Solution for Immersive Vestibular Rehabilitation in Patients with Multiple Sclerosis by using Virtual Reality and its use within the Tele-Rehabilitation Paradigm

Abdulaziz Ibrahem Altwijri¹, Sergio Albiol-Pérez², José-Antonio Gil- Gómez³, José-Antonio Lozano-Quilis³, Cristina García-Muñoz⁴, María Jesús Casuso-Holgado⁵

¹ Systems Engineering and Computing Universidad de Zaragoza, Teruel Aragon Spain

² Aragón Health Research Institute (IIS Aragón) Universidad de Zaragoza, Teruel Aragon Spain

³ Instituto Universitario de Automática e Informática Industrial, Universitat Politècnica de València, Valencia, Spain

⁴ Universidad de Cádiz, Cadiz, Spain

⁵ Universidad de Sevilla, Sevilla, Spain

Abstract

Multiple Sclerosis (MS) is the most common neurological disease responsible for handicap amongst young people aged 20-40 in North America and Europe. Although MS remains incurable, certain therapies have shown to manage its symptoms. The disorder of vestibular system has been observed amongst 49% - 59% patients with MS. An emerging tool within the context of vestibular recovery and telerehabilitation is immersive virtual reality (VRi). This paper has been written with an objective to evaluate previous studies conducted for the use of Immersive Virtual Reality (VRi) in MS patients in order to understand and highlight the importance of VRi. Statistical data extracted from selected studies was classified and pooled and then represented in tabular form. It has been discussed in detail through theoretical and tabular representations in this paper that VR represents an efficient alternative to standard motor rehabilitation forms as the studies that were reviewed provided with satisfactory results.

Keywords

Multiple Sclerosis, Usability, Accessibility, Motor Rehabilitation, Virtual Reality

1. Introduction

1.1. Multiple Sclerosis

Multiple Sclerosis (generally termed MS) is an inflammation causing ailment wherein the nerve cells of the brain and spinal cord sustain a damaged insulation cover. MS is the most common neurological disease responsible for impairment amongst young people aged 20-40 in North America and Europe [1]. It is widely accepted to be an autoimmune ailment which impacts the focal sensory system and has a female to male ratio of 1:2. MS manifests as a sudden outset of sensory and focal inconveniences including double vision, unstable walk or gait, limb weakness and bladder or bowel issues. The exact

Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR Workshop Proceedings (CEUR-WS.org)

¹Proceedings Name, Month XX–XX, YYYY, City, Country

EMAIL: <u>aialtwijri@kau.edu.sa</u> (A. Ibrahem Altwijri); <u>salbiol@unizar.es</u> (S. Albiol-Pérez); <u>jgil@upv.es</u> (J. A. Gil- Gómez); <u>jlozano@upv.es</u> (J. A. Lozano Quilis); <u>cristina.garciamunoz@uca.es</u> (C. García-Muñoz); <u>mcasuso@us.es</u> (M. J. Casuso-Holgado)

ORCID: 0000-0002-6280-1474 (S. Albiol); 0000-0002-7756-183X (J. A. Lozano Quilis); 0000-0001-9954-2480 (J.A. Gil-Gómez)

CEUR Workshop Proceedings (CEUR-WS.org)

etiology of the sickness is however unknown, though research has demonstrated that several environmental and genetic factors can result in MS. Clinical manifestation of MS includes demyelination inside the central nervous system and axonal loss. Mostly patients experience recurrent episodes of a weakened nervous system, nevertheless with time, with 60% - 80% of the patients they become tolerable and ongoing, often resulting in complete handicap and mental deficiency. The following systems normally accompany MS: (1) visual issues; (2) weakness; (3) awareness issues; (4) mental issues; (5) spasticity; (6) issues affecting coordination & equilibrium; (7) issues impacting digestive organs & bladder; (8) sexual-related dysfunction and (9) discourse issues.

Substantial developments made in the interpretation of pathology have aided in early diagnosis of the disease. Although MS remains incurable, certain therapies have shown to manage its symptoms hence they are endorsed and approved in order to adapt to the course of the disease and to improve the wellbeing of the patients. Immunomodulatory medicines and use of calming via various procedures are used as regular treatments of MS apart from therapies. Around 10 products with varying efficacy are available in the market and more are expected. These medicines however, cannot stop the loss of nerve tissue. This prompts the need for more research, the patients and caretakers should remain watchful for the signs of the progression of the disease or any reaction resulting from therapy [11].

