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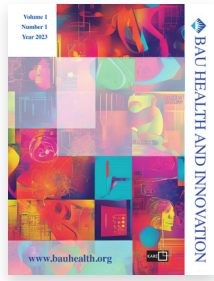

Review

Virtual Reality Efficacy in Neurological Diseases

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Abstract

The term neurological diseases are a general expression encompassing a group of disorders primarily affecting neurons. The general character of neurological diseases is that they are progressive, leading to neuronal loss and consequent impairment of motor and cognitive function. Although symptom relief is possible, current treatments for any neurological disease are not sufficient. However, modifying rehabilitation methods are used. Virtual reality therapies present an alternative treatment approach, leveraging technological advancements, as opposed to traditional rehabilitation methods. The common features of these systems are that they perceive the patient's movements and provide the opportunity to exercise by creating an interactive environment in line with their needs. Simultaneously, another significant factor is the potential to boost patient motivation through the provided exercises.

Keywords: Amyotrophic lateral sclerosis, exercise, neurological diseases, parkinson disease, virtual reality.

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Neurological diseases are an inclusive term for a range of conditions characterized by a continuous loss of neurons.[1] In the neurodegenerative disease category, diseases such as parkinson's disease (PD), amyotrophic lateral sclerosis (ALS), alzheimer's disease (AD) and multiple sclerosis (MS) are frequently encountered.[2] Current estimates suggest that millions of people worldwide are struggling with neurological diseases and that the number of individuals living with these diseases will continue to increase as the world population increases.[3]

Cognitive impairment in neurological diseases is a common problem that significantly affects quality of life. The most common problems are observed in memory, attention and information processing functions.[4] Most studies have shown that cognitive impairment is accompanied by other symptoms such as decreased gait speed, increased postural sway, and balance impairment.[5] It has also been reported that many motor disorders have also been reported.[6] Although symptomatic treatments are possible, there is no definitive cure for any neurological disease.[7]

Most of the studies on neurological diseases have focused on gait and balance[8] and physical exercise programs have been reported to be effective in the treatment of motor disorders.[9] In gait and balance training, it has been determined that treatments based on a dual-task basis including cognitive and motor intervention are effective.[10]

Virtual reality and interactive training programs offer a different treatment opportunity in gait and balance training.[11] Unlike traditional approaches, virtual reality applications that include specific task-oriented studies can provide a more valid form of training that increases motor and cognitive abilities.[12]

In the literature, there are studies on the Biodex Balance System to evaluate postural balance in pain-related

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symptoms in musculoskeletal diseases.[13] However, although balance systems such as Biodex are reliable and objective tools, they are seen as expensive equipment.[14] When virtual reality training was conducted using an integrated balance board, it was found to be highly effective in body balance training compared to training on Biodex balance systems. They also reported that it is easier to use to improve balance in real life.[15]

There are also clinical applications of neurorehabilitation using robotic rehabilitation with virtual reality. The combined application of these applications provides a significant functional improvement in cognitive flexibility and attention in relation to mental and physical state perception.[16]

Currently, virtual reality applications in neurological diseases are being researched as a therapeutic tool.[17] At the same time, it is still controversial that it can be used for diagnosis. In many studies on adolescents and adults, it has been reported to provide brain plasticity. At the same time, it has been reported that the amount of video games increases the gray matter volume of the brain and improves cognitive functions. Thus, it has been found that the individual provides the necessary cortical stimulation by increasing neuroplasticity.[18] Thanks to plasticity virtual reality; repetitive target-oriented tasks at the molecular level have been reported to play a role in the remodeling of dendritic spines and the reorganization of movement in the motor cortex, premotor cortex, additional motor area, and somatosensory cortex.[16]

Virtual reality applications for rehabilitation purposes are recognized as an alternative treatment in numerous clinical trials focusing on various neurological diseases. This review aims to examine virtual reality technology, its role in rehabilitation, and applications in neurological diseases.

Virtual Reality Technology

Virtual reality is defined as "a three-dimensional model of the environment in which simulations created by computer hardware and software offer users the opportunity to participate in a dynamic environment using real-world objects and events." In virtual rehabilitation, virtual environments and objects provide visual feedback that can be presented to the user through a head-mounted device, projection system, or flat screen.[19] Feedback can also be through the senses such as hearing, touch, movement, balance, and smell.[20]

The user interacts with the environment through various mechanisms created. These can be simple devices such as a mouse or joystick, or more complex systems using a camera, sensor, or haptic (tactile) feedback device.[20] Thus, depending on the intervention, the user's level of physical activity can range from relatively inactive (e.g., sitting at a computer using a joystick) to highly active (e.g., challenging full-body movements).[21]

In short, virtual reality is based on computer hardware and software that mediates the interaction between the user and the virtual environment. It started to be developed after the 1990s and is still being developed. This new technology can be used in many fields and for various purposes.[22]

The Place of Virtual Reality Applications in Rehabilitation

Virtual reality applications were previously used as flight simulation training for pilots and cerrahi training.[23] Interventions used in health care have been used to treat problems such as phobias, post-traumatic stress disorder, and body image disorder.[24] Research on rehabilitation has become more widespread as virtual reality has become more accessible and affordable. However, the use of virtual reality has not yet become widespread in clinical rehabilitation settings.[25] However, gaming consoles are more accessible and therefore can be used by researchers and clinicians as an alternative way of providing virtual reality.[26] As this technology becomes more accessible and affordable, virtual reality is likely to be used in clinical rehabilitation settings. In addition, they are included in treatment programs by supporting and complicating movement with robot-assisted applications.[27]

