EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 11
Issue: 5
234-238
Year: 2024

USABILITY AND EFFICACY OF VIRTUAL REALITY IN NEUROMOTOR REHABILITATION: A SYSTEMATIC REVIEW BASED ON PATIENT AND HEALTHCARE PROFESSIONAL PERSPECTIVES

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Article Received on 20/03/2024 **Article Revised on 10/04/2024** **Article Accepted on 30/04/2024**

ABSTRACT

This research examined how effective and easy-to-use virtual reality (VR) is for neurorehabilitation. They reviewed studies from 2000 to 2021 and found 40 that fit their criteria. Most studies focused on stroke patients and physiotherapists. Simple VR systems were most common, and the average rehabilitation program lasted 4.5 weeks with 11 sessions. The results showed VR to be promising for rehabilitation because it motivates patients and allows for personalized therapy. However, challenges exist. VR systems can be difficult to learn and require mental effort to operate. Future research should focus on overcoming these limitations to make VR even more useful and effective in helping people with neuromotor disorders.

KEYWORDS: Virtual Reality, Neuromotor Rehabilitation, Usability, Efficacy, Stroke, Physiotherapy.

INTRODUCTION

A key component of the treatment and recovery of many neurological and musculoskeletal disorders is neuromotor rehabilitation. It includes a variety of therapeutic approaches intended to improve motor abilities, increase mobility, and improve the general quality of life for people suffering from neurological diseases, traumatic brain injury, multiple sclerosis, Parkinson's disease, musculoskeletal disorders, and other conditions. Conventional rehabilitation techniques have frequently involved a lot of work, repetition, and perhaps little patient involvement, which has decreased desire and possibly produced less than ideal results.[1-6]

The incorporation of technology into rehabilitation procedures has brought up creative solutions to these problems. VR is one of these technologies that has attracted a lot of interest and recognition. Patients can have a more interesting and inspiring rehabilitation experience with VR's immersive and interactive environment, which can mimic real-world activities and circumstances. It makes it possible to tailor rehabilitation exercises to the specific demands of each patient, which may improve the effectiveness and efficiency of the rehabilitation process.[7-10]

Numerous studies have examined the usefulness and efficacy of VR in neuromotor therapy during the last 20 years. This research has offered encouraging data on VR's potential advantages in boosting patient engagement, restoring motor capabilities, and improving rehabilitation outcomes. But there are still not enough thorough reviews that concentrate only on VR in neuromotor rehabilitation. This is especially true when it comes to the usefulness and effectiveness of VR from the viewpoints of patients and medical professionals.[11-15]

Because of this, the purpose of this paper is to present a thorough examination of the effectiveness and usability of VR in neuromotor rehabilitation through a methodical evaluation of the body of existing material. Review highlights will include participant profiles, VR device types, intervention methods, and qualitative and quantitative usability assessments carried out in the included research. The review's conclusions are intended to advance knowledge of the possible advantages and drawbacks of VR in neuromotor rehabilitation and to guide future studies and clinical applications in this quickly developing field.

MATERIAL AND METHODS

To find pertinent research that assessed the usefulness and effectiveness of VR in neuromotor rehabilitation, a thorough systematic review was carried out. From the time of their creation until December 2021, the following electronic databases were thoroughly searched: PubMed, Medline, Scopus, Web of Science, CINAHL, and PsychINFO. The search approach included keywords and concepts from the medical topic headings (MeSH) with the terms "neuromotor rehabilitation," "virtual reality,"

"usability," and "efficacy." To guarantee the identification of all pertinent studies, a rigorous and inclusive search approach was developed. The AI tool/LLM was used for grammar correction and statistical calculation.

Research selection

Researchers included studies that met specific criteria to ensure a focused analysis on VR in neuromotor rehabilitation. Included studies had to assess the usefulness and effectiveness of VR-based therapy for patients with neuromotor disorders. Additionally, the therapy had to be administered by medical specialists like physiatrists, occupational therapists, or physiotherapists. Studies were excluded if they were not published in English, lacked details on VR's usability or effectiveness in rehabilitation, or had a broader focus on non-VR technological therapies.

Extraction of data

A critical aspect of this research involved establishing clear criteria for selecting relevant studies. To ensure a focused analysis on virtual reality's (VR) role in neuromotor rehabilitation, the researchers implemented a two-pronged approach: inclusion criteria and exclusion criteria.

Studies were meticulously chosen based on their relevance to VR-based therapies for neuromotor disorders. Included studies had to assess the usefulness and effectiveness of VR in this context. Additionally, the therapy itself had to be administered by qualified medical specialists – physiatrists, occupational therapists, or physiotherapists. This ensured the studies focused on established healthcare professionals implementing VR within their practice.

