Chapter

Vestibular Rehabilitation: Conventional and Virtual Reality-Based Methods

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Abstract

The vestibular system is responsible for sensing the velocity and acceleration of angular and linear movements of the head and sensitivity to gravity in maintaining balance with its peripheral and central structures. It performs this function through vestibular reflexes. When peripheral vestibular diseases occur unilaterally or bilaterally, the functions of vestibular reflexes are affected, resulting in deterioration in eye movements compatible with head movements and anti-gravity muscle activity coordination, which ensures upright posture against gravity. Dizziness and/or imbalance persist in patients in whom the central compensation process cannot be completed, resulting in restrictions in the patient's independent movements, daily activities, and quality of life. In the middle and long term, these restrictions cause sedentary life, fear of falling, loss of general condition, emotional problems, and social isolation. In patients diagnosed with unilateral peripheral vestibular disease, vestibular rehabilitation methods based on exercise and living environment arrangements are used as valid and reliable methods to support central compensation mechanisms and to eliminate movement restrictions. Along with conventional exercises, virtual reality-based vestibular rehabilitation systems on stable or unstable platforms are also used for this purpose. In this chapter, the essential principles of conventional and virtual reality-based vestibular rehabilitation methods take place.

Keywords: vestibular disorders, imbalance, central compensation, vestibular rehabilitation, virtual reality

1. Introduction

The vestibular nuclear complex integrates and stores inputs from the vestibular, visual, and proprioceptive sensors. With its central and peripheral connections, the vestibular system provides cortical awareness of head and body movements, control of oculomotor activity, control of posture, and control of motor skills. The vestibular system is also known to contribute to high-level cognitive processes, including spatial perception, spatial navigation, body representation, attention, memory, mental imagery, and social cognition. Therefore, in addition to weakening the vestibular reflexes in vestibular disorders, spatial navigation and memory tasks, as well as body representation and body awareness are impaired. The functional, psychological, and social effects of vestibular diseases are very important from a societal perspective [1, 2].

Vestibular sensors are located in the petrous part of the temporal bone in both inner ears, in anatomical and physiological relationship with the cochlea. The outer part is the bone labyrinth, the inner part is the membranous labyrinth. The membranous labyrinth is filled with endolymph. The space between the bony labyrinth and the membranous labyrinth is filled with perilymph. Perilymph is similar to cerebrospinal fluid. Endolymph is similar to intracellular fluid (high K+ and low Na+). The sensory structures are located in the membranous labyrinth. Sensory receptors in the vestibular organs are located close to the vertical and horizontal planes. In this way, they can detect all movements of the head. All receptors are excited by forces associated with acceleration. The utricle and saccule (otolith organs) are sensitive to linear acceleration, gravity, and head stability. Semicircular canals are sensitive to angular acceleration in their plane. Vestibular sensors differ from other sensory receptors because they produce motor reflexes as well as positional perception. The sensors of the vestibular labyrinth are innervated by the afferent and efferent fibers of the vestibular branch of the eighth cranial nerve. Nerve fibers form the Scarpa's ganglion go to the brain stem as the vestibular nerve. The vestibular nerve divides into superior and inferior branches and contains a total of 18,000 to 20,000 nerve fibers. The superior branch innervates the utricle, the antero-superior part of the saccule, and the superior and horizontal semicircular canals. The inferior vestibular nerve innervates most of the saccule and the inferior semicircular canal. Most of the vestibular nerve terminates in the vestibular nuclei and a small part in the cerebellum. The vestibular nuclei are located in the posterior part of the brainstem where the pontomedullary junction. There are four major nuclei (superior, lateral, medial, and inferior) and seven minor nuclei separately on the right and left sides of the brain stem. In addition to vestibular inputs, the vestibular nuclear complex also receives inputs from the visual, proprioceptive, cerebellar, and reticular formations. Since the cerebellum is the motor coordination center, it plays a role in the regulation of vestibular reflexes. Cerebellum has a predominantly inhibitory effect on the vestibular nuclear complex. Connections between the cerebellum and vestibular nuclei help maintain balance and posture by providing harmony between head, trunk, and eye movements. Inputs from vestibular sensors are used to create vestibular reflexes that help maintain balance. Vestibular reflexes (vestibulo-ocular, vestibulo-spinal, vestibulo-collic, cervico-ocular, and cervico-collic reflexes) are reflexes that play a role in maintaining balance as a result of processing the visual, proprioceptive, and vestibular inputs at the level of the vestibular-nuclear complex. The vestibulo-ocular reflex (VOR) provides visual focus on an object during head movements. The VOR arc between the vestibular system and the extraocular muscles performs this function. All semicircular canals and otolith organs have VOR arcs. The VOR keeps the visual image stable on the retina when the head moves. While the head is turned to the right, the VOR slowly turns the eyes to the left, and the reticular formation that tries to pull the eye to the midline also pulls the eye to the middle, this is called physiological nystagmus. Nystagmus may occur due to physiological (caloric, rotation chair, head shake) or pathology. The connections between the vestibular nuclei and the spinal cord create the vestibulo-spinal reflex (VSR). The VSR is responsible for maintaining posture. The lateral vestibulospinal tract originates from the lateral vestibular nucleus and extends to the spinal cord. It keeps the body upright by managing the head, trunk, and lower extremities against the slope using utricular input. The medial vestibulospinal tract originates from the medial, lateral, and inferior vestibular nuclei. It controls head movements with the inputs from the saccule. The vestibular nuclear complex is also connected with the contralateral vestibular nuclear complex, the brain stem centers controlling visceral reflexes, the cerebral cortex, and the hippocampus [2–4].

