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POST-STROKE REHABILITATION USING VIRTUAL REALITY-BASED PHYSIOTHERAPY: A CASE REPORT

Case Study

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ABSTRACT

Background: Post-stroke rehabilitation remains a critical component of recovery, with conventional physiotherapy often challenged by patient adherence and engagement. Virtual reality (VR)-based therapy has emerged as an innovative approach that enhances motor recovery through immersive, task-specific training. This case report highlights the therapeutic potential of VR-based rehabilitation in improving functional outcomes in a post-stroke patient.

Case Details: A 58-year-old male with right-sided hemiparesis following an ischemic stroke presented to a neuro-clinical setup in Lahore. Neurological deficits included impaired motor function, proprioception, and coordination. Conventional rehabilitation alone yielded limited progress, prompting the integration of a structured VR-based physiotherapy program. The patient engaged in VR-mediated exercises targeting upper and lower limb motor control, postural stability, and functional mobility. Over a four-week period, significant improvements were observed in motor strength, dexterity, and gait symmetry, leading to enhanced independence in daily activities. No adverse effects were reported.

Conclusion: This case underscores the efficacy of VR-based rehabilitation as a complementary therapy in stroke recovery, offering personalized, engaging, and neuroplasticity-driven motor relearning. The findings support the broader integration of VR in clinical rehabilitation programs. Future research should focus on optimizing VR protocols, assessing long-term benefits, and improving accessibility to ensure widespread application in neurorehabilitation.

Keywords: Gait rehabilitation, Hemiparesis, Motor recovery, Neuroplasticity, Stroke rehabilitation, Virtual reality therapy.

INTRODUCTION

Virtual reality (VR) has emerged as a promising adjunct in post-stroke rehabilitation, offering an interactive and engaging approach to physiotherapy. Stroke remains a leading cause of long-term disability worldwide, with survivors often experiencing motor impairments that significantly impact their daily activities and overall quality of life. Traditional rehabilitation strategies, including conventional physiotherapy, aim to restore function and improve mobility; however, they are often limited by patient motivation, accessibility, and adherence. In recent years, technological advancements have paved the way for innovative interventions such as VR-based therapy, which has the potential to address some of these limitations by providing an immersive and motivating rehabilitation environment (1,2). Stroke-induced motor impairments are primarily attributed to neural damage and disruption of motor pathways, leading to varying degrees of functional deficits. Rehabilitation is crucial during the neuroplasticity window, the period in which the brain exhibits heightened adaptability and reorganization following injury. Conventional rehabilitation techniques, including repetitive task training, strength exercises, and functional movement therapy, rely on principles of neuroplasticity to promote motor recovery. However, challenges such as patient disengagement, fatigue, and lack of continuous feedback often hinder optimal progress. This has driven interest in VR-based rehabilitation, which integrates real-time feedback, gamification elements, and customized exercises to enhance patient participation and maximize therapeutic benefits (3,4).

Virtual reality therapy leverages interactive simulations to facilitate motor learning through task-specific training, visual feedback, and sensory integration. By immersing patients in a virtual environment that mimics real-life activities, VR enhances engagement and motivation, two critical factors influencing rehabilitation outcomes. Studies have demonstrated that VR-based interventions can improve motor function, balance, and coordination in stroke survivors, with some evidence suggesting that they may yield superior outcomes compared to conventional therapy alone. Furthermore, the adaptability of VR systems allows for personalized treatment plans tailored to individual patient needs, promoting progressive and goal-oriented rehabilitation (5,6). Beyond its motor rehabilitation benefits, VR therapy also addresses cognitive and psychological aspects of stroke recovery. Stroke survivors frequently experience cognitive deficits, including impaired attention, spatial awareness, and executive functioning, which can further complicate motor rehabilitation. VR-based exercises incorporate cognitive challenges that require problem-solving, decision-making, and attention, fostering cognitive engagement alongside physical rehabilitation. Moreover, the immersive and rewarding nature of VR therapy can mitigate rehabilitation-related frustration, anxiety, and depression, which are commonly observed in stroke patients. By fostering a more positive and engaging rehabilitation experience, VR has the potential to enhance overall patient adherence and satisfaction (7,8).

