

# The Effectiveness of Vestibular Rehabilitation Including Virtual Reality Therapy in Balance Loss Due to Ménière Disease

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**Objectives:** We investigated the effectiveness of vestibular rehabilitation, including virtual reality therapy, in managing balance disorders associated with Ménière disease.

**Methods:** Fifty patients aged 18 to 65 years, with a definitive diagnosis of Ménière disease, were included in the study. In the case group, 25 patients underwent vestibular rehabilitation, including virtual reality therapy. The other 25 patients in the control group did not receive any rehabilitation treatment and were followed up with medication alone. Participants underwent the Romberg test, the Shapira Romberg test, the Unterberger test, pure tone audiometry, impedanceometry, static posturography, and videonystagmography. The dizziness disability inventory, Beck anxiety scale, and visual vertigo were also assessed. Analogue scale questionnaires were used to evaluate quality of life.

**Results:** In the case group, statistically significant differences were noted in the total, physical, emotional, and functional sub-dimensions of the Dizziness Disability Inventory (DDI) regarding improvement between pretreatment and posttreatment ( $P < 0.05$ ). Statistically significant improvements were found in the pretest and posttest scores of the Beck Anxiety and Visual Vertigo scales in the case group ( $P < 0.05$ ). Significant differences were noted in rhythmic weight shifts, right/left and anterior/posterior axis speeds, and posttest scores, favoring the case group ( $P < 0.05$ ). Statistically significant improvements were also observed in the posttest scores of the case group regarding balance error scores and tandem surface oscillation tests ( $P < 0.05$ ).

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The Istanbul Aydın University Non-Interventional Clinical Research Ethics Committee approved the study on December 20, 2023, with registration number 2023/117.

Individuals were informed about the study protocol, and the consent form was signed by those who consented.

All authors contributed to planning, designing, literature survey, data collection, and interpretation of the results.

All data for this study are presented in this paper.

Consent for publication: all authors permit publication.

The authors report no conflicts of interest.

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**Conclusion:** The authors concluded that vestibular rehabilitation, including virtual reality therapy, effectively manages balance disorders associated with Ménière disease. The virtual reality environment alleviates dizziness and imbalance symptoms by facilitating patients' sensory adaptation.

**Key Words:** Dizziness, loss of balance, Ménière, static posturography, vestibular rehabilitation, virtual reality

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Vestibular disorders pose significant health problems worldwide. Ménière disease is an idiopathic condition characterized by endolymphatic hydrops.<sup>1</sup> It can lead to hearing loss, dizziness, loss of balance, and tinnitus, resulting in substantial deterioration in quality of life.<sup>2</sup> Today, Ménière's diagnosis is primarily based on the patient's history. This is because the objective evaluation of endolymphatic hydrops associated with Ménière disease relies on a challenging invasive method. This method involves determining the ratio of intratympanic gadolinium dyestuff to the perilymph endolymph gap using MRI. Since this complex invasive procedure is rarely performed, the diagnosis is often made through exclusion, based on the patient's history and the inability to identify an alternative condition that could explain these symptoms.<sup>3</sup>

According to the diagnostic criteria for definitive Ménière disease established by the Classification Committee of the Barany Society, the diagnosis requires the presence of 2 or more spontaneous episodes of vertigo, each lasting from 20 minutes to 12 hours; low-frequency to medium-frequency sensorineural hearing loss that is audiometrically documented at least once before, during, or after one of the vertigo attacks in the affected ear; and fluctuating ear symptoms (fullness, hearing, tinnitus) in the affected ear that cannot be better explained by another vestibular diagnosis.<sup>4</sup> The diagnostic criteria have also been broadened to include balance-related complaints, such as nausea, gait problems, posture disorders, and falls. Particularly as the frequency and severity of vertigo attacks increase, the adaptability of the vestibular system decreases, leading to the development of vestibular hypofunction.<sup>5</sup>

Vestibular rehabilitation may be an essential treatment method for managing balance loss and vestibular dysfunctions. While some patients who experience loss of balance after Ménière disease use medication to manage their symptoms, they may choose not to participate in rehabilitation programs. Medication is thought to help alleviate balance problems. However, opting out of rehabilitation programs can hinder long-term management and improvement of balance issues.<sup>6</sup> The basic principle of vestibular rehabilitation, known as vestibular plasticity, refers to a mechanism of neuroplasticity through which new synaptic connections are established between brain cells, forming new connectomes. According to this principle, the brain has the capacity to adapt and compensate for sensory deficits. Patients can enhance their ability to process vestibular signals more effectively by practicing targeted exercises and maneuvers.