Vestibular system disorders can be central or peripheral. Peripheral vestibular system diseases as unilaterally or bilaterally, sudden or gradual, stable, progressive or fluctuating, temporarily or permanently, and completely or partially affect the vestibular receptor functions. Unilateral peripheral vestibular disorders disrupt the symmetry of input from vestibular sensors at the level of the brainstem. This may lead to disorientation in the perception of head movements and vestibular reflexes [2, 5].

Asymmetric vestibular inputs at the level of the vestibular nuclear complex may lead to static vestibular symptoms in the acute period and dynamic vestibular symptoms in the sub-acute and chronic period of the pathology. Static vestibular symptoms are nystagmus, vertigo, subjective visual vertical and horizontal perception disorientations, skew deviation, head and trunk tilt to the ipsilesional side, and neuro-vegetative symptoms. These symptoms occur spontaneously. In the ideal conditions, completely compensated in a few months. Dynamic vestibular symptoms are decreased and asymmetrical vestibulo-ocular reflex, vertigo, ocular counter rolling, postural instabilities, and cognitive symptoms. These symptoms occur during head movements. Compensation takes a longer time than static symptoms. It may not disappear completely [1, 6].

2. Vestibular compensation

It is a recovery mechanism after unilateral peripheral vestibulopathy. It is the central nervous system process that occurs to reduce the neural firing asymmetry at the level of the brainstem due to the lesion and to readjust the gain. In the process of regulation of peripheral function, mechanisms such as regulation of vestibular processing at the level of the brainstem, use of prediction and modulation of other senses instead of vestibular input, and adaptation to reduce the use of vestibular input are utilized. On the lesion side, the intrinsic excitability of the vestibular nuclei is increased, they are desensitized to inhibitory inputs, and their activity is gradually increased. The contralesional region is under the inhibitory effect of the cerebellum. Mechanisms involved in recovery after acute peripheral vestibular pathology with vestibular compensation, spontaneous recovery of damaged receptors and neurons, adaptation of residual vestibular function (the ability to adapt to head movement during the movement of an image on the retina), substitution for lost vestibular functions (with visual and somatosensory cues) and habituation to unwanted sensations (reduction of symptoms and pathological responses to provocative stimuli by systematic exposure to that stimulus). All of these mechanisms start simultaneously after the lesion. Achievement levels can affect each other. The success of one mechanism may obviate the need for the other. This results in the recovery processes being different from person to person. Static symptoms may improve within weeks, some of the dynamic symptoms may persist for life depending on the character of the disease. Otolytic symptoms resolve in a shorter time than semicircular canal symptoms. Vestibular compensation of static symptoms begins in the first 24–72 hours after acute unilateral peripheral vestibular lesion. The patient can walk with or without assistance after approximately 48 hours and starts to return to normal activities in two weeks. After the first three months, many patients can recover with minor static or dynamic symptoms. Static and dynamic symptoms continue to exist in vestibular compensation deficiencies. Factors affecting vestibular compensation directly or indirectly are age, type of vestibular pathology (stable/progressive/fluctuant), central nervous system function, lack of sensory input (vision, sense of touch), vestibulosuppressant use, musculoskeletal diseases (lower extremities or spine), sedentary lifestyle, poor head-eye stabilization, disturbances in the perception of stability, poor balance strategies, psychological disorders [7].

