Effects of Vestibular Rehabilitation in Patients with Unilateral Vestibular Hypofunction

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Abstract

Purpose: To investigate the effect of physiotherapy on the balance parameters and fall risk in patients with unilateral vestibular hypofunction (UVH). **Patients and Methods:** Thirty patients diagnosed with UVH were included in the study. The number of falls, Visual Analog Scale, Modified Clinical Test for Sensory Interaction in Tandem and Balance, and dynamic visual acuity assessments was performed before and after treatment. The patients were included in an individual treatment program for 8 weeks. Physiotherapy sessions were given at 2-week intervals. Along with the level of development of the treatment applied to the patients, it was requested perform a home exercise program with ten repetitions three times a day. **Results:** After 8 weeks of vestibular rehabilitation, it was observed that the balance parameters of the participants improved and the number of falls decreased. Statistically significant results were obtained in the Eyes-closed Tandem test ($P = 0.001$). Significant changes occurred in the modified Clinical Test results for Sensory Interaction in Balance from 0.37 ± 0.19 s to 0.93 ± 0.11 s ($P = 0.001$). Vestibular symptoms and dynamic visual acuity scores also improved after treatment ($P = 0.001$). **Conclusion:** It was concluded that the physiotherapy program applied to our patients with UVH positively affected fall risk and significantly improved balance parameters.

Keywords: Balance, fall, unilateral vestibular hypofunction, vestibular rehabilitation

Introduction

Unilateral vestibular hypofunction (UVH) is a condition presented with partial or complete loss of unilateral vestibular function. UVH is one of the most common causes of head movement-related dizziness and instability.[1] UVH accounts for approximately 14%–20% of all inner ear pathologies. Vestibular neuritis and labyrinthitis caused by viral or bacterial infections are the most common causes of UVH. Symptoms of UVH depend on the severity of vestibular weakness and often present with dizziness, loss of balance, falling, and decreased visual acuity.[2] Patients with UVH commonly report oscillopsia, dizziness, postural instability, and gait disturbances. These impairments significantly limit activity and participation in the affected patient.[3]

The complaints of dizziness and loss of balance in patients with UVH also significantly affect their standing and walking activities.[4] For this reason, there is an increase in the desire not to walk and the risk of falling while holding on while walking. Recent studies with comprehensive vestibular evaluation have reported an increased risk of falling in patients with vestibular dysfunction.[5]

Pharmacological and surgical treatments provide limited improvement in chronic UVH cases. Therefore, there is increasing interest in vestibular rehabilitation in this patient population. Vestibular rehabilitation exercises are designed to facilitate central nervous system plasticity by creating substitution, habituation, and adaptation mechanisms that make postural stability in disorders that lead to conflicting sensory information.[3] Its primary purpose is to reduce the severity of symptoms and improve gaze stabilization, postural stability, and balance.[6] Habituation exercises reduce dizziness and nausea by repeating symptom-aggravating head

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movements.[7] Adaptation exercises consist of repetitive head movements while focusing on a target and provide stabilization of the gaze and improvement of compensatory saccadic eye movements.[8] Sensory substitution exercises encourage the use of nonvestibular sensory systems to aid postural control.[9] A recent review indicated that vestibular rehabilitation effectively improved dizziness, quality of life, and balance, based on multiple randomized controlled trials.[10,11] Another study showed that vestibular rehabilitation methods had been shown to positively affect gait and quality of life and reductions of dizziness, depression, and anxiety.[3]

Studies on the effectiveness of vestibular rehabilitation in patients with UVH are limited due to the lack of academic studies and the number of qualified personnel with clinical experience in this area. For this reason, it was aimed to investigate the effect of vestibular rehabilitation on improving balance and reducing the frequency of falls in patients with UVH.

Patients and Methods

Study design and participation

This study was conducted as a prospective quasi-experimental study without a control group. The study protocol was approved by the medical research ethics committee of …. University (No. 10840098-342).