Our study aimed to evaluate the superiority of vestibular rehabilitation, which includes virtual reality therapy, over drug therapy in addressing balance loss caused by Ménière disease among individuals aged 18 to 65, and to assess the effectiveness of virtual reality applications in treatment. This technological innovation enhances therapeutic effectiveness.

## METHODS

The study was conducted under the Istanbul Aydın University Graduate Education Institute, Department of Audiology, Master's Program with Thesis. The ethical suitability of the research was confirmed by the Istanbul Aydın University Non-Interventional Clinical Research Ethics Committee in accordance with board decision number 2023/117, dated December 20, 2023. All participants were informed about the study; participation was voluntary, and they signed a consent form. Fifty participants (25 female, 25 male) between the ages of 18 and 65 who met the inclusion criteria were included in the study. While determining the sample size, the analysis was conducted using G\*Power 3.1.9.2 version. The effect size ( $d$ ) was calculated as 1.148 by the study. The margin of error ( $\alpha$  err probe) was set at 0.05, and the power ( $1-\beta$  err probe) was 0.95. Thus, the sample size was determined.

The study involved 25 patients with Ménière disease (8 males, 17 females) who underwent vestibular rehabilitation, including virtual reality therapy, and a control group of 25 patients (7 males, 18 females) who received only medication and dietary therapy. Betahistine and antihistamine preparations were used in drug treatment, with the same pharmacological protocol applied to both groups. Participants were randomly selected without considering specific traits, and no orientation occurred between the groups. The study group was drawn from the Uğur Özgür Vertigo Clinic.

### Inclusion Criteria

- Ages 18 to 65.
- At least 1 year and at least 3 years of being diagnosed with definitive Ménière disease.
- At least 3 Ménière attacks.
- Symptoms of balance disorder.
- Individuals who do not experience severe side effects from virtual reality applications.
- Individuals who do not have an acute attack of Ménière during the vestibular rehabilitation period.

### Exclusion Criteria

- Not being between the ages of 18 and 65.
- Individuals who have had a Ménière attack during the study period.
- Individuals with recurrent BPPV.
- Individuals who had a BPPV attack during the study period.
- Individuals with central pathology that may cause balance disorders.
- Individuals who do not comply with medical and rehabilitation treatment or discontinue treatment.

### Study Protocol

Participants who were followed up for at least one and at most 3 years before January 1, 2024, according to the Barany Association 2015 criteria, were informed about the study. During the diagnosis phase, patients reported severe dizziness accompanied by increased fullness, congestion, and buzzing in the ears lasting for at least 20 minutes to a maximum of 20 hours. A definitive diagnosis of Ménière's was made upon detecting hearing loss. In the participants included in the study, these clinical findings remained stable, and no Ménière attack was observed throughout the study.

Before starting the study, an Informed Consent Form (BGOF) was signed. Participants wishing to withdraw during the study were informed they could be excluded.

The researcher collected information about the participants, completed an anamnesis form, and began the evaluation.

## APPLIED TESTS AND METHODS

A detailed anamnesis was the first and most crucial step in diagnosing the disease. Then, a complete endoscopic otorhinolaryngology examination was conducted. The Romberg Test, the Sharpened Romberg, and the Unterberger Tests were done.

Acoustic immittance was evaluated using an AT235 (Interacoustics, Middelfart, Denmark) immittance device to rule out middle ear pathology after evaluating conditions such as plugs with endoscopic ENT examination. A type A tympanogram was evaluated as a normal finding in the middle ear. The pure tone audiometry test to evaluate hearing was performed in a silent room using the AC-440 clinical audiometry device (Interacoustics, Middelfart, Denmark).

### Static Posturography

To assess body balance and stability, the Sensing Future greater step force plate with static posturography sensor from the Physio Sensing brand was utilized. The Balance Error Scoring System and Limits of Stability tests were incorporated into the rehabilitation process using a static posturography device. The Balance Error Scoring System (BESS) and Limits of Stability (LOS) Test were conducted.