2.1 Why is vestibular compensation important?

The prevalence of vestibular diseases is high (35.4% over 40 years old, 64.8% over 60 years old, 84.8% over 80 years old), they increase the risk of falling, increase the cost of health care, decrease the quality of life, increase job loss, cause anxiety and depression. Recovery is not the same for every patient. Vestibular compensation can occur in three ways: full compensation, partial compensation, and decompensation. Symptoms of varying degrees of inadequate vestibular compensation are imbalance, impairment of visual fixation, spatial disorientation, vertigo, oscillopsia, sensitivity to environmental movements, cognitive problems, anxiety, and poor concentration. The consequences of these symptoms are inactivity, fear of falling, financial dependency, social isolation, disabilities in daily living activities/dependency, and decreased quality of life [1, 8].

3. Vestibular rehabilitation

It is a patient-oriented and exercise-based therapy program designed to support vestibular compensation after vestibular pathology. It benefits from vestibular adaptation, oculomotor movements, visual cues, somatosensory cues, postural strategies, and habituation while supporting vestibular healing mechanisms. Visual fixation exercises, head and eye movements combined with various activities, different upper extremity, head and trunk movements while maintaining balance despite reduced support surface, systematic repetition of movements that increase vertigo, and gradually exposing patients to various sensory or motor stimuli are used in the exercise program. The purposes of vestibular rehabilitation are to increase gaze stability, increase postural stability, reduce vertigo and the risk of falling, make the patient independent by improving the activities of daily living, and psychosocial well-being, and increase the health-related quality of life. In short, it is aimed to bring the patient closer to the normal state before the disease at the maximum level by increasing the safe movement and reducing the symptoms. It is an exercise-based therapy program designed to support vestibular compensation after vestibular pathology [8–12].

3.1 Indications of vestibular rehabilitation and patient selection

Vestibular rehabilitation is indicated for stable but decompensated vestibular lesions, regardless of the age of the patient, cause of pathology, duration, and intensity of symptoms. Stable and insufficiently compensated unilateral vestibular lesions, bilateral vestibular lesions, central vestibular lesions, mixed (central and peripheral) vestibular lesions, head trauma, psychogenic vertigo, age-related dizziness (with the aim of reducing the risk of falling), vertigo of unknown etiology, benign paroxysmal positional vertigo (for residual imbalance present in 2/3 of patients after a successful repositioning maneuver) benefit from vestibular rehabilitation. Vestibular compensation cannot develop in patients with active labyrinth pathology and fluctuating/progressive pathologies (Meniere's disease, perilymph fistula, superior semicircular canal dehiscence, enlarged vestibular aqueduct). Vestibulospressant use, visual and somatosensory deprivation, long-term immobilization, advanced age, and central nervous system lesions may prolong the recovery period, but do not completely prevent compensation [12, 13].

