E-ISSN: 2706-9575
P-ISSN: 2706-9567
IJARM 2021; 3(2): 18-20
Received: 11-05-2021
Accepted: 14-06-2021

Vasileios Mylonas
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Dimitrios Lytras
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Paris Iakovidis
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Anastasios Kottaras
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Andreas Fotios Tsimerakis
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Ioanna P Chatziprodromidou
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

Corresponding Author:
Vasileios Mylonas
Department of Physiotherapy, Faculty of Health Sciences International Hellenic University - Alexander Campus P.O. Box 141, 57 400 Sindos, Thessaloniki, Greece

The effect of virtual reality on restoring the balance of adult patients with spinal cord injury

Vasileios Mylonas, Dimitrios Lytras, Paris Iakovidis, Anastasios Kottaras, Andreas Fotios Tsimerakis and Ioanna P Chatziprodromidou

DOI: https://doi.org/10.22271/27069567.2021.v3.i2a.210

Abstract
Spinal cord injury (SCI) is a type of injury that presents a high degree of disability and causes motor and sensory deficits. Applying virtual reality (VR) therapy can help better rehabilitate patients with SCI by improving their balance and other functional parameters. The aim of this review is to describe recent research data on the efficacy of this method in improving balance in adult patients with SCI. The Google Scholar, PubMed, Scopus and PEDro databases were searched for articles published from 2015 to date in English with the following keywords: spinal cord injury, virtual reality, balance, rehabilitation. The review included 10 articles (five clinical trials and five systematic reviews). Discussion-Conclusions: The application of VR can significantly contribute to the improvement of static, postural and dynamic balance in patients with SCI. The results of this review show that approximately 20 sessions of 30-60 minutes each are able to improve balance in these patients. More clinical studies are needed to draw safer conclusions.

Keywords: Spinal cord injury, virtual reality, balance, rehabilitation

Introduction
Spinal cord injury (SCI) is a type of injury that has a high rate of disability. It causes loss of sensation and motor function and can lead to multiple organ dysfunction. The high cost of treatment, the long-term recovery process and the lack of a supportive environment significantly affect the life of the patient and their family, while burdening society [1]. The cost of managing the care of patients with SCI reaches $3 billion annually [2].
SCI can occur as a result of non-traumatic (16%) and traumatic causes (84%), although recent studies show a slight increase in the level of non-traumatic SCI [3]. Traumatic SCI can lead to varying degrees of paralysis, loss of sensation and bladder or bowel dysfunction [1]. Etiologically, the largest percentage of injuries occur during road accidents (36.5%), more than 25% are due to falls and the rest are caused by acts of violence (mainly shootings), sports accidents and other less common causes [2]. Non-traumatic SCI is usually due to spinal stenosis, tumor-related compression, vascular ischemia and some related disease [1].
There are two types of SCI: complete and incomplete. Complete injuries cause full loss of muscle control and sensation from the site of injury and lower. Incomplete injuries can affect either muscle energy or peripheral sensation. T1 is the pivotal point that separates quadriplegia from paraplegia [2]. The incidence rate of the condition is between 13.1-163.4 cases per million people in developed countries and between 13-220 cases per million people in underdeveloped countries [1]. The mean age of onset of SCI has increased from 26.0±11.8 in 2003 to 37.9±15.7 in cases occurring from 2009 onwards [4]. Regarding gender, 80% of patients with SCI are men [2].
Virtual reality (VR) is considered a useful therapeutic tool for various disea that require rehabilitation. It can be used for a variety of purposes in therapeutic exercise, including pain management, increasing range of motion, improving muscle strength, increasing functional ability and other parameters [5]. The application of VR can play an important role in the rehabilitation of patients with SCI and in particular in the treatment of their balancing disorders.
The aim of this review is to describe recent research data on the efficacy of the use of virtual reality in improving the static and dynamic balance of adults with SCI.

Literature review

The Google Scholar, PubMed, Scopus and PEDro databases were searched for articles published from 2015 to date with the following keywords: spinal cord injury, virtual reality, balance, rehabilitation. The review included five clinical trials and five systematic reviews. Below are their main findings and conclusions.

Tak *et al*. [6] studied the effect of exercise with VR games using the Nintendo Wii gaming console on static balance in patients with SCI. The study involved 26 patients, who were equally divided into two groups, VR and control. Both groups received the standard rehabilitation, which lasted six weeks with five sessions per week of 60-90 minutes each. The VR group performed an additional six weeks of treatment, with three 30-minute sessions per week, using the Nintendo Wii to improve static (static rocking speed and distance) and dynamic balance. The results showed a significant improvement in both parameters for both groups, while comparatively between the two groups the VR group showed a significant improvement in both parameters compared to the control group.

