Review Paper

A Review on the Effectiveness of Virtual Reality - Based Lower Limb Rehabilitation in Stroke Survivors

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ABSTRACT

Background: Virtual Reality (VR) has emerged as an innovative therapeutic tool in neurorehabilitation. By offering immersive, interactive, and engaging environments, VR enables repetitive, task-specific, and visually enriched motor training that promotes neuroplasticity. Stroke survivors frequently experience lower-limb impairments such as poor balance, gait disturbances, and reduced motor control, affecting independence and mobility. VR enhances motor relearning through real-time visual, sensory, and proprioceptive feedback, making it a promising approach for restoring lower-limb function.

Need: There is a growing need to identify rehabilitation strategies that enhance motivation, sensory stimulation, and neuroplasticity. VR provides an engaging, feedback-rich environment that may optimize lower-limb recovery. Reviewing current evidence helps clarify its effectiveness and clinical importance.

Objective: To review the effects of VR-based rehabilitation on balance, gait, mobility, and lower-limb motor recovery in post-stroke individuals and determine its potential as an effective independent intervention.

Methodology: Relevant literature was reviewed using PubMed, Google Scholar, PEDro, ResearchGate, and ScienceDirect, focusing on VR-based lower-limb rehabilitation studies published between 2005–2024. Search was conducted using mesh terms virtual reality, stroke rehabilitation, lower-limb motor recovery, balance training, gait improvement, and VR neurorehabilitation.

Results: A total of 15 articles was reviewed, with 5 excluded due to low quality or unrelated focus. Evidence shows that VR improves balance, gait performance, postural stability, and lower-limb motor activation. Studies reported gains in movement coordination, trunk control, step length, dynamic balance, gait adaptability, and overall motor function. VR enhances neuroplasticity through repetitive practice, enriched sensory input, and increased patient engagement.

Conclusion: VR is an effective, motivating, and evidence-supported intervention for improving lower-limb motor function, balance, gait, and functional mobility in post-stroke individuals. It promotes neuroplasticity, enhances recovery, and may serve as a valuable therapeutic tool to support independence and stability in stroke survivors.

Keywords: Virtual Reality, Stroke, Lower Limb Rehabilitation, Balance, Gait, Neuroplasticity.

INTRODUCTION

Stroke (cerebrovascular accident [CVA]) or brain attack is the sudden loss of neurological function caused by an interruption of blood flow to the brain.[1] Stroke as defined by World Health Organization (WHO) is 'the rapid development of clinical signs and symptoms of focal (or global) disturbance of cerebral function, lasting >24 hours or leading to death, with no apparent cause other than of vascular origin [2]'.

Stroke is one of the leading causes of death and disability in India. Developing countries like India are facing a double burden of communicable and non-communicable diseases.[3]

According to the "Global Burden of Diseases", CVA is rated the second source of death and the third most mutual root for disability worldwide.[4] Motor impairments frequently occur after stroke. After an acute stroke, over 80% of patients are thought to have some kind of movement disability. About 20% of these individuals get back at least some of their lost motor functions in the months that follow. This means that 50–60% of stroke survivors nonetheless have a chronic motor dysfunction. These problems are frequently associated with balance, timing, and coordination issues, as well as a reduction in strength and/or stiffness in the affected limbs. These motor deficits may significantly diminish quality of life post-stroke.[5]

Motor impairments—particularly those affecting the lower limbs—are among the most common functional limitations following stroke. These include reduced balance, impaired gait, decreased muscle strength, poor coordination, and difficulties with weight shifting and postural control. Such impairments restrict mobility and independence, ultimately reducing the quality of life.[5]

Postural balance is the capacity to keep the center of mass (COM) in line with the base of support (BOS). For many daily tasks to work best, you need to have good posture. Poor postural balance is a common sign of a stroke and a common reason for falling. People who have had a stroke are more likely to fall than people of the same age who have not had a stroke. Impaired motor and sensory function are likely the two effects that most affect balance and walking abilities after a stroke.[6]