3.2 Vestibular rehabilitation methods

Conventional vestibular rehabilitation methods include Cawthorne-Cooksey exercises, multimodal Cawthorne-Cooksey exercises, vestibulo-ocular reflex adaptation exercises, habituation exercises, substitution exercises, and static and dynamic balance exercises [14, 15]. Alternative vestibular rehabilitation methods include augmented sensory feedback, movable platforms, full-screen optokinetic exercises, computer games (exergames), and virtual-reality-based vestibular rehabilitation. Alternative vestibular rehabilitation methods can be applied instead of conventional exercises or in combination with them. It can be preferred in patients who do not benefit from conventional methods.

The conventional vestibular rehabilitation program should be specific to the patient's complaints, suitable for lifestyle, consisting of a reasonable number and variety of exercises, easily learned, developed from easy to difficult-from simple to complex, functional, and individual. The steps of the rehabilitation program consist of evaluation, training of the patient and family, planning of the exercise program, domestic arrangements to increase the safety of movement, suggestions for the selection of assistive walking equipment and shoes if necessary, implementation of the exercise program, evaluation after the therapy, termination of the therapy and clinical follow-up.

The evaluation should consist of vestibular function tests (video head impulse, functional head impulse, subjective visual verticality and horizontality, static or dynamic posturography) that can evaluate vestibular involvement and compensation with numerical data and special scales that subjectively evaluate the patient's quality of life or limitations. The vestibular rehabilitation evaluation protocol, which consists of qualitative and quantitative data, helps to establish the exercise program, to support the belief and motivation of the patient in the rehabilitation program, to measure the success of treatment, to compare or prove the effectiveness of different rehabilitation methods, and to make the decision to terminate the rehabilitation program of the patient [11, 12].

Conventional exercises can be started with visual fixation exercises combined with head movements to support the vestibulo-ocular reflex. It can be done lying down, sitting, standing, or combined with walking, depending on the functional status of the patient. Saccadic and smooth pursuit movements are also added to the program in bilateral or central vestibular pathologies where substitution is required. The vestibulo-spinal reflex should also be supported to improve postural stability. In accordance with the functional status of the patient, a static posture should be practiced with a regular stance, two feet together, tandem or single leg on stable ground, movable ground, or foam. This should be followed by walking exercises, stepping forward, backward, left and right, and turning around by stepping around. Normal gait, straight gait, gait with horizontal and vertical movements of the head, and gait on the foam should be practiced. Turning activities should also be added to dynamic exercises. Static and dynamic balance exercises can also be applied by making changes in the visual input [11–13, 15].

Habituation exercises should be applied to the patient to reduce vertigo caused by movement. A program consisting of movements that the patient is most uncomfortable with can be created. While sitting or standing, repetitive head movements, trunk rotation, forward bending, and reaching up can be performed. A program consisting of exercises that will not cause neurovegetative symptoms should be established [11, 12, 15].

In conventional vestibular rehabilitation, the difficulty level of the exercises should be moderate or moderate-high. The exercises that the patient does very easily are non-functional exercises for vestibular compensation. The movements that are difficult at the beginning should be gradually made more difficult as they are performed more comfortably. Exercises can be applied in the clinic or as a home program when the patient comes for control at least once a week. In both methods, the patient should do at least two sets of vestibular exercises a day, and each set should last about half an hour. In addition to vestibular complaints that occur with movement, patients with neurovegetative complaints should do habituation exercises before meals. Exercises should be done in front of a wall or in corners to prevent falls. In addition to the exercise program, daily walking, simple sports activities, cognitive exercises, and regular reading activities should be added to the program. It would be appropriate for the patient not to use vestibulo-suppressants during the vestibular rehabilitation process.

