**Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH**
Vol. XXIV, ISSUE 1, 2024, Romania
**The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories**

Science, Movement and Health, Vol. XXIV, ISSUE 1, 2024
January 2024, 24 (1): 16-20
Original article

# EXPLORING THE PROMISE AND PRACTICAL CONSIDERATIONS OF VIRTUAL REALITY TECHNOLOGY IN STROKE REHABILITATION

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**Abstract**

*Aim.* The aim of this study was to evaluate the effectiveness of virtual reality (VR) assisted therapy in stroke rehabilitation, specifically focusing on upper-limb function, balance, and quality of life outcomes.

*Methods*. A randomized controlled trial was conducted with two experimental groups: one receiving VR-assisted therapy and the other serving as a control group. Upper-limb function was measured using the Fugl-Meyer Assessment, while balance was assessed using the Berg Balance Scale. Quality of life was gauged using the Stroke Impact Scale. Statistical analysis was performed using SPSS version 27, including t-tests and chi-square examinations. Twenty participants were included in each group.

*Results*. The VR group showed superior results compared to the control group, with improved scores in Fugl-Meyer Assessment (+8.5 scores), Berg Balance Scale (mean difference = 5.2 scores), and Stroke Impact Scale. No negative occurrences were detected in either group during the intervention period.

*Conclusions*. The findings suggest that VR-assisted therapy has the potential to improve upper-limb function, balance, and quality of life in individuals recovering from strokes. However, limitations such as small sample size and short follow-up interval should be considered. Further research is needed to validate these findings and evaluate the long-term effects of VR training on stroke rehabilitation outcomes.

*Keywords:* Virtual reality, stroke rehabilitation, motor function, balance, activities of daily living, neural plasticity, clinical practice.

## Introduction

With more than 15 million cases every year, stroke remains one of the most significant contributors to worldwide disablement (Feigin et al. 2015). While conventional therapies may help manage various conditions post-stroke such as cognitive decline, loss of sensation or weakened motor control; however, it's not always enough. Among the many challenges faced by traditional rehabilitation methods are reduced patient motivation levels and limited access during post-treatment recovery phases; besides being exorbitant at times (Berg et al., 1992; Hubbard et al., 2009). Virtual reality presents an expanded palette of possibilities for optimizing brain plasticity and pairing it effectively against long-term disabilities induced by cerebrovascular incidents (Glegg & Holsti, 2010). The use of VR technology for stroke rehabilitation is gaining increasing interest. Patients who engage in immersive experiences through this modality show improvements in both physical activities like motor function improvement, balance rectification & enhancements like cognitive potential including attention control or executive functioning (Laver et al., 2015; Saposnik et al., 2016). It is a highly personalized form of therapy that caters specifically to each patient's aims leading towards adherence compliance for continuous therapeutic involvement using gamification techniques & enhancing participation in rehabilitation activities (Rogers et al, 2019; Brassel et al, 2021). This futuristic solution has gained massive acceptance among therapists worldwide. This study aims to provide a critical appraisal of VR therapy as an optimal technique for stroke rehabilitation, identifying viable strategies towards maximizing its benefits while mitigating possible downsides. Using various case studies gathered from existing research articles, we comprehensively analyze types of VR systems applied during treatment sessions and their positive impact alongside any observed complications. Furthermore, an exhaustive review of available data comparing conventional rehabilitation methods versus VR-based therapies distinguishes the superiority set forth by interactive technologies based on established research findings. The utilization of virtual reality (VR) therapy in stroke rehabilitation represents an exciting development with significant potential gains in improving patient outcomes (Laver et al., 2020). However, implementing this cutting-edge treatment approach requires addressing several practical considerations, such as therapist training and expertise needed for successful application of this technology. Addressing cost-effectiveness concerns associated with implementation along with accessibility challenges are also pivotal factors

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that need consideration. It is postulated that the escalation of social media utilization is an influential element contributing to the increased occurrences of depression among adolescents. All authors have equal contributions on write this article.

**Objectives**

The study aims to evaluate the effectiveness of virtual reality (VR) therapy in stroke rehabilitation. The primary objective is to measure upper-limb function using the Fugl-Meyer Assessment, while secondary outcomes include balance and quality of life. The study compares baseline characteristics between a VR group and a control group and assesses changes in outcomes after six weeks of intervention. A statistically significant difference in the Fugl-Meyer Assessment following VR training is sought. The study acknowledges limitations such as small sample size and short follow-up interval. The findings highlight the potential benefits of VR therapy in improving upper limb function, balance, and quality of life in stroke rehabilitation. However, further research is required to validate the results and explore the long-term effects of VR training. Practical challenges such as clinician training and financial feasibility need to be addressed for optimal utilization of VR therapy in stroke care. Overall, incorporating VR technology shows promise in advancing stroke rehabilitation outcomes and enhancing healthcare quality.

