

Improving functional rehabilitation through virtual reality-based physiotherapy: A systematic review and meta-analysis

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Abstract

Virtual reality technologies have been integrated into physiotherapy and neurorehabilitation programs in order to improve patient engagement, motor learning, and functional recovery. The aim of this study is to evaluate the effectiveness of VR-based physiotherapy interventions in improving functional rehabilitation outcomes in persons with neurological and physical impairments. A systematic review and meta-analysis will be conducted following PRISMA guidelines. Major databases including PubMed, Scopus, and Web of Science will be searched to identify randomized controlled trials and clinical studies evaluating VR-assisted physiotherapy interventions. Outcomes related to motor performance, balance, gait, and functional independence will be analysed. The results are expected to provide evidence about the clinical effectiveness of immersive technologies in physiotherapy and their potential role in modern rehabilitation practice.

1. Introduction

Technological innovation has transformed rehabilitation practices in recent decades (Chua & Kuah, 2017). Among emerging technologies, virtual reality has gained attention as a therapeutic tool that is capable of improving motor recovery, cognitive engagement, and functional outcomes in persons with neurological and musculoskeletal disorders (Kamari et al., 2024). Virtual reality environments allow patients to interact with simulated tasks that mimic real-world activities while providing immediate feedback and adaptive difficulty levels (Naqvi et al., 2024). Conventional physiotherapy interventions rely on repetitive exercises designed to restore mobility, balance and functional independence, but patient adherence and motivation can sometimes limit therapeutic outcomes (Ley & Putz, 2024). VR rehabilitation introduces immersive and interactive elements that increase patient engagement while enabling therapists to monitor performance and adjust training parameters (Capriotti et al., 2025).

Several clinical studies have investigated the potential benefits of VR physiotherapy in neurological rehabilitation, especially among individuals with stroke, Parkinson's disease, cerebral palsy and other neurological conditions (Laver et al., 2017; Dockx et al., 2016; Chen et al., 2018; De Keersmaecker et al., 2025). Evidence suggests that VR interventions may improve balance control, gait parameters, and upper limb motor function through improved motor learning and neuroplasticity mechanisms (AlSoqih et al., 2025).

Despite increasing interest in VR rehabilitation, the general effectiveness of these interventions is a topic of ongoing investigation. Previous studies vary in methodological quality, intervention protocols, and outcome measures, making it difficult to draw definitive conclusions regarding their clinical impact (Bilika et al., 2023; Kasicki et al., 2025). Therefore, the aim of this study is to systematically review and quantitatively synthesize the available evidence about the effectiveness of VR physiotherapy interventions in improving functional rehabilitation.

2. Methods

2.1 Study design

This research will use a systematic review and meta-analysis design in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The methodology will focus on evaluating the effectiveness of VR physiotherapy in improving functional rehabilitation outcomes.

2.2 Search strategy

A comprehensive literature search will be conducted in the following electronic databases: PubMed, Scopus, Web of Science, Cochrane Library. Search terms will include combinations of keywords such as “virtual reality”, “physiotherapy”, “rehabilitation”, “motor recovery”, “neurorehabilitation”. The search will include studies published between 2021 and 2026 (published until March, 2026).

2.3 Inclusion criteria

Studies will be included if they are randomized controlled trials or controlled clinical studies, if they used VR physiotherapy interventions, participants with neurological or physical impairments and evaluation of functional rehabilitation outcomes such as balance, mobility, motor function. Studies not published in English, conference abstracts without full data, and studies lacking relevant outcome measures will be excluded.

2.4 Data extraction and analysis

Data will be extracted by the reviewer with a standardized data extraction form. Extracted variables will include study design, participant characteristics, intervention protocols, outcome measures and duration of intervention. Meta-analysis will be conducted using standardized mean differences with 95% confidence intervals to evaluate the pooled effect of VR physiotherapy interventions on functional outcomes.

3. Expected results

Based on previous literature, it is expected that VR physiotherapy interventions will show moderate to significant improvements in several functional rehabilitation outcomes, including balance performance, gait parameters, motor coordination and functional independence. VR training may also improve patient adherence and motivation compared to conventional physiotherapy interventions. Also, immersive environments may facilitate task-specific motor training and stimulate neuroplasticity, contributing to improved functional recovery among individuals undergoing rehabilitation.

4. Discussion

The integration of immersive technologies into physiotherapy is a promising direction for modern rehabilitation. VR systems provide interactive environments that encourage active participation, real-time feedback, and personalized therapeutic protocols. These characteristics may improve traditional rehabilitation approaches by improving patient motivation and promoting more intensive and engaging therapeutic exercises. Moreover, VR technologies allow clinicians to design personalized rehabilitation scenarios that simulate real-life activities, thereby improving the transfer of motor skills to everyday functional tasks. Nevertheless, several challenges remain. These include variability in intervention protocols, differences in VR hardware systems, and limited long-term follow-up data. Future research should focus on standardized treatment protocols, multicentre clinical trials, and cost-effectiveness analyses to better understand the role of VR technologies in rehabilitation practice. VR physiotherapy has the potential to improve functional rehabilitation outcomes and may become an integral component of contemporary rehabilitation programs.

5. Conclusion

Virtual reality technologies are innovative and promising approach to improving functional rehabilitation outcomes in physiotherapy. Through immersive and interactive environments, VR interventions may improve motor recovery, balance, and functional independence among persons with neurological and physical impairments. The findings of this systematic review and meta-analysis aim to provide evidence-based information into the clinical effectiveness of VR physiotherapy and support its integration into rehabilitation practice.

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