Virtual reality (VR) is an important contribution of computer technology to the vestibular field in recent years. VR is a computer-generated simulation of a visual environment or an activity [16] and is defined as the user entering an interactive environment that mimics reality [17]. At the same time, VR can be defined as using computer technology to create simulations of objects, space, and events. It can represent both a real and a fictional world. This created virtual world includes not only visual content but also auditory and tactile stimuli and allows interaction with the user [8]. VR often uses a task to engage the user/patient in the system. This task can be walking through a crowded subway station, keeping an airplane on the desired route, completing the shopping list at the grocery store, painting an object, skiing, or tracking/capturing a target. In the VR system, the floor can be movable or fixed. In both cases, it is very important to prevent the patient from falling during exercise. Among the factors affecting the success of conventional vestibular rehabilitation are the patients' doing the exercises incorrectly, the active participation of the patients, and the need for their motivation. VR is an enjoyable and motivating method against the time-consuming, repetitive and monotonous conventional vestibular rehabilitation that makes it difficult for the patient to participate. VR-based vestibular rehabilitation is an enjoyable method for patients as it includes games that include real-time simulations, interactive functions, adaptation, substitution, and habituation exercises [2, 11, 14, 18].

Before VR, the use of technological equipment for vestibular rehabilitation started with exergames, which were reflected on TV screens and provided patient participation. With developments in the gaming industry, technologies have been added that combine an accelerometer and a force plate to provide visual and auditory feedback of patients' baseline pressure centers [19]. At the same time, computer games connected to the motion sensor were added [14]. In addition to these, optokinetic stimulation or creating a virtual environment by attaching smartphones to the head for use in the home environment has also been utilized [20–22].

Systems called real VR are immersive systems. Virtual reality immersion is the perception of one's physical existence in a non-physical world. This perception is created by surrounding the VR system user with visual, sound, or tactile stimuli that provide an immersive environment. In rehabilitation, the user's movements are detected and monitored by the system. It is a widely practiced technique for creating a virtual environment using a variety of spherical, flat screen, or head-mounted display formats. The user can interact with objects in VR using body movement. VR has recently gained popularity in medicine with the rapid development of mobile and visual technologies. It is used as an adjunct in psychiatry, in the treatment of anxiety, schizophrenia, or post-traumatic stress disorder, and in the treatment of cognitive disorders, Alzheimer's disease, Parkinson's disease, post-stroke hemiplegia, analgesic treatment of burns, pediatrics, cerebral palsy rehabilitation, and treatment of children with autism spectrum disorders [8, 14, 23, 24].

VR can provide visual, auditory, and tactile feedback that can motivate patients in vestibular rehabilitation, create a sense of physical presence in the virtual world, and provide personalized training. The system provides a hierarchical and customized presentation of realistic environmental stimuli adapted to patients' balance development [22]. Additional hardware can be added to monitor motion kinematics or provide force simulations and haptic feedback to participants [15]. The tactile feedback makes a significant contribution to vestibular rehabilitation, especially in upper extremity activities combined with trunk exercises and moving platform activities (for example, archery or skiing). Tactile feedback not only makes the activity more realistic and enjoyable but also strengthens proprioceptive input.

Fixed or mobile force plates or treadmills can be integrated into head-mounted VR systems. Head-mounted VE systems are very effective in improving vestibulo-ocular reflex, oculomotor movements, eye tracking, and head-eye coordination. Systems that cannot be integrated with any platform, requiring only eye or head movements or staying still, can be called "passive VR rehabilitation systems," systems that require providing or maintaining postural balance on a moving floor, stepping on a stable floor, walking on a treadmill or doing yoga can be called "active VR rehabilitation systems" [11, 15, 17, 19].