Participants invited to our study were patients aged 20–50 years, living in Istanbul and applying to our Private Hospital's Ear Nose and Throat (ENT) Unit with complaints of dizziness and loss of balance. The inclusion criteria were as follows: Patients aged 20–50 years, diagnosed with UVH by ENT specialist after detailed anamnesis, physical examination, and videonystagmography (VNG) recorded vestibular examination. Exclusion criteria: cognitive dysfunction, presence of temporal bone pathologies detected by magnetic resonance imaging, bilateral vestibular hypofunction, presence of dizziness, and other inner ear disorders that may cause imbalance (like benign paroxysmal positional vertigo, endolymphatic hydrops, labyrinthitis, vestibular neuritis, trauma, and meningitis), previous lower extremity injuries, central involvement findings in VNG-assisted vestibular examination results, light touch sensory impairment, coordination disorder.

The first evaluation of the patients was planned to be performed by an otolaryngologist. These assessments consisted of physical examination and VNG-recorded vestibular system evaluation. Afterwards, the patients were sent to the physiotherapist to review balance, dizziness, presence, the number of falls, and static and dynamic visual acuity.

Videonystagmography-assisted vestibular examination

VNG assisted vestibular evaluation, including optokinetic test, saccade, tracking, gaze dynamic vestibular position tests (particularly Dix-Halpike and supine roll tests) were taken into consideration along with bithermal caloric test. With an air-stimulated binaural bithermal caloric test, the vestibulo-ocular reflex (VOR) was evaluated: While the patient was lying in the supine position, with the head flexed at 30°, 8 l of air at 50° and 24° Celsius, respectively, were sent to both eardrums in 60 s with 5 min rest intervals. Involuntary eye movements were recorded for 120–140 s, and the results were calculated by graphing.[12] VNG equipment from Otometrics (ICS Chartr 200; Taastrup, Denmark). PC-VNG software was used for the automatic analysis of the recordings. The criteria for the determination of the weakness of vestibular response were as follows:[13]

According to our normative data, a value ≥25% was pathological, and the directional preponderance (DP) was measured using the formula DP = ([RW + LC]-[LW + RC])/(RW + LW + RC + LC) × 100. Average absolute values in our lab are below a DP of 30%.

Intervention

After the initial evaluations, the patients were included in the rehabilitation program. The rehabilitation program consisted of two phases. The first phase involved patient education. All patients received verbal training for 30 min by the physiotherapist, including the definition of UVH, its importance, risk factors, ways of prevention, and recommendations for preventing falls. The second phase consisted of the repetitive vestibular exercise program. The vestibular rehabilitation protocols were performed in individual 1-h weekly sessions for 8 weeks. The redundant exercise protocol consists of four steps: Adaptation, habituation, and substitution. In the first session, patients performed head and eye movements from VOR exercises in a sitting position. The patients first fixed their eyes on an object and turned their heads horizontally for ten repetitions. Second, the patients performed the previous exercise with their heads still, watching the moving object with their eyes. The activities were conducted with eyes open and then closed. Finally, patients walked 40 m in a straight line.

In the second session, patients moved their heads in different directions in Romberg, semi-tandem, and tandem stances while looking at a fixed object. Straight walking and walking back exercises were then performed. All activities were conducted as ten repetitions, with eyes open and closed in the third session; the training level was gradually increased, focusing on dynamic movement. Participants were asked to move their heads to the right and left while walking backward, with their hands at their sides and then their hands clasped behind their backs. Afterward, the participants performed a tandem walk with their hands at their sides and then their hands behind and in front, respectively.

In the last session, the exercises of the 1st week were applied, and the patients were asked to perform these exercises with ten repetitions once a day for a month.

After the clinical examination, the therapist gave the patients the home exercise protocol. The exercises of the first three sessions were performed three times a day with ten repetitions until the next session. The activities of the last session were applied as ten repetitions once a day for 4 weeks.

Outcome measures

The outcome measure included dynamic visual acuity, dizziness with the visual analog scale, static balance with the tandem test, postural control with a modified clinical test of sensory interaction in balance (m-CTSIB), and number of falls were recorded.

