An overview of the use of virtual reality in stroke rehabilitation

Charles North and Rebecca Gill

ABSTRACT

Stroke rehabilitation has been dominated by conventional methods such as the Bobath approach and exercise. However, these methods alone make it difficult to achieve the number of sessions and repetitions required to improve motor and cognitive function. Virtual reality is a new innovative technology that supports other conventional therapy methods. The authors carried out a review using the PubMed and ScienceDirect databases. A combination of keywords and phrases was used: 'Virtual reality' or 'Virtual reality and stroke rehabilitation' or 'Virtual reality and stroke upper limb' or 'Virtual reality in stroke and cognition'. Selection criteria included clinical trials, meta-analyses, pilot studies and systematic reviews that reviewed or assessed the use of virtual reality in all aspects of stroke rehabilitation. The article concludes that the implementation and use of virtual reality devices is growing rapidly, and virtual reality has become an effective treatment intervention in stroke rehabilitation.

Keywords implementation of virtual reality, rehabilitation, stroke, stroke rehabilitation, upper limb rehabilitation, virtual reality

Authors Charles North, Specialist Neurological Physiotherapist, PhysioFunction; Rebecca Gill, Specialist in Immersive Neurorehabilitation, Virtual Reality Therapies

Contact charlienorth@physiofunction.co.uk

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Stroke rehabilitation has been dominated by conventional methods such as the Bobath approach (Pathak et al, 2021) and exercise. However, these methods alone make it difficult to achieve the number of sessions and repetitions required to improve motor and cognitive function. Virtual reality is a new innovative technology that supports other conventional therapy methods.

To write this review, the authors carried out a literature review using the PubMed and ScienceDirect databases. A combination of keywords and phrases was used: 'virtual reality' or 'virtual reality and stroke rehabilitation' or 'virtual reality and stroke upper limb' or 'virtual reality in stroke and cognition'. Selection criteria included clinical trials, meta-analyses, pilot studies and systematic reviews that reviewed or assessed the use of virtual reality in all aspects of stroke rehabilitation.

Stroke rehabilitation and the role of virtual reality

Stroke is one of the leading causes of disability in the world and affects a person's motor, sensory and cognitive ability. Recovery is focused on regaining independence and improving quality of life. Both the upper and lower extremities can be affected, and recovery can be slow and challenging, both physically and mentally. National Institute for Health and Care Excellence (NICE) guidelines state that rehabilitation should be five times a week for 3 hours a day (NICE, 2023). This intensity of delivery is not possible for every person who has had a stroke, for a variety of reasons, including competing demands of nursing and therapy staff, and constraints on discharge (Cormican et al, 2023).

Stroke rehabilitation is ever-changing, with innovative approaches emerging to improve function. The prevailing approaches involve hands-on therapy and assisted or supervised exercise. The past 20 years have seen an incremental growth in the use of technology, including functional electrical stimulation (FES). As technology has improved, the evidence base for its use in stroke rehabilitation has also grown. This is especially the case in the use of virtual reality (VR), with studies demonstrating its effectiveness in improving overall function in stroke survivors (Lee et al, 2019; Jin et al, 2022).

VR is being used with a variety of neurological conditions, such as Parkinson's and multiple sclerosis (MS). Research has demonstrated benefits for balance, postural stability and functional mobility (Truijen et al, 2022). VR environments can be motivating and improve the uptake of exercise. It is accepted by because it is highly adaptable to the individual, which in turn enhances their engagement and works to improve motor function (Errante et al, 2022).

What is virtual reality and how does it work?

Virtual reality deploys proprietary hardware and software to replicate real-world environments in the user's visual field, most often using headsets or screen projections. Headsets include the use of motion controllers, hand tracking and head tracking to create an environment for the user (*Figure 1*).