No photographs were used in this chapter for preventing to highlighting any VR system brand. The categories of VR-based vestibular rehabilitation exercises can be defined as:

1. Environment or condition simulations: Boat, automobile, airplane, escalator, metro station, and elevator simulations in devices with stable floors are very effective for habituation in patients who cannot tolerate crowded or active environments. Patients exposed to the active environment may show neurovegetative symptoms in the early period. Fear, panic, and a feeling of being away from the environment may occur. The number, speed, and visual characteristics of the parameters in the simulation should be started at a level that can be tolerated by the patient and gradually become more complicated. Simulation should be applied first in sitting, then in standing position on hard or soft ground in the following period. In unilateral peripheral vestibulopathy, especially if the vestibulo-ocular reflex gain is very low, patients are clearly uncomfortable with the motion simulations when they turn their heads towards the pathological side, motion simulation by changing the head position is very useful in these patients. In systems where the ground is mobile, simulations of subway stations, boats or waves are more difficult exercises as they also require the preservation of postural balance during visual mobility.

2. Optokinetic simulations: Images created using horizontal, vertical, or rotatory moving points, planets, or other different shapes. Background, size, number, movement speed, and direction of objects can be adjusted according to the patient's tolerance. In fixed systems, it can be worked in sitting and standing. In systems with a movable platform, ground motion also allows the patient to try to control posture while watching moving objects.

3. Head-eye coordination: They are used as adaptation and substitution exercises as they support both oculomotor movements, head movements, and vestibulo-ocular reflex. Managing the movements of an object (for example, an airplane, planet, or bird) with head movements, watching the moving object with head movements, focusing on the target where it turns the head, trying to find the materials given as a task in the market environment from the shelves can be given as examples of exercises in this category. Movement speed, locations, and sizes of objects can be changed according to the patient. Vestibular pathology causes patients to restrict their head movements. These exercises activate the patients' head and eye movements. These exercises can be done in systems with a fixed floor, again depending on the level of the patient, while sitting or standing on a hard floor or foam. They can also be combined with moving platforms.

4. Exercises involving upper extremity: Exercises involving upper extremity movements in vestibular rehabilitation are very important as they require trunk movements or stepping on motionless platforms. The sensors held by the patients in both hands can be used for shooting arrows, popping balloons, or painting objects. These exercises involve bending forward, reaching up, turning back, or stepping. Parameters of the simulation can be changed in accordance with the patient. Items that increase cognitive activity can be added to exercises.

5. Activity simulations: These exercises are used very effectively, especially in systems with moving platforms. For example, ski simulation creates an effective dynamic balance exercise by adjusting almost all parameters of the visual environment, the task, and the movement according to the patient.

In the use of VR systems for vestibular rehabilitation, appropriate planning is required for the person and the functional level of the person. Vestibular assessment protocols are also known to be included in these systems, but will not be discussed in this section.

In studies in the literature, VR has been used together with or as an alternative to the conventional method in vestibular pathologies. There are also studies comparing the two methods with each other. Compared to conventional vestibular rehabilitation, there are studies stating that the functional effects are the same, as well as studies stating that the satisfaction level of patients is higher in the VR group [6, 8, 14–16, 18, 19, 21–25].

The systems and protocols applied to differ between studies. The use of computer games, which do not fully comply with virtual reality, and even the use of force plate home systems have also been evaluated in this category by some researchers, but as studies have increased, research with real VR systems has diverged. The reasons for using smartphones or force plate systems are to reduce costs and to enable patients to exercise at home by using computer systems. VR systems are applied in the clinic. VR-based vestibular rehabilitation protocols have been applied in various ways in publications. VR sessions were applied in the clinic for 30–40 minutes five days a week or 35–45 minutes two days a week. In some protocols, home exercises are included in the program [17].