### Virtual Reality Therapy

The VIRTUALIS PHYSIO VR (Virtualis, France) virtual reality system was integrated with the HTC VIVE PRO (HTC Corporation, New Taipei, Taiwan) device to assess and rehabilitate patients' symptoms of dizziness, imbalance, visual vertigo, and loss of balance.

First, subjective visual vertical (SVV) values of individuals were determined. In the normal population, SVV values range from  $\pm 1.5$  to  $\pm 3$  degrees, and values outside this range may indicate impairment or lack of adaptation in vestibular functions. During dynamic SVV measurement, the visual background rotation rate started between 1 degree/second and 4 degrees/second at the beginning of the treatment and was gradually increased according to the patient's adaptation level in each session. In this process, when the patient reaches the last session (12th session), the visual background rotation rate is increased to a maximum of  $\pm 50$  degrees/seconds, indicating that he responds positively to the treatment. Each individual received 30-minute exercises 1 time per week for 3 months or 30-minute exercises 2 times a week for 1.5 months. In total, 12 sessions of rehabilitation programs were applied to each individual. On the other hand, 8 patients who were treated only with virtual reality were subjected to sessions lasting 50 minutes each, including a 10-minute rest module.

In addition, the adaptation time to head movements was evaluated. Short periods of adaptation indicate high balance control, while long periods of adaptation indicate adaptation difficulties. The balance index parameter was used to assess the patient's stability in various posture positions. The status of balance performance under particularly challenging visual stimuli was evaluated. If the postural oscillations were high, it indicated balance difficulty, while their decrease as rehabilitation progressed was evaluated as a positive response to the treatment.

The SG system consists of 10 main modules that support the balance and vestibular rehabilitation processes.

The feeling of discomfort felt by the participants in different modules is evaluated on a scale of 0 to 10.

- 0: No feeling of discomfort at all.  
 1–3: Mild discomfort (uncomfortable but tolerable).  
 4–6: Moderate discomfort (uncomfortable and distracting).  
 7–8: High level of discomfort (significant distraction).  
 9–10: Very high discomfort (unbearable, inability to maintain exercise).

### ***Subjective Visual Vertical, Dynamic Visual Vertical, Optokinetic, Car Simulation, Sea Simulation, Elevator, Target Tracking, Escalator, Head-Eye Coordination, Optical Flow***

Dynamic Balance Exercises, Dizziness Disability Inventory, Beck Anxiety Scale, and Visual Vertigo Analog Scale were used.

### **Statistical Analysis**

The study's data were analyzed using SPSS (Statistical Package for Social Sciences) for Windows 25.0 program. Descriptive statistical methods (number, percentage, min-max values, mean, and standard deviation) were used to evaluate the data.

The data's normal distribution was examined using kurtosis and skewness values. In addition, the normal distribution of the data used depends on the skewness and kurtosis values between  $\pm 3$ . An independent sample *t* test was used to compare quantitative data in non-normally distributed data, and a dependent sample *t* test was used to compare 2 dependent groups.

The Mann-Whitney *U* test was used to compare the differences between 2 independent groups of quantitative data without normal distribution, and the Wilcoxon test was used to compare 2 dependent groups. The homogeneity of categorical variables was evaluated by  $\chi^2$  test analysis.

## **RESULTS**

The age and sex distribution of the participants were similar (Supplemental Tables 1, 2, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>) ( $P > 0.05$ ).

### **Mean and Standard Deviations of Participants' Hearing Thresholds**

In Supplemental Table 3, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, the values of right 125 Hz, right 250 Hz, right 500 Hz, right 1000 Hz, right 2000 Hz, right 4000 Hz, right 6000 Hz, right 8000 Hz, left 125 Hz, left 500 Hz, left 1000 Hz, left 2000 Hz, left 6000 Hz, left 8000 Hz are listed according to the groups of the participants. There are no statistically significant differences between groups ( $P > 0.05$ ).

### **Intergroup and Intragroup Comparison Findings**

In Supplemental Table 4, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, it is seen that there is no statistically significant difference between the participants in the groups on the Beck Anxiety Scale pre-test scores ( $P > 0.05$ ). The work was started on equal terms. It was seen that there was a statistically significant difference between the participants in the posttest scores of the Beck Anxiety Scale between the groups in favor of the case group ( $P < 0.05$ ).