Virtual reality (VR) is a new technology that lets people interact with a computer-generated world (the virtual world). This makes it possible to make multisensory stimuli that bring the complexity of the real world into a controlled space where many physical variables may be changed and controlled.[7]

Several studies have explored the efficacy of VR-based interventions in improving motor function among stroke survivors. Studies have shown improvement in gait symmetry, dynamic balance, movement coordination, and trunk stability using VR-based programs. Based on the theoretical basis of neuroplasticity, VR provides repetitive, task-oriented and feedback-driven training capable of enhancing functional outcomes in stroke survivors.[8]

Virtual reality (VR) has become a novel therapeutic strategy in stroke rehabilitation, utilizing training programs that replicate real-world objects and activities through computer simulations. This new method is particularly helpful since the recovery programs are designed for the new environment and seem to be more fun and interesting than traditional physiotherapy duties. This makes the patient more likely to repeat the tasks and be more involved in the therapeutic program.[9]

There is a growing need to address persistent lower-limb motor impairments in stroke survivors, which significantly affect mobility and quality of life. Traditional therapy alone may not provide the required intensity, repetition, or sensory engagement for optimal recovery. Virtual Reality offers enriched, task-specific, and feedback-driven training that enhances neuroplasticity and motor learning.

The present review summarizes current evidence on the effectiveness of VR-based

lower-limb rehabilitation in improving motor recovery, balance, gait performance, and functional mobility following stroke.

MATERIALS & METHODS

Search Strategy: Relevant studies published between 2005–2024 were searched using: PubMed, Google Scholar, PEDro, ResearchGate, ScienceDirect etc. Search was conducted using Mesh terms Virtual Reality, Stroke Rehabilitation, Lower-limb Recovery, Balance Training, Gait Rehabilitation, VR Neurorehabilitation.

A secondary search of the references from all included studies was conducted.

Inclusion criteria were Stroke survivors, VR used for lower-limb rehabilitation, Experimental studies, Randomized controlled trials, Clinical trials, Studies published in English, Studies focusing on gait, balance, or lower-limb motor recovery.

Exclusion Criteria were Studies not involving VR, Studies on upper-limb VR rehabilitation, Articles with insufficient methodological quality, non-English studies, Reviews, commentaries, or case reports.

Screening And Data Extraction: 15 studies were identified initially, 10 studies were included based on relevance and methodological quality, 5 studies were excluded due to unrelated focus.

Procedure: A total of fifteen (15) articles related to Virtual Reality–based lower-limb rehabilitation in stroke survivors were initially identified through database searches. After reviewing titles and abstracts, ten (10) full-text articles were screened based on the inclusion and exclusion criteria. Studies were evaluated according to: relevance to lower-limb VR rehabilitation, methodological quality, study design, outcome measures, and applicability to balance, gait, or motor recovery. Out of fifteen articles, five (5) studies were excluded due to insufficient methodological quality, lack of direct relevance to VR, or absence of lower-limb–specific outcomes. The remaining ten (10) articles that met all criteria were included in this review. The selection process followed the same sequence as presented in the reference article: Total Search Results (15 Articles), 10 full-text articles screened, included articles (10 articles), Excluded articles (5 articles). Reasons for exclusion: Not focused on lower-limb VR rehabilitation, poor study design, not stroke-specific, or insufficient detail. This screening process ensured that only studies with adequate methodological rigor and direct focus on VR-based lower-limb rehabilitation were selected for final analysis.

