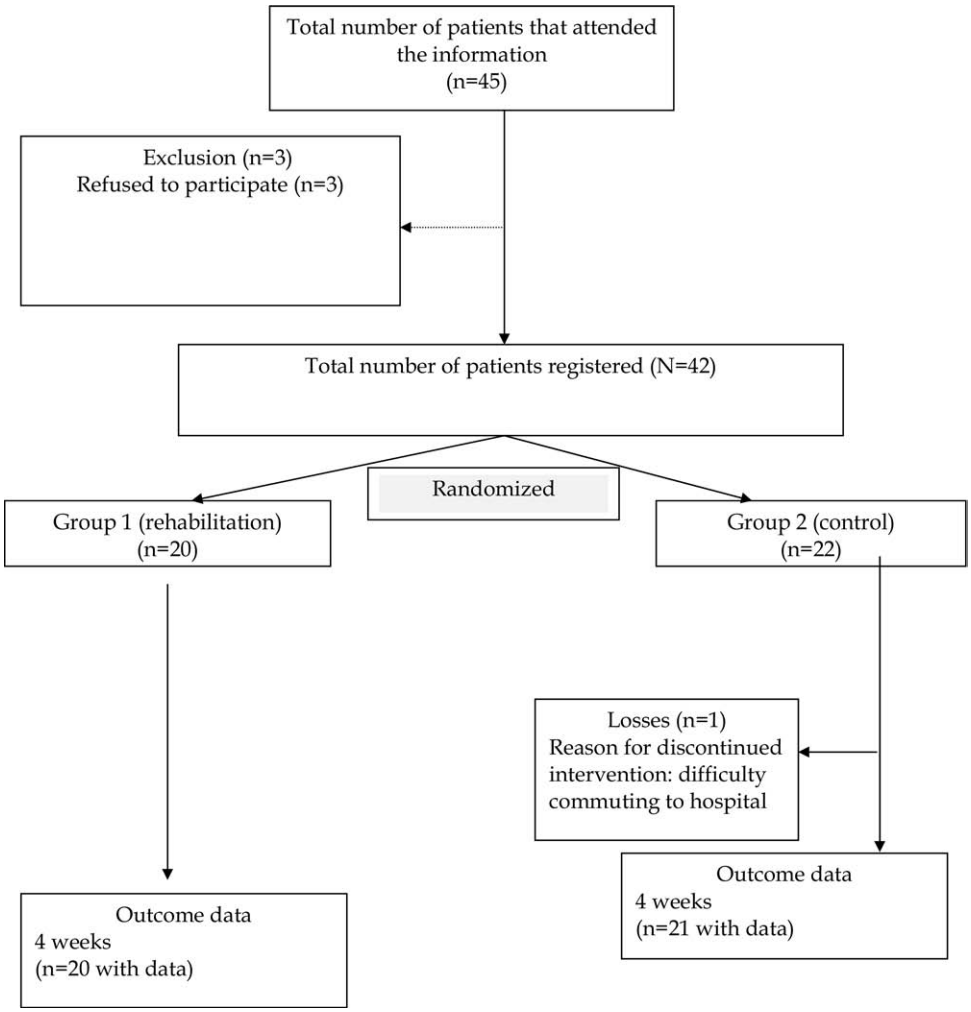

Fig 1. Flow diagram of the study.

Patients with any problem that compromised rehabilitation (ambulatory problems; restricted cervical movement [flexion, extension, lateral flexion, rotation $<30°$]; a disorder affecting visual and somatosensorial system; or cognitive, orthopedic, or neurologic disorder); those with fluctuating and intermittent vertigo, benign paroxysmal positional vertigo, and symptoms of less than 2 months' duration; and patients with bilateral decompensated vestibular disorder were excluded from the study. All vestibular suppressing medications used by the patients were stopped a week before the commencement of the study.

All patients referred from the Dizziness Council to vestibular rehabilitation were screened by a rehabilitation physician for sociodemographic data (age, sex, occupation, education), duration of the illness, diagnosis, history of the illness, past medical history (migraine and so forth), factors that aggravated dizziness (walking, climbing stairs, head movements, and so forth), hearing, vision, and history of falls.