The VR system needs standardization of exercise protocols and assessment tools. Especially in head-mounted systems, cybersickness caused by the inability of patients to tolerate the image should be evaluated, the side effects of virtual environment use should be documented, and algorithms are needed to decide which patients are suitable for the conventional program and which patients are suitable for the VR program. Only validated methods should be used to evaluate rehabilitation success, both functionally and with questionnaires. In the rehabilitation program, the number and duration of sessions and the duration of sessions should be documented. Special assessment tools should be used to evaluate side effects such as cybersickness caused by virtual reality. Complications of virtual reality rehabilitation, such as falls and fractures, should be documented. Patients' use of symptom-suppressing drugs should be documented during the period of VR. Since VR cost systems are high, it is recommended to determine session costs [15, 16, 26].

VR-based vestibular rehabilitation combined with conventional vestibular exercises is a very effective method. Home exercises must be included in the protocol. It is known that patients who do home exercises regularly recover in a shorter time. It may be preferable to include virtual reality in the program after conventional exercises, safe standing, and walking are gained in the first few weeks for patients to gain the habit of doing regular vestibular exercises at home and for movement safety [2]. In protocols implemented using only VR or similar systems from the beginning of the rehabilitation program, the patient may misunderstand that he or she should exercise with only one device. The main thing in vestibular rehabilitation is the active participation of the patient and increasing his activity in the living area. Basically, vestibular rehabilitation is not a device-based method, it is a movement-based method. VR is an important part of the conventional vestibular rehabilitation protocol.

Advantages of conventional vestibular rehabilitation program are as follows:

- Vestibular rehabilitation is basically an equipment-free therapy method. Equipment is only an auxiliary tool.
- Conventional vestibular rehabilitation is a cost-effective and practical method.
- It strengthens the communication and cooperation between the patient and the clinician.
- It gives the patient the habit of exercising regularly in the living area.
- It ensures the active participation of the patients in the rehabilitation process.

Advantages of the virtual reality-based vestibular rehabilitation program are as follows:

- Enjoyable
- Motivating
- It can create a real-life perception as it completely covers the visual field

- Provides an effective habituation in patients who cannot tolerate environmental movement
- It can simulate special environments that cannot be achieved in clinical conditions
- The floor can be movable or fixed
- The amount of movement on the moving floor can be adjusted
- Provides the opportunity to gradually complicate the exercise

4. Conclusions

If the imbalance continues after vestibular disease, the patient should definitely be included in the vestibular rehabilitation program. Conventional vestibular rehabilitation methods enable the patient and family to be informed about both pathology and vestibular rehabilitation.

The patient should actively participate in the vestibular rehabilitation process. Home exercises are the most important part of vestibular rehabilitation. The patient should do at least one session of vestibular exercises every day. They should continue these exercises on the days they do not come to the clinic.

Vestibular rehabilitation is a patient-centered approach, not an instrument-oriented approach. Of course, virtual-reality systems are unrivaled in terms of the use of conditions that cannot be provided in the clinic within the scope of the rehabilitation program. Conventional vestibular rehabilitation methods are not sufficient to gain tolerance to external motion, especially in motion sickness patients.

In the clinic, starting the vestibular rehabilitation program with conventional exercises and continuing the program with virtual reality after the patient gains the ability to move safely is very effective in terms of strengthening the patient's active participation in the program and patient-clinician communication.

Vestibular rehabilitation is an exercise-based therapy program designed to support central compensation after vestibular pathology. While supporting vestibular compensation mechanisms: it benefits from vestibular adaptation, oculomotor movements, visual cues, somatosensory cues, postural strategies, and habituation. The aims of vestibular rehabilitation are to increase gaze and postural stability, to reduce vertigo and fall risk, and to make the patient independent by improving daily living activities and psychosocial well-being.

Recently, computer games augmented reality and virtual reality systems have been used in vestibular rehabilitation programs with the developing computer technology. In particular, augmented and virtual reality systems enable the patient to perform challenging visual conditions and special activities in a controlled manner which cannot be provided in standard clinical conditions. In this chapter, a literature review is presented about the roles of classical vestibular rehabilitation and virtual reality systems in improving vestibular compensation.

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