A statistically significant difference between the pretest and posttest scores of the Beck Anxiety Scale participants ( $P < 0.05$ ) was observed. However, there was no statistically significant difference between the groups' pretest scores of the Visual Vertigo Analog Scale ( $P > 0.05$ ).

A statistically significant difference was found between the case group participants' pretest and posttest scores of the Visual Vertigo Analog Scale ( $P < 0.05$ ).

In Supplemental Table 5, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, there was no statistically significant difference between the participants' pretest scores of the Dizziness Disability Inventory between the groups ( $P > 0.05$ ). It is seen that there is a statistically significant difference between the posttest scores of the Dizziness Disability Inventory between the groups in favor of the case group ( $P < 0.05$ ). It was seen that there was a statistically significant difference between the pretest and posttest scores of the Dizziness Disability Inventory of the case group participants ( $P < 0.05$ ).

It was seen that there was no statistically significant difference between the physical disability pretest scores of the participants ( $P > 0.05$ ). It is seen that there is a statistically significant difference between the participants in terms of improvement in favor of the case group between the groups' Physical Disability posttest scores ( $P < 0.05$ ). It is seen that there is a statistically significant difference between the pretest and posttest scores of the Physical Disability of the case group participants ( $P < 0.05$ ).

There was no statistically significant difference between the Emotional Disability pretest scores of the participants ( $P > 0.05$ ). It is seen that there is a statistically significant difference between the participants in terms of improvement in favor of the case group between the Emotional Disability posttest scores ( $P < 0.05$ ), and there was a statistically significant difference between the Emotional Disability pretest and posttest scores of the case group participants ( $P < 0.05$ ).

In Supplemental Table 6, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, it is seen that there is no statistically significant difference between the groups in the tandem hard surface oscillation cop oscillation rate pretest scores ( $P > 0.05$ ). It is seen that there is a statistically significant difference between the tandem hard surface oscillation cop oscillation rate posttest scores of the participants in favor of the case group ( $P < 0.05$ ). It was seen that there was a statistically significant difference between the pretest and posttest scores of tandem hard surface oscillation cop oscillation speed among the case group participants ( $P < 0.05$ ). It was seen that there was a statistically significant difference between the pretest and posttest scores of tandem hard surface oscillation cop swing speed of the control group participants ( $P < 0.05$ ).

Tandem hard surface oscillation orbital area mm<sup>2</sup> pretest scores of the participants ( $P > 0.05$ ) were similar. It is seen that there is a statistically significant difference in favor of the case group between the tandem hard surface oscillation orbital area mm<sup>2</sup> posttest scores according to the groups of the participants ( $P < 0.05$ ). There was a statistically significant difference between the pretest and posttest scores of the tandem hard surface oscillation orbital area mm<sup>2</sup> ( $P < 0.05$ ). There was no statistically significant difference between the tandem hard surface oscillation orbital area mm<sup>2</sup> pretest and posttest scores of the control group participants ( $P > 0.05$ ).

There was no statistically significant difference between the pretest scores of the participants in tandem sponge oscillation and cop oscillation speed between the groups ( $P > 0.05$ ). But there is a statistically significant difference in favor of the case group between the posttest scores of tandem sponge swing cop swing rate according to the groups of the participants ( $P < 0.05$ ). It was seen that there was a statistically significant difference between the pretest and posttest scores of tandem sponge oscillation, cop swing speed, and case group participants ( $P < 0.05$ ). It was observed that there was no statistically sig-

nificant difference between the tandem sponge swing cop swing speed, pretest and posttest scores of the control group participants ( $P > 0.05$ ).

In Supplemental Table 7, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, there was no statistically significant difference between the participants' front, back, right, and left direct control pretest scores between the groups ( $P > 0.05$ ). The 2 groups started the comparison on equal terms.

It was seen that there was a statistically significant difference between the front, back, right, and left direct control posttest scores of the participants in favor of the case group ( $P < 0.05$ ).

In the pretest-posttest comparison of the case group, the increase of 31.14 points in front direct control, 24.27 points in back direct control, 37.95 points in proper direct control, and 20.67 points in left direct control was statistically significant ( $P < 0.05$ ). In the pretest-posttest measurements of the stability limits of the control group, an increase of 0.81 points in front direct control, an increase of 3.89 points in back direct control, an increase of 3.02 points in right direct control and a decrease of 0.47 points in left direct control were not statistically significant ( $P > 0.05$ ).