1.2. Vestibular Rehabilitation

The disorder of vestibular system has been observed amongst 49% - 59% patients with MS. With the support of vestibular rehabilitation, these symptoms can be improved, resulting in better life quality of the patients.

Basing upon techniques of adaptation, habituation and substitution, vestibular rehabilitation can be effectual in tackling central as well as peripheral vestibular disabilities. The goals of vestibular rehabilitation including improving ocular stability & fixation, minimizing dizziness and therefore having better everyday life performance are beneficial for patients with MS [4,5,6].

1.3. Immersive Virtual Reality

To thoroughly engage the user inside the computer created virtual world is the objective of immersive virtual reality (VRi). It can supply the VR user with a sense as if they had entered inside the fabricated world [7,8].

Within the domains of VRi, the mode which blends physical activity into the virtual surrounding and with the advantages mentioned previously termed as exergame. Exergame has proven to be very efficient for the treatment and management of neurological diseases. Regardless of exercising through a VR system, the patient considers it to be very less tiring. VRi also allows the patient total immersion inside the 360° virtual environment, boosting the feeling of actual presence. The methodology within the VRi framework progresses along with the patient's understanding, willingness and compliance with the treatment. The patient's willingness thereby brings about mental recuperation and allows the patients to readily practice useful developments by estimating their own exhibition [3,4].

1.4. Tele-Rehabilitation

In the aftermath of COVID-19, a paradigm shift has been set up regarding the assimilation of telehealth into rehabilitation service delivery. However, the willingness of healthcare professionals and their training and experience using telehealth is significantly varied [9].

Tele rehab has the potential for giving an advantage in MS treatment as these systems include remote checking of signs and action, videoconferencing, and dispersion of customized and specific data through electronic components. Therefore, the overlooking of tele rehab with regard to treating MS is unfortunate. Whilst these treatments are in no way or form a replacement for clinical treatment, they have been established to relieve some of the side effects of extreme clinical procedures. An emerging

tool within the context of vestibular recovery and telerehabilitation is vivid augmented experience or immersive virtual reality (VRi) which has been discussed.

2. Methodology

This paper has been written with an objective to investigate and evaluate previous studies conducted for the use of Immersive Virtual Reality (VRi) in MS patients in order to understand and highlight the importance of VRi. The articles and studies that have been included for the evaluation are those with keywords "Multiple Sclerosis" and "Virtual Reality". These studies are randomized control trials (RCTs) carried out according to guidelines stated for Good Clinical Practice and CONSORT Statement Guidelines.

A bibliographic analysis was performed by using PubMed (Medline) and Virtual Health Library Search Portal (BVS) databases. The review conducted was in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The utilization of PRISMA checklists refines the quality of reporting of the methodical reviews and also supplies with considerable transparency in the selection procedure for the articles.

Three measures were undertaken for the selection of the articles. Firstly, articles were looked upon in the databases specified above and the titles and abstracts were studied. Secondly, inclusion criteria analysis was performed and, on this basis, works were excluded based upon only their titles and /or abstracts. As a third and final step, the articles that were screened and deemed eligible in the second step, a full-text examination was carried out for them.

2.1. Selection of Study

There were no limitations placed upon the sample size. Articles and texts that were published only in English language were qualified if they fulfilled the following benchmarks.

- 1. The study carried out only involved the people diagnosed with MS.
- 2. The population in (1) underwent an immersive VR analysis through a randomized controlled trial (RCT).

Similarly, exclusion criteria for article analysis included:

- 1. Articles not in English language.
- 2. The patients examined in the study were not precisely diagnosed with MS and had a psychiatric history.
- 3. Non-inclusion of VR analysis.
- 4. Also, articles that were not databased e.g., theoretical papers, secondary reviews, books.

After the elimination of duplicates, articles were then finalized for the current study. Statistical data from these studies whether quantitative or qualitative was classified and pooled. The data extracted was then summarized and has been discussed.

3. Results

Through analysis of the studies that were selected in the methodology phase, it has been seen that the use of immersive VR in MS patients improves balance control, arm movement and walking abilities. It is suggested by the authors that interventions brought about by VR can assist as a successful therapeutic alternative and also as an efficient alternative to standard motor rehabilitation. The positive feedback and improvements observed in all the studies cannot be ignored. The evolution of VR technologies will prompt enhanced rehabilitation with minimum therapist intervention [6].

The benefits of VR also include: oriented tasks, repetition and performance of exercises in an incentivizing environment, development of adherence, extrinsic feedback and multisensory stimulation [2].