Despite its potential advantages, the integration of VR into stroke rehabilitation is not without challenges. The availability of VR systems, cost considerations, and the need for specialized training among healthcare professionals may limit widespread implementation. Additionally, patient-specific factors such as severity of impairment, cognitive limitations, and susceptibility to motion sickness must be considered when designing VR-based rehabilitation programs. Ongoing research continues to explore optimal VR parameters, treatment protocols, and comparative effectiveness against traditional rehabilitation approaches to further refine its role in clinical practice (9-11). This case report explores the application of VR-based physiotherapy in post-stroke rehabilitation, illustrating its feasibility, therapeutic impact, and potential advantages over conventional rehabilitation strategies. By examining the patient's progress and outcomes, this study aims to provide insights into the practical integration of VR in stroke recovery and contribute to the growing body of evidence supporting its clinical utility (12-15).

CASE DESCRIPTION

A 58-year-old male, previously independent in daily activities, presented to a neuro-clinical setup in Lahore with complaints of right-sided weakness and difficulty in coordinating movements following an ischemic stroke. The stroke had occurred six weeks prior, involving the left middle cerebral artery territory, resulting in hemiparesis predominantly affecting the right upper and lower limbs. The patient reported significant challenges in performing fine motor tasks, standing for prolonged periods, and maintaining balance while walking. Additionally, mild expressive aphasia and impaired proprioception were noted, affecting his ability to communicate fluently and navigate spaces confidently. His past medical history included well-controlled hypertension and type 2 diabetes mellitus, both managed with oral medications, along with a sedentary lifestyle prior to the stroke. On clinical examination, motor assessment revealed a Medical Research Council (MRC) grade of 2/5 in the right upper limb and 3/5 in the right lower limb. Muscle tone was mildly increased, suggesting early spasticity. Deep tendon reflexes were brisk on the affected side, and there was evidence of mild sensory impairment, particularly in proprioception and light touch discrimination. The patient exhibited difficulty in executing coordinated movements, particularly in tasks requiring bimanual dexterity. Gait assessment revealed an antalgic pattern with reduced stance phase duration on the affected side, requiring minimal external support for ambulation. Functional independence measures indicated moderate dependency in activities of daily living, primarily related to dressing, feeding, and personal hygiene.

Neuroimaging, including magnetic resonance imaging (MRI) of the brain, confirmed an infarct in the left frontoparietal region, corresponding with the observed deficits. Carotid Doppler studies revealed mild atherosclerotic changes but no significant stenosis. Echocardiography ruled out cardioembolic sources, and laboratory investigations showed well-controlled glycemic indices and lipid profile within acceptable limits. A comprehensive rehabilitation plan was initiated, integrating conventional physiotherapy with an adjunctive virtual reality (VR)-based intervention aimed at enhancing motor recovery, balance, and functional mobility. The VR rehabilitation program was structured to incorporate task-specific training within an immersive digital environment. The patient engaged in repetitive reaching, grasping, and object manipulation tasks, designed to reinforce neuroplasticity-driven motor relearning. Visual and auditory feedback facilitated real-time error correction, optimizing movement execution. Additionally, dynamic balance exercises were integrated into the VR regimen, challenging postural control and weight-shifting abilities in progressively complex scenarios. Sessions were conducted five times per week, each lasting approximately 45 minutes, complementing conventional physiotherapy that included muscle strengthening, proprioceptive training, and gait re-education.