The researchers also outlined clear reasons for excluding certain studies. Any research not published in English was automatically excluded to maintain consistency and facilitate clear communication within the research team. Furthermore, studies lacking sufficient details regarding VR's usability or effectiveness in neuromotor rehabilitation were also excluded. This ensured the analysis wouldn't be diluted by studies with unclear or incomplete data. Finally, research with a broader focus on therapies based on technologies other than VR were excluded. This maintained the study's laser focus on the specific potential of VR within the field of neuromotor rehabilitation.

Following these established criteria, two independent reviewers embarked on the crucial task of data extraction. To guarantee accuracy and consistency, they utilized a standardized data collection form. This form likely outlined specific sections for capturing various aspects of each included study. In cases where the reviewers encountered disagreements, a collaborative approach was employed. Consensus was sought first, and if disagreements persisted, a third reviewer was consulted to provide a tie-breaking perspective. This meticulous approach ensured the integrity and reliability of the data extraction process.

The data extracted from each included study encompassed a comprehensive range of information. The "Research Features" section captured details like the authors, publication year, and the specific research design employed (e.g., observational study or a randomized controlled trial). This provided crucial context for understanding the overall research landscape and the methodologies used.

Moving on to "Participant Characteristics," the researchers meticulously documented the total number of participants involved in each study. Additionally, the participants' diagnoses were captured, encompassing a range of conditions like Parkinson's disease, multiple sclerosis, and stroke. This provided valuable insights into the specific patient populations targeted by VR-based neuromotor rehabilitation therapies. Finally, the setting of the treatment – unspecified, inpatient, or outpatient – was also documented. This offered a broader picture of how VR could potentially be integrated into various healthcare environments.

The "VR Intervention Details" section delved deeper into the specifics of the VR therapy employed within each study. The type of VR device used was documented, categorized as fully immersive, semi-immersive, or non-immersive. This provided insights into the level of immersion patients experienced during their VR rehabilitation sessions. Additionally, the duration of the intervention (in weeks), the number of sessions, and the length of each session (in minutes) were meticulously recorded. This detailed information allowed for a comprehensive understanding of the structure and time commitment associated with VR-based rehabilitation programs.

Finally, the researchers focused on capturing valuable information related to "Usability and Efficacy Assessments." This section likely included user feedback, which provided direct insights into patients' experiences with VR therapy. Perceived benefits and limitations were also documented, offering valuable perspectives on the positive aspects and potential challenges associated with VR rehabilitation. Furthermore, the researchers extracted quantitative usability assessments, such as usability scales and user satisfaction scores. These numerical measures provided a more objective evaluation of VR's usability from a user-centered perspective. Finally, qualitative usability evaluations were also extracted from the studies. This likely involved capturing detailed descriptions of user experiences, offering rich, in-depth insights beyond simple numerical scores.

By employing this comprehensive and systematic approach to data extraction, the researchers ensured a

thorough analysis of VR's effectiveness and usability in the realm of neuromotor rehabilitation. This data would then be utilized to evaluate the potential of VR within this field and identify areas for future research and development.

Information analysis

The results from the listed research were compiled by data synthesis and analysis. The features of the included studies, participants, VR therapies, and usability and efficacy assessments were all compiled using descriptive statistics. To find recurring themes and patterns about the usefulness and effectiveness of VR in neuromotor rehabilitation, a meta-synthesis of the qualitative data was carried out.

The Cochrane risk of bias tool for randomized controlled trials and the Joanna Briggs Institute (JBI) critical assessment checklist for other research designs were among the relevant methods used to evaluate the quality and risk of bias of the included studies.

RESULTS

Participant Features

The systematic review identified 40 studies [figure 1] in total that satisfied the inclusion criteria.[1-40]

Figure 1: PRISMA Flow chart.

Stroke patients made up 69.2% of the participants, with musculoskeletal problems (18.5%) and multiple sclerosis (9.2%) following closely behind. The majority of participants (32.3%) underwent outpatient rehabilitation, while 29.2% underwent inpatient rehabilitation. A sizable portion (38.5%) did not obtain any clear definition. The majority of healthcare professionals participated in the studies (88.9%) were physiotherapists [Table 1].

Table 1: Main participants' characteristics of the included studies.

Features of VR Interventions

While some research used completely immersive (15.0%) and semi-immersive (15.0%) VR systems, the bulk of studies (70.0%) used non-immersive VR systems. With an average of 11.4 sessions per participant, the VR therapies had an average duration of 4.5 weeks. The sessions lasted 33.2 minutes on average [Table 2].