More research is required to analyze the ability of VR to treat and manage other symptoms of MS. Taking into account limitations such as small sample size etc. in these studies, the results have to be accurately comprehended and further studies are required as well. Several technologies have been partial in comparison to the cost and analysis for their evaluation strategy nevertheless, results shown by use of VR are promising and follow up research is required in order to boost the effects of treatment in patients with MS [6].

4. Discussion

It has been discussed in detail through theoretical representations in this paper that VR represents an efficient alternative to standard motor rehabilitation forms as the studies that have been reviewed provided with satisfactory results.

Neurorehabilitation programs are one of the most common and popular therapies that are directed at reducing impairments and social disadvantages following MS. Patients with MS start their rehabilitation processes by virtual exercises for rehabilitation including games with simple and intuitive interactions. VR comes about as an innovative tool for the differently abled population other than those with MS including Cerebral Palsy, Parkinson's Disease, Down Syndrome and Autism [10].

Hence, immersive virtual reality (VRi) is an important and emerging tool but there has been little to no research of its consequences in MS. Therefore, there is also a need to establish a standard VR protocol for vestibular rehabilitation [3,12, 13].

5. References

- J. Howard, S. Trevick, D. S. Younger. Epidemiology of Multiple Sclerosis. Neurol Clin. 2016 Nov;34(4):919-939.
- [2] D. Bezzini, M. A. Battaglia. Multiple Sclerosis Epidemiology in Europe. Adv Exp Med Biol. 2017;958:141-159.
- [3] C. García-Muñoz, M. J.-H.-R.-P.-C.-D.-V. Feasibility and safety of an immersive virtual realitybased vestibular rehabilitation programme in people with multiple sclerosis experiencing vestibular impairment: a protocol for a pilot randomised controlled trial. National Library of Medicine - National Institutes of Health. 2021.
- [4] C. García-Muñoz, M.-D. C.-V.-C.-R.-S.-P.-H. Immersive Virtual Reality and Vestibular Rehabilitation in Multiple Sclerosis: Case Report. JMIR Publications. 2022.
- [5] S. A. Zachary Boychuck, (2020). A paradigm shift toward telerehabilitation: Adapting rehabilitation services across an integrated health and social services university network in the wake of the COVID-19 crisis. Montreal, Quebec, Canada: PCHI Lab.
- [6] García-Muñoz C, Cortés-Vega MD, Heredia-Rizo AM, Martín-Valero R, García-Bernal MI, Casuso-Holgado MJ. Effectiveness of Vestibular Training for Balance and Dizziness Rehabilitation in People with Multiple Sclerosis: A Systematic Review and Meta-Analysis. J Clin Med. 2020 Feb 21;9(2):590.
- [7] B. Furht. Immersive Virtual Reality. Encyclopedia of Multimedia. Ottawa, Canada: Springer, Boston, MA. 2008.
- [8] C. Winter, F. Kern, D. Gall, M. E. Latoschik, P. Pauli, I. Käthner. Immersive virtual reality during gait rehabilitation increases walking speed and motivation: a usability evaluation with healthy participants and patients with multiple sclerosis and stroke. J Neuroeng Rehabil. 2021 Apr 22;18(1):68.
- [9] M. Grazia Maggio. Virtual reality in multiple sclerosis rehabilitation: A review on cognitive and motor outcomes. Journal of Clinical Neuroscience. 2019.
- [10]T. Massetti, I. L.-P. Virtual reality in multiple sclerosis A systematic review. Multiple Sclerosis and Related Disorders. 2016.

- [11]W.-J. Huang, W.-W. C. Multiple sclerosis: Pathology, diagnosis and treatments. Experimental and Therapeutic Medicine, 3163–3166. 2017.
- [12]M. G. Maggio, R. De Luca, A. Manuli, A. Buda, M. Foti Cuzzola, S. Leonardi, G., et al. Do patients with multiple sclerosis benefit from semi-immersive virtual reality? A randomized clinical trial on cognitive and motor outcomes. Appl Neuropsychol Adult. 2022 Jan-Feb;29(1):59-65.
- [13] R. Bertoni, F. G. Mestanza Mattos, M. Porta, F. Arippa, E. Cocco, M. Pau, D. Cattaneo. Effects of immersive virtual reality on upper limb function in subjects with multiple sclerosis: A crossover study. Mult Scler Relat Disord. 2022 Sep;65:104004.