There are various types of VR, but in neurological rehabilitation it is generally fully immersive and augmented reality (AR). Fully immersive VR creates a completely artificial environment for the user within the headset. Augmented reality most often uses goggles where computer-generated content is internally projected onto the lens to merge with the real-world view. For example, virtual lines can be projected, giving the user the perception that there are lines drawn on the floor that they are required to step over.

Both VR and AR have their advantages: VR improves patient motivation, task-specific and repetition training. AR promotes real-time feedback for functional tasks in the real world. Both work for improving motor skills, neuroplasticity and cognitive functions (Khokale et al, 2023).

Concept of neuroplasticity in stroke recovery

Neuroplasticity is the ability of the brain to change, rewire and create new connections after motor or cognitive function has been affected, enabling the re-learning of skills. In conventional therapy methods, the use of task-specific and repetition training is acknowledged as fundamental for improving functional ability, cognitive ability and strength in the upper and lower limbs through neuroplasticity (French et al, 2016; de Sousa et al, 2018).

Huang et al (2022) explored the impact of VR in chronic stroke patients and showed that there is increased cortical excitability in the affected areas of the brain, suggesting improved neural activity. Patients also exhibited significant improvements in motor function, showing that VR can facilitate motor recovery through neuroplasticity.

The use of VR in rehabilitation has also been explored to amplify the effects of treatment in cognitive recovery. Participants showed significant improvements in cognitive function, indicating that VR interventions promote neuroplasticity (Gangemi et al, 2023).

Applications of virtual reality in stroke rehabilitation

Virtual reality for upper limb rehabilitation

Several companies are demonstrating innovative uses of VR to support upper limb rehabilitation following a stroke. Systems such as Neuro Rehab VR, for example, deliver exercises with adaptable difficulty, giving users instant feedback that supports motor learning principles. Advanced motion-tracking enables clinicians to precisely monitor movement, providing real-time data on range of movement, accuracy and functional task completion. Inmotion VR uses these data to support motor relearning by aligning exercises with clinically relevant goals *(Figure 2)*.

Some systems, such as Tyromotion, combine VR with robotic-assisted therapy, enabling repetitive, targeted movement with haptic feedback. Others, such as OROI VR, take a more immersive approach, letting users 'cycle' or 'kayak' through virtual environments while using stationary equipment. This makes therapy feel more like an experience than a chore, which is helpful in keeping people motivated and increasing the number of repetitions.

Courtesy of VR Therapies

Figure 1. Use of virtual reality in a seated position using head tracking

Courtesy of Inmotion

Figure 2. Inmotion VR using tablets to depict data from VR

The upper limb is often a challenging and prolonged aspect of stroke rehabilitation. VR in upper limb rehabilitation is being used more and more to support other conventional methods of therapy. The evidence for VR as a therapy alone is limited and most studies combine the use of conventional methods and VR. Laver et al (2017) used conventional methods such as physical exercise and therapeutic exercise around activities of daily living (ADLs) with a control group, while the experimental group received the same intervention supplemented with the use of VR. Significant improvements were seen in the experimental group for both upper limb activity and ADLs. This evidence highlights the impact physiotherapists and occupational therapists can have on individuals living with stroke symptoms when integrating VR in rehabilitation.

Chen et al (2022) conducted a meta-analysis of 19 studies and concluded that individuals who had VR-supported exercise showed significant improvements in upper limb function, range of motion, muscle strength and performance of ADLs, compared to participants who only had conventional therapy.

Encouragingly, the use of VR is also shown to be of benefit in chronic stroke treatment (Kiper et al, 2018). It has been demonstrated that VR and conventional therapy also showed significant improvements when measured with the Fugl-Meyer upper extremity scale (Kiper et al, 2018). In addition, this study demonstrated notable improvements in quality of life, also highlighting the positive impact VR can have not only on physical rehabilitation but also mental wellbeing.