Virtual reality allows rewarding movements in situations simulated in a computer environment. In this way, it is thought to activate dopaminergic pathways by stimulating reward regions in the brain.[28]

Recent studies support that the primary motor cortex involved in motor learning in healthy individuals responds to rewarding successful behavior.[28] Rewarding reports that motor memory is long-lasting whereas punishment is short-lasting. Therefore, strategies that match virtual reality with reward signals for correct movement sequences may provide clinical benefit.[29]

There are some limitations in virtual reality therapy. Virtual reality cannot stimulate some senses. In fact, real technology is more effective in stimulating the extraceptive properties of the body using visual and auditory stimuli, but less effective in stimulating other senses (touch and smell).[30] It has also been reported to be partially effective in stimulating the proprioceptive properties of the body using tactile technologies. However, it has not yet been determined to be effective in the interoceptive/vestibular properties of the body.[31]

Use of Virtual Reality Applications in Neurological Diseases

When randomized controlled studies were examined in the literature, virtual reality and interactive interventions were used in treadmill walking,[32] stepping tasks,[33] and dynamic balance board.[34]

Virtual Reality Training in Parkinson's Patients

More than half of patients with PD have impaired step-taking and freezing phenomenon, an episodic gait disturbance. Along with motor impairment, both executive dysfunction and attention disorder may accompany these patients.[7] Mirelman et al. (2011)[35] reported an increase in walking speed after virtual reality training in patients with PD and fewer cognitive errors in a dual task simultaneously with walking (35%). In a study by Galna et al. (2014) aiming to improve walking in PD, it was concluded that the use of virtual reality is a safe and valid method. In addition, a moderate improvement in stride and stride length can be achieved compared to traditional physiotherapy. Another study showed a remarkable improvement in stepping time and rhythmic arm oscillations in patients with PD. It has also been determined that interventions for home use of virtual reality can significantly improve the quality of life for patients.

Virtual Reality Training in MS Patients

MS is a chronic inflammatory disease of the central nervous system. Both relapses and remissions and progressive phases seen in these patients can cause irreversible axonal losses.[36,37] In addition, gait disturbances are commonly observed. Recently, studies on the use of video games have increased in the field of motor rehabilitation. Studies have determined that virtual reality applications for these patients are a more motivational, cognitive, and motor recovery alternative to traditional motor rehabilitation. He reported that additional research is needed to support rehabilitation protocols with virtual reality applications and to increase the effects of treatment-reported improvements in gait speed, stride length, and cognitive attention after virtual reality-based treadmill training.[38] In a meta-analysis, Webster et al. (2020)[39] provided evidence that virtual reality provides upper extremity motor improvement. Another study reported an increase in functional independence and satisfaction of patients with MS in an intervention using virtual reality telerehabilitation.

Virtual Reality Training in Alzheimer's Patients

AD is the most common cause of dementia. It is a progressive neurological disease characterized by progressive cognitive decline with loss of independent function seen in these patients.[40] Virtual reality education offers an effective educational potential by transferring educational outcomes to daily life. In a study conducted for AD, it was emphasized that significant improvements should be made to make virtual reality a versatile assessment and treatment tool. It is also hoped that it can be easily transported at the most affordable price for these patients in their living environments such as in-home and nursing homes.[41]

Moreno et al. (2019)[42] reported that virtual reality can be used to improve memory, dual-task and visual attention, and psychological functioning such as reduced anxiety and increased coping strategies in Alzheimer's patients.

Virtual Reality Training in ALS Patients

The main symptoms of ALS are degeneration involving multiple regions of the spinal cord and brain stem.[43] Impairments like weakness of the inner muscles of the hand, early deterioration of speech, and loss of innervation in the respiratory muscles, which are commonly seen, can make it difficult for patients to perform functional tasks that affect communication, entertainment, work and social activities.[44] There are different approaches to improve the quality of life in individuals with ALS, the most recommended is the use of assistive and augmented technology, but it is still difficult to address most of the needs of patients with ALS in treatment.[45]

In the literature, interventions with virtual reality applications in neurological diseases have shown promising results for improvement.[8–10] These results have shown that the use of virtual reality treatments can be effective in MS,[32] Parkinson's,[33] Alzeirmer,[40] ALS[44] and many other diseases. For this reason, researchers and therapists have identified the need for further studies to select an intervention that can be effectively applied and beneficial to patients. Virtual reality therapies used as a treatment option can work on cognitive attention by adding simultaneous cognitive challenges to existing balance and gait studies.[38,45]

However, these studies show that video games used in neurological diseases may need to be adapted to specific clinical populations and that safety and applicability as a home-based rehabilitation tool have not yet been fully established.[46]

Conclusion

In conclusion, virtual reality therapies are effective in improving motor function, but there is no clear consensus on which virtual reality-based approaches are most effective or the optimal duration and intensity of intervention. More studies on this topic are needed.

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