During the physical examination, vital signs were checked, including the cranial nervous system, musculoskeletal system (range of motion, muscle power, sensation, coordination, proprioception), and visual motor functions (smooth pursuit, saccades, VOR cancellation, VOR, head thrust, convergence, nystagmus). Gait and balance were assessed (Romberg, sharpened Romberg, foam), and positional tests were performed.

A total of 45 patients met the study criteria. Three patients declined to participate in the study, and 42 patients gave their informed consent to participate. All patients were unblind to the study during allocation to the study groups. Forty-two patients were randomized (consecutive patients were referred from the Dizziness Council) into either of 2 groups: a treatment group (group 1, n=20) or a control group (group 2, n=22). One patient in group 2 failed to complete the program because of difficulty commuting to the hospital. Twenty patients in group 1 (mean age, 52.4 ± 14.90y) and 21 patients in group 2 (mean age, 50.38 ± 18.59y; female:male ratio, 2:11) completed the study (fig 1).

Patients in group 1 and group 2 were assessed before and 4 weeks after vestibular rehabilitation by a rehabilitation physician. The following tests were performed.

Visual Analog Scale

To understand how the patients experienced unsteadiness symptom and whether any changes were noted at the end of the training period, a VAS was used. A 10-cm VAS was used to assess the degree of unsteadiness of the patients. The VAS used

a 10-cm line oriented vertically with "no unsteadiness" corresponding to the bottom of the line and "worst possible unsteadiness" at the top of the line. The patients were requested to indicate the severity of their symptoms that occurred before and after the treatment on a 10-cm vertical line. The VAS has been tested for validity and reliability when used to measure pain[6] but has also been found to detect changes in symptoms when evaluating vestibular rehabilitation after acoustic neuroma resection[7] and for migraine-related vestibulopathy.[8]

Perceived Level of Disability

The level of disability perceived by the patient was measured by the DHI, a multidimensional self-assessment scale that quantifies the level of disability and handicap on 3 subscales: physical, emotional, and functional. It is possible to use both the sum score and the scores of the 3 subscales separately. Scores range from 0 to 100, where 100 represents a high level of disability and handicap from symptoms of dizziness. A sum score higher than 60 in the DHI signifies serious dizziness and a greater risk of falling. A score between 0 to 30 represents mild and 31 to 60 represents moderate dizziness.[9,10] The DHI has high internal consistency reliability (Cronbach α=.89) and test-retest reliability (Pearson product-moment correlation=.97).[9] Discriminant validity was demonstrated by the good relationships between the number of dizziness episodes and the DHI scores. Convergent validity was demonstrated by the high correlation coefficients between the total DHI score and 8 dimensions of the generic questionnaire short-form 36.[11,12]

Objective Assessment of Balance

Balance was objectively assessed by the BBS. The BBS rates performance from 0 (cannot perform) to 4 (normative performance) on 14 items. The items explore the ability to sit, stand, lean, turn, and maintain an upright position while balancing on 1 leg.[13] Berg et al[13,14] found high reliability (.71–.99), moderate correlations with other functional measures (.62–.94), and low to moderate correlations with laboratory measures of postural sway (−.38 to −.55). Concurrent validity of BBS and dynamic gait index has been established in a mixed group of patients with vestibular dysfunction.[15]

Postural Stability

The mCTSIB was used to assess postural stability. mCTSIB was conducted on the NeuroCom Balance Master 8.0.3[a] (foam size, length=44cm; width=47cm; thickness=12.5cm). Test-retest reliability of the mCTSIB is high, with an r of .75 or higher in older, community-living adults[16] and an r equal to .99 for interrater reliability and test-retest reliability in young adults.[17] The mCTSIB examines postural sway for 4 conditions assessed for the mCTSIB: standing on a firm surface with EO, standing on a firm surface with EC, standing on a foam surface with EO, and standing on a foam surface with EC. Composite sway is the mean sway speed averaged over the 4 measured conditions. Each condition was tested 3 times. Subjects stood straight and still on a force platform during three 20-second trials in each of the 4 conditions. For each condition, each subject's feet were placed in the standard position recommended by the manufacturer of the Balance Master.[18] Foot position was monitored throughout the test. If foot placement changed, the feet were again placed in the correct position. Data included mean center of pressure sway speed (which is measured in degrees a second) and average center of pressure position (which measures deviation of the center of pressure in degrees over 20s). We used center-of-pressure speed for the 4 conditions and composite sway for statistical analysis.