Virtual reality for gait and balance training

One-fifth of stroke survivors have impaired walking abilities (Yoo et al, 2025), showing the importance of these innovative interventions to improve functional outcomes such as gait and balance. A meta-analysis compared conventional therapy and VR in stroke rehabilitation (Yoo et al, 2025). For balance, there were substantial improvements in the Berg balance scale and the timed up and go (TUG) outcome measures, indicating improved functional balance in participants. This study also demonstrated that gait speed and distance improved in participants undertaking the VR training (Yoo et al, 2025).

A similar study showed that the effect of conventional therapy combined with VR training produced significant improvements in balance, the functional reach test and reductions in postural sway (In et al, 2016). These results from multiple studies show that VR training has a substantial effect on stroke recovery and aids the improvement of motor function.

Motek Medical's CAREN (Computer-Assisted Rehabilitation Environment) and GRAIL (Gait Real-time Analysis Interactive Lab) platforms combine immersive VR environments with instrumented treadmills to help patients retrain gait and postural control. These systems allow real-time adaptation to patient performance and detailed analysis of balance, co-ordination and symmetry.

Similarly, h/p/cosmos quasar treadmills offer feedback on weight distribution and gait phase asymmetries, which is valuable in hemiparetic stroke rehabilitation. These tools promote self-correction and improved awareness of posture and movement strategies.

For settings with limited space or resources, platforms such as Corpus VR offer accessible, home-based VR focusing on balance, weight-shifting and obstacle navigation. These include dual-task and cognitive-loading features to simulate real-life walking challenges, promoting functional carryover into daily mobility tasks.

Virtual reality for cognitive rehabilitation after stroke

Post-stroke cognitive deficits often affect executive function, attention and memory. Platforms such as OROI, Corpus VR, NeuroVive and XR Health offer targeted cognitive training using virtual environments that simulate functional activities (eg shopping, navigation, cooking) (*Figure 3*). This helps make the therapy more relevant and easier to transfer into real life. Clinicians can set individual goals and track progress over time using both recorded performance and patient feedback.

VR exposure therapy (VRET) creates controlled environments where users can confront their fears. This technology is gaining ground as a tool for post-stroke anxiety, including fear of falling and driving-related phobias (Kaussner et al, 2020; Akkan et al, 2022).

Driving simulators are particularly valuable, enabling patients to assess their capabilities in a safe space. This promotes a shift from clinician-led risk assessment to patient-led insight and decision-making, fostering autonomy and engagement in the recovery process.

Implementation challenges

Technical barriers

Although VR holds a lot of potential, technical challenges are still a barrier, particularly in busy healthcare environments. Shared headsets raise concerns about infection control and motion-tracking systems can be unreliable, requiring consistent lighting and calibration. Encouragingly, new hardware developments, including lighter wireless headsets and intuitive interfaces, are improving usability and safety. These changes help reduce the mental load on both patients and clinicians, making the systems easier to adopt in everyday practice.

Clinical integration and standardisation

One of the biggest obstacles to wider use is the lack of standard clinical guidelines. Despite increasing support, there remains limited consensus on treatment dosage, progression and inclusion criteria (Khan et al, 2024; te Boekhorst et al, 2025).

Furthermore, wide variability across studies in terms of patient selection, outcome measures and intervention design make it difficult to translate evidence into consistent clinical practice. This gap is compounded by the rapid evolution of VR technology, which often outpaces clinical validation.

Cost and accessibility

High-quality VR systems with adequate motion-tracking and processing capabilities require considerable financial investment. In addition to hardware capital costs, licensing models and software subscriptions can introduce ongoing revenue expenses, posing challenges for both public and private healthcare providers.

However, some groups are finding ways around this.

For example, VR Therapies provides mobile services that bring VR directly into communities to support health and social care. This kind of approach can help reduce waiting times and make therapy more accessible, especially for people who might struggle to travel or engage.

From a health economics perspective, there is growing evidence to suggest that VR may offer long-term savings by reducing therapist time, accelerating recovery and decreasing hospital readmissions (Gómez Bergin and Craven, 2023).