### Comparative Findings of the Case Group

In Supplemental Table 8, Supplemental Digital Content 1, <http://links.lww.com/SCS/I38>, the participants started under equal conditions according to the pre-test results within the group. There is no statistically significant difference between the visual vertigo analog scale, tandem hard surface swing orbital area mm<sup>2</sup>, tandem sponge swing baton swing speed, tandem sponge swing orbital area mm<sup>2</sup>, dizziness disability inventory, physical disability, emotional disability, and functional disability posttest scores ( $P > 0.05$ ).

## DISCUSSION

Ménière disease occupies a significant role among the common conditions leading to balance disorders. Therefore, assessing balance functions is crucial during the course of the disease. Static posturography is a commonly employed method for this evaluation, and numerous studies have been conducted using various devices in the literature.<sup>7</sup> It has been noted that both the increase and oscillation rates in the elliptical area rise significantly with the severity of the damage occurring in Ménière disease.<sup>8</sup> Conversely, Black stated in 1982 that vestibular disorders in Ménière disease can be identified through static posturography, emphasizing that more visual data is necessary compared with non-Ménière individuals.<sup>9</sup>

In our study, static posturography measurements were applied using 2 different techniques in both the case group and the control group, which had Ménière disease. Specifically, in accordance with 2 literature studies, we compared oscillation velocities and orbital area measurements in the balance error scoring system.

In 2009, Sevilla-Garcia et al<sup>10</sup> published a study called "Limits of Stability," in which they identified the limits of stability in Ménière disease, measuring the ability to shift around pressure centers on a moving balance platform. They assessed the speed, direction, orbital range, and reaction time of the patients. Consequently, they found that dynamic balance is moderately disturbed in individuals with Ménière disease.<sup>10</sup> In Ménière's patients, posturographic findings are severely impaired.<sup>11</sup> The findings from our study support the existing literature. When we compared the pretest stability limits of both groups, we found no statistically significant difference ( $P > 0.05$ ). This result indicates that both groups began the

comparison on equal terms. In the comparison of pretest and posttest averages in the case group, a statistically significant difference in the direction of improvement was observed ( $P < 0.05$ ). However, there was no statistically significant difference in the pretest and posttest measurements of the direct control values of the control group ( $P > 0.05$ ). When the stability limits of the control and case groups were compared with the posttest, it was seen that the case group was significantly higher. According to these results, the rehabilitation treatment, including virtual reality therapy, which we added to the Ménière's patients of the case group, showed a significantly different improvement effect on the chronic balance disorder of Ménière's.

In their 2023 study, Rezaeian and colleagues concluded that traditional vestibular rehabilitation after treatment improved the quality of life of Ménière patients in 3 studies examining 465 patients. They stated that longer-term and high-quality studies should be conducted to achieve effective results.<sup>12</sup> In a randomized controlled study conducted in 2022, Zhuang and colleagues investigated the effectiveness of vestibular rehabilitation in patients with chronic imbalance across 22 experimental and 22 control groups. The patients were evaluated with the Dizziness Disability Inventory at an 8-week follow-up, and they reported that traditional vestibular rehabilitation improved balance disorders and reduced the risk of falls in chronic imbalance patients with Ménière disease, and that it was a treatment method worth applying in the clinic.<sup>7</sup> In our study, the effectiveness of vestibular rehabilitation, including virtual reality treatment, was evaluated with VVAS, BAI, and DHI questionnaires, bedside tests, and a static posturography test. We found that rhythmic weight static posturography had a high impact on vestibular rehabilitation, including virtual reality treatment. According to these results, since there was no significant difference in the pretest comparison of right-left axis velocities between the case and control groups, both groups participated in the study under equal conditions. In the posttest comparison of right-left axis velocities, a significant improvement was observed in favor of the case group. These values are consistent with the results of Rezaeian and Zhuang and their colleagues, indicating that vestibular rehabilitation is a very effective treatment for balance disorders due to Ménière disease.