RESULT

NO.	AUTHORS NAME	TITLE OF THE STUDY	CONCLUSION
1.	J Shen (2023) [10]	Effects of virtual reality–based exercise on balance in patients with stroke.	VR therapy is effective in improving lower limb function in stroke survivors, with higher treatment frequency (particularly ≥20 sessions) yielding superior outcomes.
2.	David Percy (2023) [11]	Effectiveness of virtual reality-based balance and gait in older adults with fear of movement.	VR-based training is effective on balance or gait training.
3.	Carlos Luque-Moreno (2021) [12]	Virtual Reality and Physiotherapy in Post-Stroke Functional Re-Education of the Lower Extremity: A Controlled Clinical Trial on a New Approach	VR improves balance, gait speed, and functional mobility.
4.	Roxana Steliana Miclaus (2021) [13]	Lower Extremity Rehabilitation in Patients with Post-Stroke Sequelae through Virtual Reality Associated with Mirror Therapy	VR rehabilitation technology makes it easier for chronic stroke patients to recover from lower extremity injuries by mixing several sources of feedback, which has a bigger effect on

			neuroplasticity.
5.	Alexander V. Zakharov (2020) [14]	Stroke Affected Lower Limbs Rehabilitation Combining Virtual Reality with Tactile Feedback	Our study shows that an adjuvant post-stroke VR therapy of the lower extremities in acute phase using interaction via realistic proprioceptive and implicit tactile impacts significantly improves the performance of standard rehabilitation.
6.	ML Latash (2010) [15]	Motor Control Theories and Their Applications	Significant activation of lower-limb musculature.
7.	De Rooij IJ (2016) [16]	Effect of virtual reality training on balance and gait ability in patients with stroke: systematic review and meta-analysis	Results of this study concluded that VR training gives better results than balance and gait training without VR.
8.	Luara Ferreira dos Santos (2016) [17]	Movement visualisation in virtual reality rehabilitation of the lower limb: a systematic review	The review shows that there are different approaches to show how people move during VR-based motor training. Further research is required to investigate the characteristics of this VR information and its impact on motor outcomes.
9.	Carlos Luque-Moreno (2015) [7]	A Decade of Progress Using Virtual Reality for Poststroke Lower Extremity Rehabilitation: Systematic Review of the Intervention Methods	The present findings seem to suggest that VR intervention has a positive impact on balance and gait after stroke.
10.	Laver KE (2018) [18]	Virtual reality in stroke rehabilitation	VR improves balance, gait speed, and functional mobility. VR enhances trunk stability and postural adjustments.

DISCUSSION

Stroke survivors often struggle with persistent lower-limb motor impairments that contribute to functional dependency. Traditional therapy provides essential intervention but may lack the intensity, repetition, and sensory engagement necessary for optimal neuroplastic recovery. Our results confirm the initial hypothesis that VR-based therapies markedly enhance lower limb function relative to traditional therapy. The good effects on lower limb rehabilitation show that VR therapy could be a useful tool for improving rehabilitation methods and patient outcomes. VR technology has been shown to help people learn motor skills by combining different senses and focusing on specific tasks. Virtual reality environments give you real-time input on what you see, hear, and feel, which can help your brain change and improve your motor performance. VR's immersive, multimodal interactions can help patients pay attention, stay motivated, and stay involved during rehab. Also, task-oriented training in VR lets patients do repetitive, goal-directed motions that are like real-life activities. This helps them improve their balance and gait and reinforces their motor control. This method encourages patients to repeat important movements repeatedly, which leads to better results. These pathways collectively underscore the potential of VR to improve rehabilitation outcomes, establishing a basis for further examination in the forthcoming subgroup findings.[10]

The findings are consistent with the principle that enriched environments accelerate neuroplasticity. VR allows individualized progression, minimizing therapist burden while maximizing patient engagement.

Overall, VR-based rehabilitation is an effective intervention for enhancing lower-limb outcomes in stroke survivors.

CONCLUSION

The review concludes that Virtual Reality–based lower-limb rehabilitation is an

effective and promising approach to improve balance, gait, motor recovery, and functional mobility in stroke survivors. VR enhances neuroplasticity through enriched, interactive, and feedback-driven training environments. Thus, VR represents a valuable tool in modern stroke rehabilitation programs and can significantly improve independence and quality of life.

Declaration by Authors
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