Demographic data form

Patients' age, gender, conditions that provoked dizziness, smoking, and alcohol use were questioned.

Tandem test

The patient stood with one foot just in front of the other foot, with the heel of one foot touching the toe of the other foot. The hands were placed crosswise over the shoulders. He was asked to maintain this position with eyes open and eyes closed separately. Measurements were made with a stopwatch. The 1st s he couldn't stop was noted. The test was considered complete in patients who could stand for 30 s.[14]

Modified clinical test of sensory interaction in balance

This test evaluates the effect of vestibular, somatosensory, and visual inputs on postural control. By standing on soft ground and closing the eyes, the m-CTSIB modifies somatosensory input and eliminates visual input. Patients with uncompensated peripheral vestibular loss may have difficulty maintaining an upright posture when visual and support surface information are altered. In this test, separate evaluations were made on soft and hard surfaces with eyes open and d. Before the test, the patients were placed on the platform where the test would be performed. During each part of the test, patients were asked to stand still and maintain their position on the platform for 30 s.[15] During this time, the number of seconds the patients stood was recorded. It was done three times in total, and an average of 3 applications were taken.

Number of falls

The number of falls in the last 6 months was questioned and recorded.

Patients documented falls that were reported monthly. Falls were defined as unintentionally falling to the ground or some lower level for no reason.

Evaluation of dizziness severity

Subjects rated their intensity of dizziness using a 10-cm Visual Analog Scale (VAS) for dizziness ranging from no symptoms (0 cm) to the worst possible symptoms (10 cm).[16]

Dynamic visual acuity

The test was performed using the Snellen visual acuity chart. During the test, the patient was first asked where he read on the eye board on the wall while the head was fixed, and it was recorded. Then, while the patient's head was turned to the right and left rapidly two times per second, the patient was asked to continue reading on the eye board, and the answers were recorded.[2] Visual acuity in normal individuals can vary by one order in young people and two in older individuals. In uncompensated patients, visual acuity may differ by three or four lines in unilateral vestibular losses.[17]

Statistical analysis

Statistical analyzes were performed in the SPSS v18.0 (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc) package program. Mean, standard deviation, percentage, and frequency values were used for appropriate demographic data. Since the data showed a normal distribution, Student's *t*-paired test was used for statistical analysis of numerically measured dependent variables. A probability value of $P < 0.05$ was accepted for statistical significance.

Results

The study was completed with 30 patients who met the inclusion criteria. The mean age of the patients included in the study was 40.00 ± 9.24 years. Eight participants (26.7%) were men, and 22 were women (73.3%). While none of the patients used alcohol, 9 of them smoked [Table 1].

In addition, most participants (70%) stated that dizziness was provoked during sudden movements. Conditions that provoke vertigo are shown in Figure 1.

After 8 weeks of vestibular rehabilitation, it was observed that the participants improved their balance and fall parameters. In the tandem test with eyes open, patients maintained the position

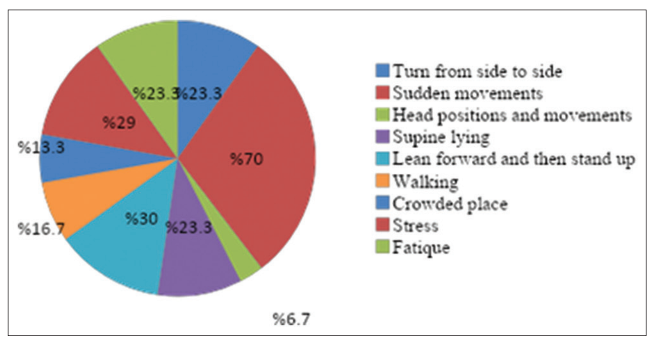

Figure 1: Conditions that trigger the formation of vertigo

Table 1: Demographic variables of participants

Demographic variables	Mean±SD, *n* (%)
Age (years)	40.10±9.24
Gender (female/male)	22 (73.3)/8 (26.7)
Smoking use	9 (30)
Alcohol use	0
Hypertension	5 (16.7)
Diabetes mellitus	6 (20)
Migraine	5 (16.7)
Right vestibular hypofunction	13 (43.3)
Left vestibular hypofunction	17 (56.7)