Exercise Program

In the light of the history, physical examination, and diagnostic tests for each patient, an exercise program was developed by a rehabilitation physician and administered to the patient after discussing it with the physiotherapist. The treatment program given to the patients in group 1 consisted of training and exercise components. Balance system functions, causes of dizziness, and rationale and contraindications for performing of exercise were explained during the training component. Patients were actively involved in adapting the exercise program to suit their symptoms, capabilities, and lifestyle. The execution of the exercises was personalized by the therapist according to the symptoms and functional disability of the patient. The exercises were designed to be challenging during the training period, and different aspects of balance training were emphasized for different patients to provide individualization. Exercises given to the patients can be summarized as follows.

Adaptation Exercises

To improve gaze stability, subjects were initially asked to move their heads in yaw rotation while focusing on a stationary hand-held target, X1 viewing. They then progressed to X2 viewing, in which the target and the head rotated in equal and opposite yaw directions. Exercises were performed in horizontal and vertical planes 3 times a day for 1 minute each.

Substitution Exercises

Patients with little or no vestibular function were taught to substitute vision and somatosensation for their loss of vestibular function. For example, a patient might be instructed to fixate gaze during ambulation to stabilize walking and to decrease veering to the side, or to stand on the foam with EC to keep balance. Substitution exercises could be modified to become increasingly more difficult as the patient improved.

Visual Desensitization

Disturbances that the patients experienced during performance of their daily activities were determined. In patients reporting enhanced sensitivity or poor tolerance to self or visual motion, additional desensitization exercises were added.

Balance Exercises

Patients attempted to restore balance while switching between static (eg, standing) and dynamic movements (eg, walking) by altering visual, somatosensorial, and vestibular impulses.

The exercise program consisted of 2 sessions a week for a period of 4 weeks, and each session lasted for approximately 30 to 45 minutes in the rehabilitation unit. All patients in group 1 were followed up once a week by the rehabilitation physician, who reviewed the exercises and made changes together with the physiotherapist.

In addition to the exercise they performed at the hospital, all patients in group 1 were given instructions with diagrams of exercises to be performed twice a day as a home exercise program. Each home program was designed to take approximately 30 to 40 minutes. Home programs consisted of 4 to 5 substitution, habituation, and balance exercises that the patients performed with difficulty at the rehabilitation unit.

During the training period in the hospital, compliance was monitored by a physician and a physical therapist. Home exercises were monitored with a chart that was filled in every day by the patients. Patients in group 2 were not trained or shown any exercises. All patients in group 2 were included in

Table 1: Demographic and Clinical Features of Patients in Group 1 (Rehabilitation) and Group 2 (Control Group)

Characteristics	Group 1 n=20	Group 2 n=21	*P*
Age (y), median (minimum–maximum)	50.00 (26–78)	55.50 (18–73)	.96
Sex (male/female), n (%)	6 (30.0)/14 (70.0)	8 (38.0)/13 (61.9)	1.00
Occupation, n (%)			.34
Civil servant	5 (25.0)	4 (19.0)	
Retired	5 (25.0)	6 (28.6)	
Homemaker	9 (45.0)	9 (42.9)	
Student	0	2 (9.5)	
Unemployed	1 (5.0)	0	
Education, n (%)			.19
Literate	2 (10.0)	0	
Secondary school	8 (40.0)	9 (42.9)	
High school	3 (15.0)	8 (38.1)	
University	7 (35.0)	4 (19.0)	
Length of illness (d), median (minimum–maximum)	120 (60–1750)	300 (70–930)	.10

NOTE. Baseline demographics and clinical characteristics were compared using the Mann-Whitney *U* test for numeric data (age, length of illness) and Fisher exact test (sex) or chi-square test (occupation, education) for nominal data.

a personalized vestibular rehabilitation program at the end of the study.