Progressive improvements were observed over the subsequent four weeks. Motor power in the right upper limb improved to an MRC grade of 4/5, with notable enhancements in grip strength and finger dexterity. The patient demonstrated improved coordination in functional tasks such as buttoning shirts and holding utensils, reflecting regained fine motor control. Lower limb strength increased to 4+/5, contributing to improved stability during walking. Gait assessment at follow-up revealed a more symmetrical walking pattern with reduced compensatory movements. Balance assessment showed enhanced postural control, with the patient achieving independent stance maintenance without external support. By the end of the rehabilitation period, functional independence scores reflected significant gains, with the patient regaining autonomy in most self-care activities. Subjective reports indicated increased confidence in mobility and overall physical well-being. No adverse effects, including VR-induced motion sickness, were noted during the intervention period. The findings from this case underscore the potential benefits of integrating VR into stroke rehabilitation, particularly in enhancing motor recovery, engagement, and adherence to therapy.

Table 1: Patient Rehabilitation Progress

Assessment Parameter	Initial Evaluation	Post VR Rehabilitation
Upper Limb Motor Strength (MRC)	2	4
Lower Limb Motor Strength (MRC)	3	4.5
Grip Strength	Weak	Improved
Gait Stability	Unstable	Stable
Balance Control	Poor	Good
Functional Independence	Moderate Dependency	Independent