Virtual reality treatments have introduced a new dimension to vestibular rehabilitation, breaking new ground in the field. A study from 2018, conducted by Diez-Cirarda et al,<sup>13</sup> demonstrated that despite the neurodegenerative nature of Parkinson disease, virtual reality treatment can enhance neuroplasticity, eliminate balance disorders, and lead to significant improvements in cognitive motor functions. In 2019, Moreno et al<sup>14</sup> observed notable enhancements in consciousness levels and motor functions among Alzheimer's patients receiving SG treatments with both high immersion and low immersion features. The study showed that treatment improves quality of life, gait, and balance.<sup>15</sup> In line with existing literature, our study also emphasized vestibular rehabilitation involving virtual reality treatment, allowing for clear observation of the healing effects that virtual reality applications can have on balance and their positive impact on motor functions and cognitive systems. In 2013, Garcia et al<sup>16</sup> compared outcomes between 23 patients diagnosed with definite Ménière disease who underwent vestibular rehabilitation—including virtual reality treatment—and 21 patients in the control group who received medication. They found that vestibular rehabilitation incorporating virtual reality improved dizziness complaints in patients with Ménière disease, enhanced their quality of life, and effectively improved their balance functions. Our study yielded similar results. Among our

2 groups of 25 patients with a definitive Ménière's diagnosis, only the control group received drug treatment while the case group underwent vestibular rehabilitation that included virtual reality treatment. Our findings, evaluated using DHI, VVAS, bedside tests, and static posturography, were consistent with those of Garcia and colleagues in 2013, revealing significantly better outcomes in the group that received vestibular rehabilitation, including virtual reality, compared with the drug treatment group. Dizziness complaints were most frequently reported in female patients, regardless of the disease.<sup>17</sup> In our study, the number of female patients presenting with this complaint was significantly higher than that of male patients ( $P < 0.05$ ). However, the distribution of male and female patients in both the case and control groups was homogeneous.

Jacobson and Newman<sup>18</sup> stated in their 1990 study that the dizziness handicap inventory was useful for the evaluation of Ménière patients. In the study, they showed that the participants in the control and case groups had similar Dizziness Handicap Inventory (DHI) scores at the beginning. After the treatment, a significant improvement was observed in the DHI scores of the patients in the experimental group, while only a slight improvement occurred in the control group. In addition, all 16 participants in the experimental group completed the study after the treatment and no adverse events were reported. This supports the safety and effectiveness of vestibular rehabilitation treatment for dizziness in individuals with Ménière disease.<sup>18</sup> Zeigelboim and colleagues examined the effect of traditional vestibular rehabilitation treatment using the Cawthorne and Cooksey protocol in 6 patients (2 male, 4 female) aged between 43 and 70 years with dizziness, imbalance, depression, and tinnitus in 2008. The analysis of the DHI questionnaire indicated that patients showed functional and emotional improvement, but this improvement was not statistically significant.<sup>19</sup> Zhuang et al<sup>17</sup> emphasized that vestibular rehabilitation was effective in Ménière patients with chronic imbalance using the DHI criteria in 2022. They reported that this treatment improved balance disorder and reduced the risk of falling. The findings obtained in our study are similar. In the first evaluation before the intervention, the DHI scores obtained from the dizziness disability inventory in the case and control groups were similar in the pretest comparison, and no significant difference was found; both groups started under equal conditions. In the posttest comparison, the DHI mean prescore (84.00) and postscore (12.00) were obtained in the case group subjects. The case group gave significantly better results than the control group. In the DHI posttest comparison of the control and case groups, a statistically significant difference was found in favor of the case group. This shows us that the vestibular rehabilitation that includes virtual reality treatment is very effective in the treatment of balance loss due to Ménière disease. These results are consistent with the study conducted by Jacobson and Zhuang, but not with the study conducted by Zeigelboim et al.<sup>19</sup> Zeigelboim and colleagues used a limited number of patients, with only 6 in their study and selected a weak vestibular rehabilitation method by applying only the Cawthorne-Cooksey rehabilitation technique. In contrast, a larger participant group was reached with 50 patients in our study. The applied vestibular rehabilitation methods include more effective approaches such as virtual reality, classical rehabilitation techniques and static posturography. This situation is considered to be an important factor in the successful results of our study. In another study conducted in the literature, Chen et al<sup>20</sup> stated that the level of dizziness disability is associated with depression, anxiety, and somatization in 2012. These findings emphasize the importance of evaluating the psycho-

logical states in individuals experiencing dizziness. Some patients with peripheral dizziness may also frequently experience psychiatric or psychological mood disorders. Similarly, dizziness may also often occur in patients with psychiatric disorders, and this should be considered an essential factor in the treatment process.<sup>21</sup>