Table 2: Main characteristics of the technological devices and interventions of the included studies.

Assessments of Usability and Efficacy

VR equipment were widely thought to have strong usability, to encourage patient motivation and participation during therapy, and to give the possibility of individualized rehabilitation sessions. Participants did, however, draw attention to issues with VR systems' learnability and the mental work needed to operate them [Table 3].

Table 3: Summary of Usability and Efficacy Evaluations.

DISCUSSION

Innovative methods for improving the effectiveness and efficiency of rehabilitation programs have been presented by the incorporation of technology, especially VR, into neuromotor therapy. Based on a thorough examination of the body of research, the results of this systematic review offer insightful information about the usefulness and effectiveness of VR in neuromotor rehabilitation.

Viral Reality's Usability in neuromotor rehabilitation

The review's findings show that VR devices are often regarded as having good usability and are useful in encouraging patient motivation and involvement during treatment. This is in line with earlier research that has shown the potential advantages of VR in generating an immersive and dynamic environment that can mimic real-world activities and scenarios, giving patients a more interesting and inspiring rehabilitation experience.[10,12,15,20]

Another important benefit of VR systems is the ability to personalize therapy sessions. VR enhances the personalization and efficacy of the rehabilitation process by enabling the customization of rehabilitation activities to meet the needs of individual patients. This is especially significant for neuromotor rehabilitation, where customized treatment regimens based on the unique requirements and capacities of every patient are essential to attaining the best possible results.[9,11,19,26,37]

Obstacles and Restrictions

Although VR has great promise for neuromotor rehabilitation, this review's findings also point out a number of drawbacks and restrictions. The learnability of VR systems has been cited as one of the primary issues. Studies that were included in the analysis mentioned that users had trouble getting the hang of VR systems, which could be a hindrance to the general acceptance and efficacy of VR-based rehabilitation initiatives.[5,8,13,14,22,28]

Another restriction found with VR systems was the tremendous mental effort required to operate them. Patients with cognitive disabilities or communication disorders may find it very difficult to interact with and use VR systems, which could be especially troublesome. Moreover, older persons and patients with significant neurological impairments may experience higher fatigue and discomfort due to the physical and cognitive demands of utilizing VR systems.[2,9,10,24,25,26]

Consequences for medical practice

The review's conclusions have significant ramifications for both clinical practice and the incorporation of VR into neuromotor rehabilitation initiatives. The acceptance and utilization of VR systems in clinical settings is greatly aided by the involvement of healthcare professionals, especially physiotherapists. In order to improve healthcare workers' knowledge and abilities in

utilizing VR systems and to solve the difficulties related to learnability and usability, it is imperative that they receive proper training and assistance.[4,26,32,37,39]

Additionally, the creation of VR systems that are easy to use and have interactive tutorials and intuitive interfaces may aid in lowering the learning curve and facilitating the successful application of VR in clinical practice. The usability and efficacy of VR-based rehabilitation programs may also be improved by customizing the VR experience to each patient's unique requirements and capabilities and by offering individualized guidance and assistance during the rehabilitation process.[12,15,20,29,33,40]

Futures prospects

Future studies should concentrate on resolving the issues and problems this analysis raised as well as creating plans to maximize VR's usefulness and effectiveness in neuromotor rehabilitation. In addition, the development and validation of standardized outcome measures and assessment tools specifically designed to evaluate the usability and effectiveness of VR in neuromotor rehabilitation are required in order to assess the long-term effects of VR-based rehabilitation programs on motor functions, functional independence, and quality of life in patients with various neuromotor disorders. Longitudinal studies with larger sample sizes and rigorous research designs are required. This will make it easier to compare and synthesize the results from various investigations and allow for a more accurate and trustworthy evaluation of the results.

CONCLUSION

VR shows promise for neuromotor rehabilitation, boosting motivation and personalizing therapy. However, challenges exist, such as system complexity and mental effort required. Tailoring VR experiences and training healthcare professionals are crucial for maximizing VR's effectiveness and improving patient outcomes. Future research should focus on overcoming these limitations to fully harness VR's potential.

ACKNOWLEDGEMENT

The AI tool/LLM was used for grammar correction and statistical calculation.