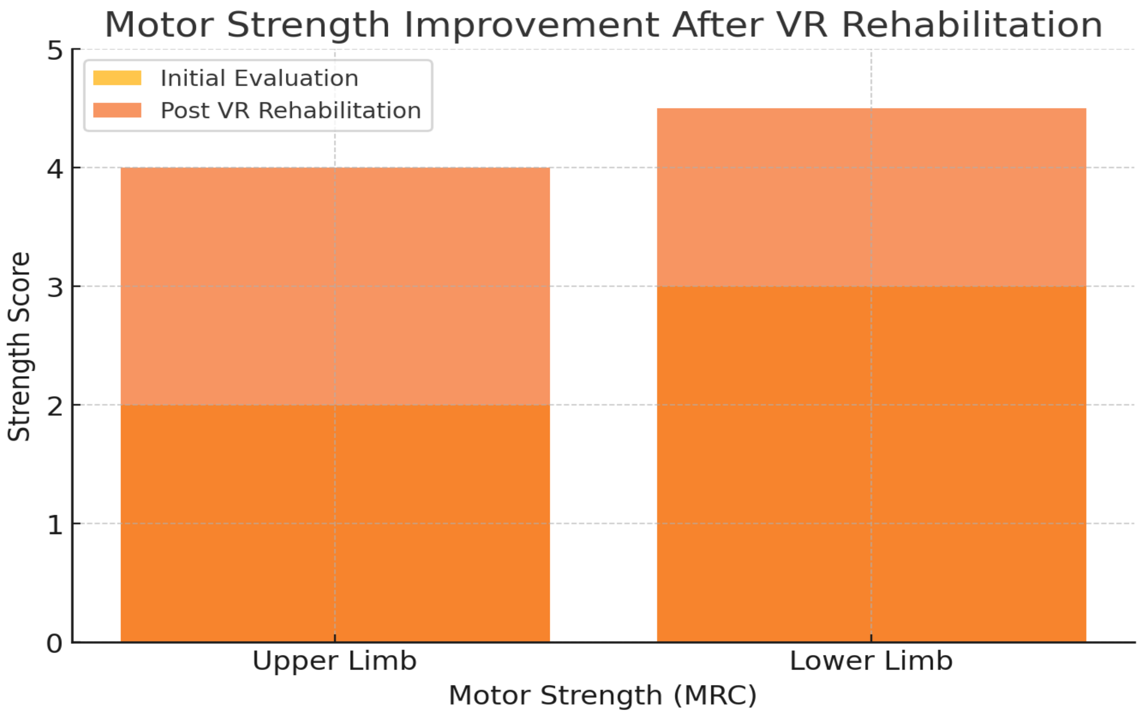

Figure 1 Motor Strength Improvement After VR Rehabilitation

DISCUSSION

The integration of virtual reality (VR) into post-stroke rehabilitation represents a significant advancement in therapeutic interventions, offering immersive environments that enhance motor recovery, cognitive function, and patient engagement. The case of a 58-year-old male from Lahore, who demonstrated substantial improvements in motor function and independence following a VR-based physiotherapy program, aligns with emerging evidence supporting the efficacy of VR in neurorehabilitation (16). Recent studies have highlighted the potential of VR to augment traditional rehabilitation methods. For instance, a systematic review and meta-analysis indicated that VR training significantly improved balance and gait abilities in stroke patients, suggesting that VR can serve as a valuable adjunct to conventional therapy. Similarly, research has demonstrated that VR-based interventions can enhance upper extremity function and postural control in individuals with neurological impairments, further supporting its application in stroke rehabilitation (17).

The patient's engagement in task-specific VR exercises, such as reaching and grasping within simulated environments, likely facilitated neuroplasticity and motor relearning. This approach aligns with motor learning principles that emphasize repetitive, goal-oriented tasks to promote neural reorganization. Additionally, the incorporation of cognitive challenges within VR scenarios may have contributed to improvements in attention and executive function, addressing cognitive deficits commonly observed post-stroke (18). A notable strength of VR-based rehabilitation is its ability to provide real-time feedback, enhancing patient motivation and adherence to therapy. The gamification elements inherent in VR platforms can transform repetitive exercises into engaging activities, potentially leading to better outcomes compared to traditional methods. Furthermore, VR allows for the customization of therapy to match individual patient needs, facilitating personalized rehabilitation plans (19).

However, the integration of VR into rehabilitation protocols is not without limitations. Factors such as the cost of VR equipment, the need for technical training among healthcare providers, and the potential for VR-induced motion sickness must be considered. Additionally, while VR can simulate functional tasks, it may not fully replicate the complexities of real-world environments, potentially limiting the transferability of skills acquired during therapy (20,21). The case also underscores the importance of accessibility in rehabilitation services. Implementing VR in telerehabilitation has shown promise in extending therapeutic interventions to patients in remote or underserved areas, thereby reducing barriers to care. This approach can enhance continuity of care and support ongoing recovery beyond the clinical setting (22,23).

This case contributes to the growing body of evidence supporting the use of VR in post-stroke rehabilitation. The observed improvements in motor function, balance, and independence highlight the potential of VR as an effective adjunct to conventional therapy. Future research should focus on large-scale randomized controlled trials to further elucidate the efficacy of VR-based interventions, explore cost-effectiveness, and establish standardized protocols to optimize patient outcomes (24,25).

CONCLUSION

Virtual reality-based physiotherapy demonstrates significant potential in post-stroke rehabilitation by enhancing motor recovery, functional independence, and patient engagement. The case presented highlights the effectiveness of VR as an adjunctive therapy, contributing to improved motor function, balance, and coordination in a patient with post-stroke hemiparesis. The immersive nature of VR, coupled with real-time feedback and task-specific training, facilitated neuroplasticity-driven recovery, reinforcing its role as a valuable tool in neurorehabilitation. This case underscores the need for wider integration of VR in clinical practice, particularly in structured rehabilitation programs. While cost and accessibility remain challenges, advancements in technology and tele-rehabilitation may offer feasible solutions to expand its reach. Future research should focus on optimizing VR protocols, evaluating long-term outcomes, and exploring cost-effectiveness to ensure broader implementation in stroke rehabilitation. Clinicians should consider VR as a complementary approach, particularly for patients requiring enhanced motivation and engagement in their recovery process.

Author Contribution

Author	Contribution
Nafeesa Ishfaq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Aminah Khalid	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Nazia Mauhammad Razzaq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Wesam Taher Almagharbeh	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ahmar Zafar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Tayab Hashmi	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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