In our study, high levels of anxiety were detected in patients in both groups because the quality of life decreased due to balance disorders. There was a decrease of 27.00 in the mean score of the case group from the pretest (average = 34.00) to the posttest (average = 7.00). Statistically significant results were obtained. The Beck Anxiety Scale pretest scores were also high in the control group. There is no statistically significant difference between the groups of the participants' pretest scores of the Beck Anxiety Scale ( $P > 0.05$ ). The study was started under equal conditions. There is a statistically significant difference between the posttest scores of the Beck Anxiety Scale between the groups of the participants, in favor of the case group ( $P < 0.05$ ). The patients were relieved of their anxiety complaints to a significant extent after the treatment. The anxiety complaints of the patients whose dizziness complaints decreased also decreased. Aust and colleagues examined the patients with vertigo complaints in 1999. In the study, patients with panic disorder, together with vertigo symptoms, were compared with 53 patients who had only vestibular symptoms but were not diagnosed with anxiety or panic disorder. The results obtained showed that although no abnormal findings were detected in the rotation test and caloric test in patients with anxiety, the rate of spontaneous nystagmus was significantly higher. These findings emphasize the potential effects of anxiety on vestibular functions.

The visual vertigo analog scale, which is used as an essential tool to evaluate visual vertigo in patients with Ménière disease, is widely preferred, especially to monitor the course of dizziness after vestibular rehabilitation treatment.<sup>22</sup> Gazzola et al's<sup>23</sup> 2006 studies confirm the frequency of moderate classifications (between 4 and 6 points) regarding the VVAS average. Tsukamoto and colleagues' 2015 study investigated how vestibular rehabilitation protocols affect quality of life and postural balance in patients with vertigo. The study was conducted on 20 patients diagnosed with vestibular disorders, without a randomized controlled trial. The patients' quality of life was assessed using the DHI, and the severity of dizziness was assessed using the VVAS. The patients treated for 12 weeks were divided into 2 groups: those using and those not using medication. There were 9 patients using medication and 11 patients not using medication in the study. As a result of the treatment, an improvement was observed in the patients' quality of life and dizziness severity. In addition, improvement was noted with functional tests of postural balance.<sup>24</sup> In a study conducted by Garcia and colleagues in 2013, the severity of dizziness determined by VVAS in patients with Ménière disease was generally classified as severe between 7.17 and 7.81 points. This situation shows that the patients examined in the present study were at a more advanced stage than those in other studies. The present study's findings revealed a regular and positive correlation (54%) between the subjective perception of symptoms measured by DHI and VVAS. In other words, an increase in the DHI score generally causes an increase in the VVAS score; similarly, this relationship is also valid in reverse. Dannenbaum et al<sup>25</sup> evaluated the reliability and validity of the visual vertigo analog scale in their study conducted on 102 Ménière's patients in 2011. The results of the study showed that this scale was effective in assessing the severity of vertigo. In addition, a positive relationship was revealed between the severity of vertigo in the evaluation made between DHI scoring and VVAS<sup>25</sup>

( $r=0.67$ ,  $P<0.0001$ ). In our study, VVAS tests were applied to both groups. When we made a pretest comparison of the control and case groups in our study, it was seen that the groups started the study statistically equal. In our study, there was a positive relationship between the severity of vertigo, which we evaluated using the DHI scoring and the visual vertigo analog scale. In our study, a statistically significant difference was found in favor of the case group in the posttest comparison of the visual vertigo analog scale of the case group and the control group. These results show that the vestibular rehabilitation treatment, including virtual reality treatment, that we performed on our case group patients was effective.

## CONCLUSION

We concluded that vestibular rehabilitation, including virtual reality therapy, effectively manages balance disorders associated with Ménière disease. The interactive and controlled framework of the virtual reality environment alleviates dizziness and imbalance symptoms by facilitating patients' sensory adaptation. The data obtained indicate that rehabilitation incorporating virtual reality therapy presents an innovative and effective treatment alternative for Ménière's patients experiencing balance loss and offers broader benefits by enhancing patients' adherence to treatment.

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