SD: Standard deviation

for 5.69 ± 2.84 s before the treatment, while this time increased to 19.64 ± 8.97 s after treatment ($P = 0.001$). Statistically significant results were also obtained when the same test was performed with closed eyes ($P = 0.001$). In the m-CTSIB test, which evaluates the effect of sensory inputs on postural control, the results increased from 0.37 ± 0.19 s to 0.93 ± 0.11 s, resulting in significant changes ($P = 0.001$). After the treatment, the number of falls, the severity of dizziness (VAS), and dynamic visual acuity improved ($P = 0.001$). Balance, fall, and dynamic visual acuity parameters results are shown in Table 2.

Discussion

Patients with chronic UVH may be symptomatic or asymptomatic, and physical therapy is a safe and effective way to treat symptomatic vestibulopathies.[18] The main symptoms of unilateral vestibular insufficiency are vertigo, gait, and balance disability, falling, and oscillopsia. The Main symptoms of the patients included in our study were vertigo, loss of balance, and falling. After an 8-week vestibular rehabilitation program, patients' dizziness decreased, and significant improvement in dynamic visual acuity was noted.

Dizziness is an important symptom seen in all patients enrolled in our study. For the treatment to be successful, there should be a decrease in the severity of dizziness and frequency of falls. In the survey carried out by Karapolat *et al*., they worked with 33 patients with unilateral peripheral vestibular disorders and achieved improvement in measures assessing balance, such as tandem, semi-tandem, and m-CTSIB with vestibular rehabilitation.[19] Horak *et al*., in their study aiming to evaluate the effectiveness of vestibular suppressant drugs, conditioning exercises, and vestibular rehabilitation programs in patients with chronic UVH, found that all three approaches reduced dizziness, but only the vestibular rehabilitation improved balance.[20]

Table 2: Difference between the mean variables in the pretest and posttest

Evaluation methods	Pretreatment evaluation	Posttreatment evaluation	P
Tandem test EO	5.69±2.84	19.64±8.97	0.000*
Tandem test EC	1.67±1.21	10.64±7.83	0.000*
Romberg test	6.13±6.08	27.60±6.04	0.000*
OLST firm EO right foot	6.38±5.78	21.20±8.06	0.000*
OLST firm EO left foot	6.41±4.88	23.59±7.30	0.000*
OLST firm EC right foot	1.58±0.99	9.99±8.76	0.000*
OLST firm EC left foot	1.69±1.47	11.15±8.56	0.000*
OLST soft EO right foot	3.76±2.53	22.01±7.00	0.000*
OLST soft EO left foot	4.55±3.08	23.23±7.82	0.000*
OLST soft EC right foot	1.38±1.14	5.90±4.05	0.000*
OLST soft EC left foot	1.49±1.180	7.25±5.77	0.000*
m-CTSIB	0.37±0.19	0.93±0.11	0.001*
Unterberger test EO	1.23±0.43	1.00±0.00	0.008*
Unterberfer test EC	1.83±0.37	1.16±0.37	0.000*
Head ımpulse test	1.96±0.18	1.10±0.30	0.000*
Number of falls	2.43±2.77	0.00±0.00	0.001*
VAS	5.92±2.93	0.81±1.15	0.001*
Dynamic visual acuity	0.47±0.28	0.19±0.22	0.001*

*Statistically very significant difference. Wilcoxon test. m-CTSIB: Modified clinical sensory ınteraction test in balance, EC: Eyes closed, EO: Eyes open, OLST: One leg standing test, VAS: Visual Analog Scale

The m-CTSIB test is a test that is frequently used in the diagnosis, treatment planning, and follow-ups of vestibular pathologies.[20,21] Shah and Kale applied m-CTSIB to 20 patients diagnosed with chronic unilateral vestibulopathy to evaluate the effectiveness of vestibular rehabilitation. In their study, they performed m-CTSIB on all the participants before the vestibular rehabilitation and after 4 weeks and 6 weeks of treatment. They stated that they achieved significant improvements.[22] We also used m-CTSIB to evaluate the effectiveness of our treatment program, but our last evaluation was done in the 8th week of follow-up. Our results were similar to the study results of Shah and Kale.