**Methods**

Eligible stroke patients admitted to the examined rehabilitation center between January 2022 and December 2022 participated in a randomized controlled trial (RCT) approved by the institution's review board. By applying exclusions to individuals who had a history of epilepsy, neurological disabilities or significant cognitive impairments that could hinder intervention implementation, informed consent was obtained for the randomized controlled trial focused on examining how virtual reality (VR) training may improve upper extremity functionality. Participants were split at random into two groups: one being the VR group that went through a six-week training program that consisted of various custom-designed exercises aimed towards enhancing both balance and trunk movement-related issues using standard commercial VR equipment such as Oculus Quest 2 for thirty minutes each day, for five days a week, while the other group formed part of the control arm where they didn't receive any intervention beyond regular care they usually got. Upper-limb function measured via Fugl-Meyer Assessment served as our primary outcome measure.

To evaluate the effectiveness of VR-assisted therapy in stroke rehabilitation, secondary outcomes such as balance (as measured on the BBS) and quality of life (as gauged via SIS) were examined. The dataset underwent statistical analysis within SPSS version 27 program to compare baseline characteristics between the two experimental groups, with continuous inputs scrutinized through t-tests while categorical data was subjected to chi-square examination. Independent t-tests contrasts changes in outcomes from initial levels till after six weeks post-intervention amongst both groups; a value below 0.05 indicates statistical significance. A statistically significant difference between two groups on the FMA following VR training needed to be detected as part of this study, thus prompting a sample size calculation. Using an alpha level set at two-sided at .05 and accounting for an estimated power of about eighty percent while seeking to detect seven-point differences between both groups; we arrived at forty participants being necessary for this work (20 in each grouping). Results previously obtained signifying mean improvement after Virtual Reality Training validated our choice. To ensure unbiasedness during participant distribution into groups, we enlisted the help of a third-party statistician to perform randomized computer generation sequencing. While it was not possible to blind participants and therapists in this study due to practical constraints of the intervention, careful attention was paid to blinding the assessor conducting outcome assessments. Nevertheless, we must acknowledge that limitations such as our small sample size and short follow-up interval limit broader generalization of the results obtained from this single-center trial. Admittedly, further research should aim at investigating sustainable effects of VR training on enhancing post-stroke recovery.

**Results**

Two groups - VR and control - consisting of twenty participants each were examined during this research project over a span of six weeks intervention period where their upper limb functionality was measured using FMA along with their overall balance analyzed via BBS scores and quality of life assessed by SIS analysis tools respectively prior to commencement. While there existed no distinctions in regards to baseline characteristics between these two categories initially, it should be noted that following this experimental series VS Group recorded superior results when compared against its counterpart concerning an improved FMA score exhibiting an encouraging mean differential value change from baseline readings (+8·5 scores), whereas advancing improved standings for BBS (mean difference=5·2 scores), lead betterment within SIS quality-of-life observations also apparent. Over the duration of this randomized controlled trial investigating VR training's effects on post-stroke rehabilitation measures no negative occurrences were detected within either participant group. Analysis showed that the results indicate possible efficacy concerning improvements in upper limb functioning and balance as well as boosting quality-of-life metrics among individuals recovering from strokes with virtual reality interventions. Because shortcomings are apparent regarding our utilization methodologically speaking further investigation remains critical for affirming our findings and evaluating prospective longitudinal influences stemming from incorporating V.R into post-stroke rehabilitative practices.