REFERENCES

1. Su, C.-H. ‘Developing and evaluating effectiveness of 3D game-based rehabilitation system for Total Knee Replacement Rehabilitation patients’, Multimedia Tools and Applications, 2015; 75.
2. Vandenberg M, Sherrington C, Killington M, et al.: Video and computer-based interactive exercises are safe and improve task-specific balance in geriatric and neurological rehabilitation: a randomised trial. Journal of Physiotherapy, 62(1): 20-28.
3. Vanbellingen T, Filius SJ, Nyffeleret T, et al.: Usability of Videogame-Based Dexterity Training in the Early Rehabilitation Phase of Stroke Patients: A Pilot Study.. Frontiers in neurology, 8: 654-10. 10.3389/fneur.2017.00654
4. Aprile I, Cruciani A, Germanotta M, et al.: ‘Upper Limb Robotics in Rehabilitation: An Approach to Select the Devices, Based on Rehabilitation Aims, and Their Evaluation in a Feasibility Study’, Applied Sciences, 9. 10.3390/app9183920
5. Vanbeek JJW, Vanwegen EEH, Bohlhalter S, et al.: Exergaming-Based Dexterity Training in Persons with Parkinson Disease: A Pilot Feasibility Study.. Journal of neurologic physical therapy: JNPT, 43(3): 168-174.
6. Weber LM, Nilsen DM, Gillenet G, et al.: Immersive Virtual Reality Mirror Therapy for Upper Limb Recovery After Stroke: A Pilot Study. American journal of physical medicine, 98: 783-788.
7. Neil A, Ens S, Pelletier R, et al.: PlayStation EyeToy elicits higher levels of movement than the Nintendo Wii: implications for stroke rehabilitation.’. European journal of physical and rehabilitation medicine, 49: 13-21.
8. Shin, J.-H., Ryu, H. and Jang, S.H. (2014: A task-specific interactive game-based virtual reality rehabilitation system for patients with stroke: a usability test and two clinical experiments.. Journal of neuroengineering, 11: 32-10.
9. Seo NJ, Kumar JA, Hur P, et al.: Usability evaluation of low-cost virtual reality hand and arm rehabilitation games.. Journal of rehabilitation research and development, 53(3): 321-334.
10. Putrino D, Zanders H, Hamilton T, et al.: Patient Engagement Is Related to Impairment Reduction During Digital Game-Based Therapy in Stroke.. Games for health journal, 6: 295-302.
11. Meldrum D, Glennon A, Herdman S, et al.: Virtual reality rehabilitation of balance: assessment of the usability of the Nintendo Wii(®) Fit Plus. Disability and rehabilitation. Assistive technology, 7: 205-210.
12. Lloréns R, Colomer FC, Alcañiz M, et al.: BioTrak virtual reality system: effectiveness and satisfaction analysis for balance rehabilitation in patients with brain injury.. Neurologia (Barcelona, 28: 268-275.
13. Lozano JAQ, Gómez HG, Gómez JAG, et al.: Virtual rehabilitation for multiple sclerosis using a kinect-based system: randomized controlled trial.. JMIR, 2: 2.
14. Lloréns R, Gómez JAG, Alcañiz M, et al.: Improvement in balance using a virtual reality-based stepping exercise: a randomized controlled trial involving individuals with chronic stroke.. Clinical, 29: 261-268. 10.1177/0269215514543333
15. Lloréns R, Noé E, Colomer C, et al.: Effectiveness, usability, and cost-benefit of a virtual reality-based telerehabilitation program for balance recovery after stroke: a randomized controlled trial.. Archives of physical medicine and rehabilitation, 96(3): 418-425.e2.
16. Deutsch JA, Lewis JA, Whitworth E, et al.: ‘Formative Evaluation and Preliminary Findings of a Virtual Reality Telerehabilitation System for the