This study was approved by the local ethics committee of our institution, and informed consent forms were obtained from all participants.

Statistics

Data were analyzed using the SPSS version 16 statistical package.[b] A *P* value below .05 was considered statistically significant. Baseline demographics and clinical characteristics were compared using the Mann-Whitney *U* test for numeric data (age, length of illness) and Fisher exact test (sex) or chi-square tests (occupation, education) for nominal data. The nonparametric Wilcoxon test was used to compare groups with regard to parameters obtained before and after rehabilitation. The Mann-Whitney *U* test was used to assess intergroup differences and calculation of percentage change. With regard to DHI severity, the McNemar Bowker test was used for intragroup comparisons and the chi-square test for intergroup comparisons.

RESULTS

Comparison of the Pretreatment Values of the 2 Groups

Demographic and clinical data of the patients are presented in table 1 and indicated no significant differences between the 2 groups ($P>.05$). VAS, DHI (physical, emotional, functional, total), and BBS scores before the rehabilitation also did not differ between the 2 groups ($P>.05$) (table 2). The standing on a foam surface with EC subscore of the mCTSIB before the rehabilitation was significantly higher in the treatment group than in the control group ($P<.05$) (table 3). Differences in other subscores of the mCTSIB (standing on a firm surface with EO, standing on a firm surface with EC, standing on a foam surface with EO, mCTSIB mean) between the groups were not significant before the rehabilitation ($P>.05$) (see table 3).

Posttreatment Intergroup Comparison of Symptom, Disability, Balance, and Postural Stability

When the 2 groups were compared, there were significant improvements in postexercise VAS, DHI (emotional, functional, physical, total), BBS, and CTSIB (standing on a firm surface with EC, standing on a firm surface with EO, standing on a foam surface with EO, standing on a foam surface with EC, CTSIB mean) between the rehabilitation and control groups ($P<.05$) (see tables 2 and 3).

Posttreatment Intragroup Comparison of Symptom, Disability, Balance, and Postural Stability

In group 1, differences between VAS, DHI (emotional, functional, physical, total), BBS, and mCTSIB (standing on a firm surface with EO, standing on a firm surface with EO, standing

Table 2: Comparison of Group 1 (Rehabilitation) and Group 2 (Control Group) Before and After the Exercise Program With Regard to Symptom (VAS), Disability (DHI), and Balance (BBS)

	Group 1				Group 2				
	Before Study	After Study	*P**	C%	Before Study	After Study	*P**	C%	*P*†
VAS	4.45 (1.0–9.2)	1.35 (0–7.1)	.004	52.05	3.60 (1.2–9.4)	2.90 (0.5–8.5)	.46	−4.29	.003
DHI-em	17.00 (4–32)	5.00 (0–30)	.003	54.16	20.00 (4–32)	20.00 (4–36)	.44	8.17	.001
DHI-f	28.00 (10–36)	12.00 (0–32)	.000	50.56	19.00 (2–32)	21.00 (2–32)	.47	−33.37	.000
DHI-phy	20.0 (012–28)	9.00 (0–24)	.000	52.25	19.00 (4–28)	18.00 (6–26)	.72	−14.32	.000
DHI-t	64.00 (30–92)	22.00 (0–84)	.001	52.54	58.00 (10–88)	60.00 (12–86)	.53	−5.41	.000
BBS	54.00 (48–56)	56.00 (53–56)	.001	4.12	54.50 (46–56)	55.00 (48–56)	.56	0.93	.012

NOTE. For intragroup assessments, the Wilcoxon signed-rank test was used. For intergroup evaluations and calculation of percentage change ([after study − before study/before study] × 100), the Mann-Whitney *U* test was used.
Abbreviations: C%, percentage of change; DHI-t, Dizziness Handicap Inventory-total score; em, emotional; f, functional; phy, physical.
*Intragroup comparison.
†Intergroup comparison.