**Discussion**

Through meticulous attention to detail, the methods section of this medical article presents a comprehensive overview of the study design, including information on participants, interventions, outcome measures and data analysis (Peretti et al., 2020; Lohse et al., 2014). The findings of the randomized controlled trial are further bolstered by incorporating objective measures such as the Fugl-Meyer Assessment (FMA), Berg Balance Scale (BBS) and Montreal Cognitive Assessment (MoCA) that substantiate its validity (Lohse et al., 2014; Turolla et al., 2013). A comprehensive description of the virtual reality system employed in this investigation was provided as to allow replications in alternate settings (Boian et al. 2002). Despite being easier for clinicians to implement into their standard care practices due to the use of commercial VR systems, there remains a need for cost-effectiveness analyses – particularly relevant when operating under resource-limited conditions.(Lepilkina et al., 2023; Standen et al., 2015) Caveats listed by researchers include limited follow-up data and small sample sizes (Gatica-Rojas et al., 2017), underscoring how future research necessitates larger groups over longer observation periods for validation purposes regarding stroke rehabilitation via VR therapy (Lim et al., 2020). In addition to the lack of evaluation of long-term VR therapy effects on stroke rehabilitation outcomes, this study discusses potential challenges associated with its use (Kizony, Katz & Weiss, 2003; Santos et al., 2013). Addressing these challenges is essential to maximize the benefits of utilizing VR technology in clinical practice (Kumar et al., 2018). One such challenge identified in this article involves ensuring therapists possess sufficient skill and knowledge to employ and integrate VR technology effectively (Esfahlani et al., 2018). Thus, it emphasizes the necessity for proper training and education for clinicians before implementing this method (Parke et al., 2020). The contrasting nature of potential benefits versus limitations associated with VR therapy use within stroke rehabilitation settings is highlighted in this article as it details some insights on how best practices can be established to ensure positive therapeutic outcomes while improving general healthcare standards offered to such group of people (Cai et al., 2021; Keshner & Kenyon, 2004). While certain practical challenges surrounding using such an approach exist that must not go unnoticed clinical studies have shown significant improvements through interventions utilizing Virtual Reality Technologies within therapeutic treatment plans specifically enhancing patient's upper body strength, (Broeren et al., 2008) postural stability & perceived self-reported Quality of Life (Straudi & Cano-de-la-Cuerda, 2023). Significantly improved hemiplegic upper limb function was demonstrated by participants undergoing VR-assisted therapy when compared to their counterparts who underwent traditional therapy (Rodrigues et al., 2020). A remarkably lower incidence of adverse events indicated the safety of using this option as an adjunctive approach in stroke care (Zhang et al., 2018; Khan, Podlasek & Somaa, 2023). The notable enhancement in balance levels that were assessed via Berg Balance Scale (BBS) attests to the potential benefits of employing virtual reality (VR) training techniques as part of stroke rehabilitation programs (Lee, 2021; Cho et al., 2022). These advantages extend beyond balance proficiency, encompassing overall well-being through evidence demonstrating an enhanced quality of life according to Stroke Impact Scale (SIS) measures (Harvey & Ada, 2012). While caveats such as limited sample sizes may temper our optimism, the findings point toward a bright future for incorporating VR into existing protocols for recovery from stroke (Corbetta Imeri & Gatti, 2015; Ji & Lee, 2016). Confirmation of the results and research into the prolonged implications of virtual reality (VR) training on stroke recuperation are imperative for future exploration in this area. Subsequently, (Fugl-Meyer et al., 1975; Mathew et al., 2022) prospective inquiries could be executed to explore the ideal timing, rate, and strength of VR training for determining the most efficacious method for post-stroke rehabilitation (Chen et al., 2021; Ji & Lee, 2016).

**Conclusion**

A groundbreaking development within stroke rehabilitation is the use of virtual reality (VR) technology. Empirical investigations reveal impressive evidence concerning its usefulness for improving outcomes experienced by stroke patients. Included among these benefits are significant advancements noted in upper limb functionality, balance, and gait capabilities, as well as cognitive capacity. One distinctive feature associated with VR therapy is its engaging nature which inspires robust patient buy-in to therapy regimens and fosters sustained participation throughout recovery efforts. Predicated upon fundamental principles surrounding both neuroplasticity and motor learning concepts through objective outcome measuring techniques used increasingly by random control trial methodologies has further fortified support for this intervention modality. Effectively integrating virtual reality (VR) into stroke rehabilitation may be impeded by certain practical factors that require scrutiny before optimal utilization can be ensured. Such impediments comprise clinician-specific training criteria, financial feasibility concerns pertinent to implementing this technology in stroke care centers, accessibility limitations concerning widespread distribution within clinical settings. In addition to these practicalities is the need for further research to validate the efficiency of employing VR as therapy for post-stroke recovery while evaluating its prolonged effects on patients' state or progress. Nevertheless, exposure to such novel intervention bears enormous benefits in advancing healthcare quality a notch higher through precise stroke healing mechanisms fostering positive outcomes. Through acknowledging both the probable advantages and drawbacks of utilizing VR therapy and deliberating on pragmatic factors, healthcare specialists and scholars can propel the utilization of this technology in stroke rehab forward, leading to better outcomes for individuals suffering from a stroke.

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