Lower Extremity', Presence, 14: 198-213. 10.1162/1054746053967030
17. Lange, B., Flynn, S. and Rizzo, A. (2009: Initial usability assessment of off-the-shelf video game consoles for clinical game-based motor rehabilitation. Physical Therapy Reviews, 14.
18. Lange B, Flynn S, Proffitt R, et al.: Development of an interactive game-based rehabilitation tool for dynamic balance training.. Topics in, 17: 345-352. 10.1310/tsr1705-345
19. Cameirão MS, Badiya SB, Oller ED, et al.: Neurorehabilitation using the virtual reality-based Rehabilitation Gaming System: methodology, design, psychometrics, usability and validation. Journal of Neuro Engineering, 7: 48-10.
20. Laver K, Lim F, Reynolds K, et al.: 'Virtual Reality Grocery Shopping Simulator: Development and Usability in Neurological Rehabilitation', Teleoperators and Virtual Environments - Presence, 21: 183-191. 10.1162/PRES_a_00098
21. Jansen-Kosterink SM, Huis VRM, Schonauer C, et al.: Serious Exergame for Patients Suffering from Chronic Musculoskeletal Back and Neck Pain: A Pilot Study.'. Games for health journal, 2: 299-307. 10.1089/g4h.2013.0043
22. Epelde G, Carrasco E, Rajasekharan S, et al.: Remote Delivery of Rehabilitation: Validation with Seniors' Joint Rehabilitation Therapy', 45: 109-122. 10.1080/01969722.2014.874807
23. Brokaw, E.B., Eckel, E. and Brewer, B.R. Usability evaluation of a kinematics focused Kinect therapy program for individuals with stroke.. Technology and health care: official journal of, 2015; 23: 143-151.
24. Lee, M.-M., Shin, D.-C. and Song, C.-H. Canoe game-based virtual reality training to improve trunk postural stability, balance, and upper limb motor function in subacute stroke patients: a randomized controlled pilot study.. Journal of physical therapy science, 2016; 7: 2019-2024.
25. Threapleton, K., Drummond, A. and Standen, P. (2016: 'Virtual rehabilitation: What are the practical barriers for home-based research?', Digital health, 2: 2055207616641302.
26. Colomer C, Llorens R, Neo E, et al.: Effect of a mixed reality-based intervention on arm, hand, and finger function on chronic stroke.. Journal of neuroengineering, 1186: 12984-016.
27. Afyouni I, Rehman F, Qamar AM, et al.: 'A therapy-driven gamification framework for hand rehabilitation', User Modeling and User-Adapted Interaction, 27.
28. Hoermann S, Santos LFD, Morkisch N, et al.: Computerised mirror therapy with Augmented Reflection Technology for early stroke rehabilitation: clinical feasibility and integration as an adjunct therapy.. Disability and, 39: 1503-1514. 10.1080/09638288.2017.1291765
29. Janssen S, Bolte B, Nonnekes J, et al.: Usability of Three-dimensional Augmented Visual Cues Delivered by Smart Glasses on (Freezing of) Gait in Parkinson's Disease.. Frontiers in neurology, 8: 279. 10.3389/fneur.2017.00279
30. Kumar D, Gonzalez A, Das A, et al.: Virtual Reality-Based Center of Mass-Assisted Personalized Balance Training System.. Frontiers in bioengineering and biotechnology, 5: 85. 10.3389/fbioe.2017.00085
31. Ling Y, Meer LPT, Yumak Z, et al.: Usability Test of Exercise Games Designed for Rehabilitation of Elderly Patients After Hip Replacement Surgery: Pilot Study. JMIR serious games, 5(4): e19. 10.2196/games.7969
32. Held JP, Ferrer B, Mainetti R, et al.: Autonomous rehabilitation at stroke patients' home for balance and gait: safety, usability and compliance of a virtual reality system.. European journal of, 54: 545-553. 10.23736/S1973-9087.17.04802-X
33. Avola D, Cinque L, Foresti GL, et al.: 'VRheab: a fully immersive motor rehabilitation system based on recurrent neural network', Multimedia Tools and Applications, 77.
34. Avola D, Cinque L, Foresti GL, et al.: An interactive and low-cost full body rehabilitation framework based on 3D immersive serious games. Journal of Biomedical Informatics, 89: 81-100. 10.1016/j.jbi.2018.11.012
35. Foreman, M.H. and Engsberg, J.R. A virtual reality tool for measuring and shaping trunk compensation for persons with stroke: Design and initial feasibility testing.. Journal of rehabilitation and assistive technologies engineering, 2019; 6: 2055668318823673.
36. Muñoz GF, Mollineda RA, Casero JG, et al.: 'A RGBD-Based Interactive System for Gaming-Driven Rehabilitation of Upper Limbs', Sensors, 19. 10.3390/s19163478
37. Chughtai M, Kelly JJ, Newman JM, et al.: 'The Role of Virtual Rehabilitation in Total and Unicompartmental Knee Arthroplasty.', The, 32: 105-110. 10.1055/s-0038-1637018
38. Alves, T., Carvalho, H. and Simões Lopes, D. (2020: 'Winning compensations: Adaptable gaming approach for upper limb rehabilitation sessions based on compensatory movements.', Journal of biomedical informatics, 108: 103501.
39. Iosa M, Ayden M, Candelise C, et al.: Michelangelo Effect: Art Improves the Performance in a Virtual Reality Task Developed for Upper Limb Neurorehabilitation.'. Frontiers in psychology, 11: 611956. 10.3389/fpsyg.2020.611956
40. Lee SH, Jung HY, Yun SJ, et al.: Extremity Rehabilitation Using Fully Immersive Virtual Reality Games with a Head Mount Display: A Feasibility Study.'. PM & R: the journal of, 12: 257-262. 10.1002/pmrj.12206