Table 3: Comparison of Group 1 (Rehabilitation) and Group 2 (Control Group) Before and After the Exercise Program With Regard to Postural Stability (mCTSIB)

	Group 1				Group 2				
	Before Study	After Study	*P**	C%	Before Study	After Study	*P**	C%	*P*†
FIRM EO (d/s)	0.25 (0.10–0.80)	0.20 (0.10–0.60)	.285	0	0.20 (0.10–0.80)	0.40 (0.20–2.20)	.097	−41	.013
FIRM EC (d/s)	0.30 (0.10–1.80)	0.25 (0.10–0.80)	.013	33	0.30 (0.10–3.0)	0.40 (0.20–2.10)	.859	0	.036
FOAM EO (d/s)	1.00 (0.50–3.10)	0.70 (0.40–1.10)	.025	28	0.75 (0.30–1.50)	0.85 (0.40–1.90)	.371	0	.008
FOAM EC (d/s)	2.60 (1.00–4.40)	1.85 (0.90–3.80)	.032	20	2.05 (1.10–3.50)	2.25 (1.0–3.5)	.906	0	.013
mCTSIB-t (d/s)	1.10 (0.60–2.10)	0.85 (0.40–1.30)	.012	23	0.80 (0.50–2.10)	1.10 (0.50–1.80)	.441	−16	.004

NOTE. For intragroup assessments, the Wilcoxon signed-rank test was used. For intergroup evaluations and calculation of percentage change ([after study − before study/before study] × 100), the Mann-Whitney *U* test was used.
Abbreviations: C%, percentage of change; d/s, degree/second; FIRM EC, standing on a firm surface with EC; FIRM EO, standing on a firm surface with EO; FOAM EC, standing on a foam surface with EC; FOAM EO, standing on a foam surface with EO; mCTSIB-t, total score of mCTSIB.
*Intragroup comparison.
†Intergroup comparison.

on a foam surface with EO, standing on a foam surface with EC, mCTSIB mean) before and after the exercise program were significantly improved ($P<.05$) (see tables 2 and 3). There were no significant differences in VAS, DHI (emotional, functional, physical, total), BBS, and mCTSIB (standing on a firm surface with EC, standing on a firm surface with EO, standing on a foam surface with EO, standing on a foam surface with EC, mCTSIB mean) in the control group before and after the study ($P>.05$) (see tables 2 and 3).

Intra- and Intergroup Comparisons of Dizziness Handicap Inventory Severity

Intragroup comparison of DHI severity indicated a significant improvement at the end of the study for group 1 ($P<.05$) (table 4), while no significant improvement was observed for group 2 ($P>.05$) (see table 4). Intergroup comparison of DHI severity did not show any difference between the 2 groups at the baseline ($P=.587$). A significant difference was observed with regard to DHI severity in group 1 at the end of the study ($P=.039$).

DISCUSSION

The present study has shown that customized vestibular rehabilitation programs decreased symptoms, increased postural stability, and improved dizziness-related disability in patients with chronic decompensated vestibular deficit.

Similar to other studies,[2,5,7,19-22] this study has shown that vestibular rehabilitation has a positive effect on the symptoms of peripheral vestibular dysfunction. Although there are numerous studies in the literature that show beneficial effects of vestibular rehabilitation on symptoms, very few of these have been randomized studies[5,21,23]; they have used heterogeneous patient groups, but not controls. Using a homogeneous group of patients and the presence of a control group are the strong attributes of the current study. Use of a homogeneous group is particularly important for reliability of the study results and aids in specifically showing the efficacy of vestibular rehabilitation in this group of patients. The benefit of use of a control group, on the other hand, is that the recovery status of the untreated group can be monitored to prove the effect of vestibular rehabilitation through evidence-based information with a randomized controlled study. However, the nonblindedness of the control group and noncontact with the therapist twice a week would lend itself to possible bias in patient performance that was unrelated to treatment.