Clinician training and acceptance

Many therapists remain unfamiliar with immersive technologies and may lack the confidence to integrate VR into their clinical toolkit. This learning curve can create psychological resistance, particularly when digital tools disrupt established workflows.

Translating therapeutic principles to digital platforms requires a conceptual shift from physical guidance to technology-mediated feedback. As a result, successful implementation depends on both technical support and ongoing training to build clinician confidence and competence.

Patient-centred considerations

Acceptance and engagement

Initial patient acceptance is shaped by factors such as age, prior exposure to technology, education and cultural beliefs. Some older adults may associate VR with gaming or entertainment, resulting in scepticism about its therapeutic value. Others may feel intimidated by the equipment.

Stroke-related cognitive deficits, particularly impaired self-awareness (anosognosia), can also affect engagement. VR offers a unique opportunity for experiential learning. Simulations such as virtual driving let people experience their own limitations first-hand, which can be more effective than being told about them. Features such as gamification also make therapy more motivating while increasing adherence. Programs that use scoring, levels and real-world scenarios encourage repeated practice and increase therapy dosage, critical for driving neuroplasticity (Asadzadeh et al, 2021).

Managing adverse effects

Cybersickness, which includes symptoms such as nausea, dizziness or visual discomfort, remains a concern, particularly in stroke patients with vestibular or visual impairments. Incidence rates vary between 15%–40%, depending on individual sensitivity and system quality (Simón-Vicente et al, 2024). Careful calibration, shorter sessions and introducing the technology gradually can help reduce these risks.

Personalisation and flexibility

One of VR's greatest strengths lies in its adaptability to the user's presenting condition. Systems that accommodate seated or standing use, target different limbs and

Courtesy of OROI

Figure 3. OROI VR system depicting how devices can be linked with other equipment and streamed to a TV for wider viewing

adjust difficulty levels offer significant clinical value. Personalisation should begin with a comprehensive assessment and continue with ongoing performance-monitoring, allowing clinicians to tailor therapy in real time.

Importantly, activities that resonate with a patient's personal goals or interests, such as virtual travel or hobby simulations, tend to enhance motivation and emotional wellbeing. This highlights the value of narrative and context in therapy design, particularly in long-term rehabilitation (Soleimani et al, 2024).

Psychosocial impact

Beyond motor and cognitive outcomes, VR rehabilitation offers considerable psychosocial benefits.

KEY POINTS

- The use of virtual reality combined with conventional methods improves overall function.
- Virtual reality is highly adaptable to each individual.
- Virtual reality increases engagement and motivation in exercise.

CPD REFLECTIVE QUESTIONS

- How might virtual reality complement traditional stroke rehabilitation approaches?
- What barriers need to be addressed before virtual reality can be integrated into practice?
- What ways could virtual reality – based interventions be tailored to meet individual needs?
- How can future research strengthen the evidence base for the effectiveness or virtual reality in stroke rehabilitation?

Programs such as OROI combine physical exercises with wellbeing-focused modules such as meditation and nature exploration. These experiences may help reduce the psychological burden of hospitalisation, support emotional recovery and improve overall quality of life (Chan et al, 2023). By providing a sense of achievement, autonomy and progress (Aderinto et al, 2023), immersive therapies can improve mood, confidence and hope – all essential ingredients in stroke recovery.

Conclusions

The use of VR has hugely positive effects in stroke recovery. This review outlines the significant improvements for the upper limb, lower limb and cognitive rehabilitation. While conventional therapy methods have been shown to also improve outcomes of stroke survivors, the research on these two interventions together is positive and encouraging, with significant improvements having been seen. These findings reinforce the potential that VR has and its place as a tool in neurorehabilitation to improve functional outcomes, motivation and quality of life. More evidence is needed to explore the use of VR therapy alone and not alongside conventional therapy methods. BJNN

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