In the study of Khurana *et al*. [7], the effect of balance exercises with VR games on the static balance and functioning of patients with paraplegia was compared to that of performing activities in real conditions. The study involved 30 patients (28 men, two women) with traumatic SCI, who were divided into two groups. Their injuries occurred between the T6 and T12 vertebrae. Group A received the VR treatment, while group B was treated with real-life activities. Regarding VR equipment, the Sony PlayStation 2 game console with the EyeToy accessory was used in three different settings (birds and balls, football and snowball games), whereas group B performed activities such as ball throwing and catching, dressing, tying and untying knots, etc. Measurements were performed with the modified Functional Reach Test (mFRT), the t-shirt test and the self-care component of the Spinal Cord Independence Measure–III (SCIM-III). The intervention lasted four weeks, with five 45-minute sessions per week. The results showed that group A improved further, in terms of balance and functioning.

Furthermore, Lee and Lee [8] investigated the effect of a VR program on the balance in a sitting position in patients with SCI. The study involved 20 patients, who were equally divided into two groups. The first group received the VR program along with rehabilitation therapy, while the second group (control) performed a typical balance exercise program combined with rehabilitation therapy. The intervention lasted eight weeks, with three 30-minute sessions per week. The results showed significant improvement in the balance in a sitting position in the VR group compared to the control group.

In their study, Wall *et al*. [9] focused on the effect of a VR program using the Nintendo Wii Fit game console on balance, gait and quality of life of ambulatory patients with incomplete SCI. Participants were five men with a mean age of 58.6 years, who were injured for more than a year. The intervention included one-hour sessions, twice per week for seven weeks, using several Nintendo Wii Fit games. The results showed significant improvement in gait speed and functional extension. In addition, improvements in balance, endurance and general activities mobility were reported; however, not at the level of the first two parameters.

Moreover, van Dijsseldonk *et al*. [10] studied the effect of a six-week exercise program with the Gait Real-time Analysis Interactive Lab (GRAIL) system on gait and dynamic balance in ambulatory patients with incomplete SCI. The study involved 15 patients with chronic incomplete SCI. Exercise with the GRAIL system consisted of 12 one-hour sessions in a period of six weeks. The results showed increase in gait speed and balance-related confidence after the intervention. Significant improvements were found in gait distance and stability in the posterior-anterior level. Gait frequency, width and stability on the lateral level did not improve.

The study focus of de Araújo *et al*. [11] was the possible benefits and the effect of VR-based rehabilitation on patients with SCI. Their systematic review included 25 studies that involved 482 patients. In general, the studies used VR devices in different rehabilitation protocols to improve motor function, driving ability, balance, aerobic capacity, pain level as well as the psychology and motivation of the patients. There was great heterogeneity in the design, VR protocols and result analysis of the studies. Even though only seven studies had excellent/good evidence quality, most of the studies provided substantial evidence for significant effects of VR on all parameters in patients with SCI. The researchers noted the need for the conduction of further high-quality studies to create guidelines and draw strong conclusions regarding the benefits of VR therapy in patients with SCI.

Abou *et al*. [12] also studied the effect of VR therapy on gait and balance improvement in patients with SCI. Their systematic review included 10 studies (three randomized clinical trials and seven pre-post trials), which involved 149 patients. In the three clinical trials, a significant improvement was found in the static balance of the intervention groups, which received VR and typical rehabilitation therapies, in contrast to the control groups, which received only the typical rehabilitation programs. In the other seven trials, a significant improvement was found in the standing position and a tendency for gait improvement. The researchers also noted the need for further clinical trials to confirm the effects of VR in patients with SCI.

In addition, Alashram *et al*. [13] studied the effect of VR in patients with incomplete SCI, in an attempt to find an efficient exercise protocol. Their systematic review included five pilot studies, none of which had more than 20 participating patients. The researchers found a positive effect of VR on the improvement of balance in patients with incomplete SCI. The suggested protocol was 12-20 sessions, 30-60 minutes each. However, the need to conduct more studies was emphasized.

In their review, Miguel-Rubio *et al*. [14] also investigated the effect of VR systems on the rehabilitation of patients with SCI. Their systematic review included 12 low-quality studies, which involved 188 patients (two of the studies were included in the meta-analysis). The researchers found positive results regarding balance in the sitting positions in patients with SCI. The positive effect of VR on static balance comes from its combination with typical physiotherapy to rehabilitate patients. However, the need to conduct more clinical trials and to obtain better quality of evidence was noted.

Lastly, Mohamad *et al*. [15] studied the effect of VR on the

balance and motor function of patients with SCI. Their systematic review included six low-quality trials, which involved 97 patients in total. The results showed that the application of VR for the rehabilitation of these patients is beneficial, as it facilitates movement learning through motor control retraining. The intervention was suggested to consist of 2-5 sessions per week, for 30-60 minutes each and for at least 3-7 weeks in order for the positive effect of VR on the balance and motor function of patients with SCI to show.