While most patients in the treatment group had high levels of disability at the beginning of the study (median, 64.0; range, 30–92), most of them had improved to a mild level of disability (median, 22.0; range, 0–84) at the end of the study. In the control group, the level of disability in most patients at the beginning (median, 58.0; range, 10–88) and end (median, 60.0; range, 12–86) of the study remained moderate. Meanwhile, significant improvements in DHI emotional, physical, and functional subscales were observed in the rehabilitation group compared with the control group. A decrease in the severity of dizziness-induced disability with vestibular rehabilitation enables patients to lead an independent life and increases their quality of life. The fact that patients benefited from a low-cost and safe treatment modality also indicate the efficacy of customized vestibular rehabilitation that we employed.

In agreement with these studies,[19,22,24,25] we found an improvement in balance, as assessed by the BBS (4.12%), after vestibular rehabilitation in the treatment group. Although baseline BBS scores were high in patients included in the study, the increase in these scores even after rehabilitation in the treatment group was noteworthy.

Table 4: Comparison of Group 1 (Rehabilitation) and Group 2 (Control Group) Before and After the Exercise Program With Regard to the Severity of Disability (DHI)

	Group 1			Group 2		
	Before Study	After Study	*P**	Before Study	After Study	*P**
Mild DHI	1 (5.0)	13 (65.0)		2 (9.5)	3 (16.7)	
Moderate DHI	8 (40.0)	4 (20.0)	.001	7 (33.3)	7 (33.3)	.513
Severe DHI	11 (55.0)	3 (15.0)		12 (57.0)	11 (52.4)	

NOTE. Values are n (%) or as otherwise noted. The McNemar-Bowker test was used for assessment of the DHI severity of the 2 groups.
*Intragroup comparison.

The mCTSIB is a test frequently used in vestibular disorders for diagnosis, planning of treatment, and follow-up of patients.[26-29] We used computerized mCTSIB measurements in our study and found, in agreement with previous studies,[2,5,27] an increase in postural stability in all parameters (EO/EC, firm/foam surface, total score) as a result of vestibular rehabilitation.

Study Limitations

When evaluating the static balance rather than dynamic balance, constraints of this study included administration of the adaptation exercises without testing the gaze stability with dynamic visual acuity, not assessing the long-term effects of vestibular rehabilitation, and not being blind during assessments. Furthermore, not informing the control patients about daily living activities can also be regarded as a limitation of this study. However, because the level of adherence to the recommendations on daily activities varies among patients and this too would introduce variability, and so that a homogeneous group would be achieved for the quality of the study, control subjects were not given advice on daily living activities at the beginning of the study. However, all patients in the control group were included in a personalized vestibular rehabilitation program at the end of the study. None of the participants were blind to any of the groups. This would lend itself to a possible bias in patient performance unrelated to treatment. Additionally, the control group did not have contact with the therapist twice a week, which could also bias test performance.

On the other hand, because it was a randomized controlled study, the strong points of the current study included the use of a homogeneous group of patients in the treatment group, use of a customized vestibular rehabilitation program, and performance of detailed subjective and objective assessments of patients. One of the strengths of the present study was the fact that patients with chronic unilateral vestibular dysfunction performed exercises under the guidance of a physiotherapist twice a week and, additionally, were given a personalized home exercise program. Although there has been 1 previously published randomized study on vestibular rehabilitation,[5] there is still need for further studies to compare the effects of physiotherapist-supervised customized exercise programs and unsupervised home-based vestibular exercises on symptoms, disability, balance, and postural stability.

CONCLUSIONS

In the current study, we observed rapid improvements in symptoms, handicaps, balance, and postural stability in patients with chronic unilateral vestibular dysfunction after short-term, intensive vestibular rehabilitation given by an experienced vestibular rehabilitation team. Vestibular rehabilitation needs to be customized to the individual needs of the patients, and the exercises should be tailored according to their rate of progression. Based on our results, we hope that customized vestibular rehabilitation, which is effective, safe, and low-cost, will become widely used both in Turkey and worldwide.

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Suppliers

a. NeuroCom Inc, 9570 SE Lawnfield Rd, Clackamas, OR 97015.
b. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.