Vestibular rehabilitation stimulates neural plasticity by using adaptation, habituation, and substitution mechanisms through systematically performed repetitive exercises.[4,23] It is an effective treatment method to prevent and reduce the risk of falling.[24] According to our results, vestibular rehabilitation effectively reduced the number of falls in patients with UVH. It is possible to come across studies in the literature stating that vestibular rehabilitation causes a decrease in fall numbers.[25,26] In addition, in a study conducted on animal experiments, it was stated that exercises after unilateral labyrinth lesions supported the central compensation of spontaneous nystagmus and effectively reduced the tendency to fall.[27] Another study led that vestibular rehabilitation reduced the risk of falling from 98% to 67%.[26] Our results were similar to the literature. Apparently the reason for this is the correction of balance with vestibular rehabilitation, and the tasks of vestibular, visual, and proprioceptive systems are balanced with replacement exercises, thus reducing the risk of falling.

Many studies evaluated patients with UVH include gaze stabilization therapy but do not assess this variable. However, dynamic visual acuity is also seriously affected in patients with UVH. For this reason, it is recommended that dynamic visual acuity should also be evaluated.[28] Alghadir *et al*. also stated in their meta-analysis that m-CTSIB and dynamic visual acuity should also be evaluated in patients diagnosed with "vestibular dysfunction."[29] In our study, we used dynamic visual acuity among the evaluation methods and witnessed statistically significant improvements in the results.

There are three main directions of vestibular rehabilitation treatment. These; are VOR adaptation, habituation, and replacement exercises.[29] These exercises it is aimed to support the central compensation mechanisms. Deficient or insufficient stimuli are balanced with the help of intensified connection of the visual, somatosensory, and vestibular systems with the central nervous system.[30]

To date, many protocols aiming for vestibular rehabilitation have been developed. One of the most popular of them was described by Cawthorne and Cooksey. These are voluntary eye movements and fixation to improve impaired gaze stability, active head movements to recalibrate the VOR, balance training to improve vestibulospinal regulation of posture, and goal-directed movements, and walking exercises.[31] These exercises help the organism arrange peripheral sensorial information and feedback mechanisms, stimulating new vestibular impulses necessary for new experiences to become a conditioned reflex. Cawthorne and Cooksey's exercises are widely used to enhance the formation of new environmental sensory adaptation, and it has the potential to improve balance responses and, thus, reduce falls.[32]

In a study by Jung *et al*., statistically significant results were obtained in the scales of balance and vertigo in the patient groups who underwent gaze stabilization and balance exercises.[33] In the our study, we achieved significant improvement with vestibular rehabilitation exercise training in our patients by providing balance training with adaptation, habituation, and replacement exercises.

Our research has some limitations; First, there is no study group versus a control group. Due to the small number of patients who applied to the clinic, a control group could not be formed by looking at the patient's responses to the treatment. Second, computer-based objective assessment methods are not used. However, we believe that nowadays, when the frequency of vestibulopathy is increasing, our study, which emphasizes the importance of vestibular rehabilitation treatment will contribute to the scientific environment.

Conclusion

In patients diagnosed with UVH, a significant improvement was observed in balance parameters after vestibular rehabilitation treatment, while a substantial decrease was observed in the risk and number of falls. Vestibular rehabilitation increased the VOR gain, provided a reduction in the discomfort of the patients from the crowd, and therefore led to a decrease in psychological problems by becoming more involved in social life. At the same time, vestibular rehabilitation has been shown to benefit patients in balance, gait, and conditioning.

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Conflicts of interest

There are no conflicts of interest.

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