Discussion-Conclusions

From the results of this review, it can be concluded that the application of VR therapy, either alone or in combination with a typical rehabilitation treatment, can significantly contribute to the improvement of the static, postural and dynamic balance of patients with SCI. There is evidence that VR therapy with a frequency of 20 sessions and 30-60 minutes per session can substantially improve the balance of these patients [6-9, 13, 15]. An improvement was also observed in other functional parameters of the patients, such as gait, endurance, aerobic capacity, pain level and psychology.

Despite VR gradually gaining ground in physiotherapy and rehabilitation, there are not enough studies and high-quality evidence to support its efficacy in improving balance in patients with SCI. Consequently, it is important to conduct more clinical trials to create specific guidelines for the application of VR in the rehabilitation of these patients and to solidify the results of recent studies with better quality evidence.

References

1. Kang Y, Ding H, Zhou H, Wei Z, Liu L, Pan D, *et al*. Epidemiology of worldwide spinal cord injury: a literature review. J Neurorestoratology 2017;6(1):1-9.
2. Vegou Larentzaki R. Needs of People with Paraplegia in the Community. The Nurse´s Contribution. Technological Educational Institute of Western Greece 2019.
3. Paddison S, Middleton F. Chapter 8 - Spinal cord injury. In: Stokes M, editor. Physical Management in Neurological Rehabilitation. 2nd Editio 2004, 125-52.
4. Bellucci CHS, De Castro Filho JE, Gomes CM, De Bessa J, Battistella LR, Rubio De Souza D, *et al*. Contemporary trends in the epidemiology of traumatic spinal cord injury: Changes in age and etiology. Neuroepidemiology 2015;44(2):85-90.
5. Asadzadeh A, Samad-Soltani T, Salahzadeh Z, Rezaei-Hachesu P. Effectiveness of virtual reality-based exercise therapy in rehabilitation: A scoping review. Informatics Med Unlocked [Internet] 2021;24:100562. Available from: https://doi.org/10.1016/j.imu.2021.100562
6. Tak S, Choi W, Lee S. Game-based virtual reality training improves sitting balance after spinal cord injury: A single-blinded, randomized controlled trial. Med Sci Technol 2015;56:53-9.
7. Khurana M, Walia S, Noohu MM. Study on the effectiveness of virtual reality game-based training on balance and functional performance in individuals with paraplegia. Top Spinal Cord Inj Rehabil 2017;23(3):263-70.
8. Lee MJ, Lee SM. The effect of virtual reality exercise program on sitting balance ability of spinal cord injury patients. Healthc 2021;9(2):1-7.
9. Wall T, Feinn R, Chui K, Cheng MS. The effects of the Nintendo™ Wii Fit on gait, balance, and quality of life in individuals with incomplete spinal cord injury. J Spinal Cord Med 2015;38(6):777-83.
10. Van Dijsseldonk RB, De Jong LAF, Groen BE, Van Der Hulst MV, Geurts ACH, Keijsers NLW. Gait stability training in a virtual environment improves gait and dynamic balance capacity in incomplete spinal cord injury patients. Front Neurol 2018;9:1-12.
11. De Araújo AVL, Neiva JFDO, Monteiro CBDM, Magalhães FH. Efficacy of Virtual Reality Rehabilitation after Spinal Cord Injury: A Systematic Review. Biomed Res Int. 2019.
12. Abou L, Malala VD, Yarnot R, Alluri A, Rice LA. Effects of Virtual Reality Therapy on Gait and Balance among Individuals with Spinal Cord Injury: A Systematic Review and Meta-analysis. Neurorehabil Neural Repair 2020;34(5):375-88.
13. Alashram AR, Padua E, Hammash AK, Lombardo M, Annino G. Effectiveness of virtual reality on balance ability in individuals with incomplete spinal cord injury: A systematic review. J Clin Neurosci [Internet]. 2020;72:322-7. Available from: https://doi.org/10.1016/j.jocn.2020.01.037
14. Miguel-Rubio De A, Rubio MD, Salazar A, Moral-Munoz JA, Requena F, Camacho R, *et al*. Is Virtual Reality Effective for Balance Recovery in Patients with Spinal Cord Injury? A Systematic Review and Meta-Analysis. J Clin Med 2020;9(9):2861.
15. Mohamad A, Latir A, Manaf H. Virtual reality in spinal cord injury rehabilitation: a systematic review of its effectiveness for balance performance and functional mobility. Heal Scope [Internet] 2020;3(2):19-24. Available from: http://healthscopefsk.com/index.php/research/article/view/156