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REVIEW ARTICLE

Role of Virtual Reality in Physiotherapy

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ABSTRACT

Virtual Reality (VR) has restructured the comprehension of neuroplasticity and opened new pathways for rehabilitation. It can transform the mundane conventional Physiotherapy treatment into an interactive and motivating tailored program which is target and task specific, thereby improving the efficiency as well as the effectiveness of the Physiotherapy treatment. Neural plasticity is cardinal to VR which works by altering synaptic connections, neural circuitry, and functional brain networks. It is effective in promoting motor recovery in conditions such as stroke, Parkinson's disease, and spinal cord injury by helping patients relearn movements and improve balance & coordination. It provides a safe, user friendly environment which helps regain confidence and motor control.

KEYWORDS

• Virtual Reality • Neuroplasticity • Rehabilitation • Physiotherapy • Exercise

INTRODUCTION

Virtual Reality (VR) has revolutionized the field of rehabilitation therapy by providing immersive and interactive experiences that exceed conventional boundaries and greatly enhance patient outcomes and care.[1] It works by stimulating the user's senses in such a way that a computer generated world is experienced as real and has the potential to transform how Physiotherapy is delivered by making it more immersive and patient friendly. VR uses computer-generated three-dimensional interactive simulation models, allowing users to engage in environments resembling real-world objects and events.[2]

Conventional Physiotherapy sessions are demanding due to lack of patient engagement (especially in neurological cases), are stressful, repetitive and mundane leading to low adherence, along with accessibility issues in remote areas. So, there is a need for an innovative solution like Virtual Reality in rehabilitation. VR gamifies Physiotherapy to make exercises more interesting and there is

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real-time feedback which provides constant monitoring and feedback to improve patient performance and adherence.

VR has been employed in the rehabilitation of a wide range of motor impairments, particularly those resulting from neurological conditions such as Parkinson's disease (PD), Multiple Sclerosis (MS), Cerebral palsy, and Stroke.[3]

As global life expectancy increases, the burden of neurological disorders on public health continues to grow. In 2016, motor impairments represented one of the leading causes of increased disability-adjusted life years (DALYs), with upper limb dysfunction being particularly prominent.[4] VR can help in both preventing deterioration as well as facilitating recovery.[5]

VR based rehabilitation by therapists is explained by eight attributes, namely learnability (easy to learn the system), appropriateness or usefulness (suitability of the product or system according to the patient's need), effectiveness (accuracy and completeness by patients in achieving specified goals), efficiency (efficient system use for high-level productivity), memorability (easy to remember system functions), patient error protection and recovery (degree of protection against errors by the system), satisfaction (the system should be pleasant and acceptable), and operability (ability to control and operate the system software).[6] VR has shown promising results in improving motor function, balance, gait, and ADL in patients with neurological and musculoskeletal disorders. It is an effective treatment option for stroke, multiple sclerosis, and traumatic brain injury.[7]

Virtual Reality for Stress Reduction

Virtual reality (VR) is used in healthcare to distract patients from pain during medical procedures by immersing them in an alternate reality. This helps reduce their awareness of their physical surroundings away from painful stimuli. VR has also proven to be effective in alleviating symptoms and improving outcomes for individuals dealing with both psychiatric conditions such as PTSD and various health conditions including pain management.[8]

VR provides a sensory escape that can effectively lower stress levels and promote relaxation by immersing the patients in a virtual world. From serene nature scenes to guided mindfulness exercises, VR offers a versatile range of experiences tailored to individual preferences.[9]

Virtual Reality in Pain Management

Virtual reality has consistently been demonstrated to decrease pain, anxiety, unpleasantness, time spent thinking about pain and perceived time spent in a medical procedure.[10] VR actively engages the brain's attention pathways and not just offer distraction. Studies have shown that VR can enhance patient comfort, lower the need for sedatives, and support quicker recovery by improving mental resilience.

Virtual reality has been found to attenuate pain, and this effect has been called 'VR analgesia'[11,12] The subjective ratings of pain reduction by VR has been corroborated with functional MRI (fMRI) data showing reduced brain activity increases in regions commonly strongly activated by experimental thermal pain stimulation. Gold *et al.* hypothesized that VR analgesia originates from intercortical modulation among signalling pathways of the pain matrix through attention, emotion, memory and other senses (e.g., touch, auditory and visual), thereby producing analgesia.[13]

Virtual reality technology has also been studied with burn patients undergoing physical therapy. Hoffman *et al.* examined the use of pharmacologic analgesia alone versus VR in addition to analgesia during physical therapy[14] and found that patients in the VR group reported lower ratings of pain and an increased range of motion. A recent systematic review of nine studies by Morris *et al.* also found that VR coupled with standard analgesia was effective in reducing pain during burn care in eight of the nine studies.[15]

Virtual Reality in Stroke

VR can help Stroke survivors regain motor control through immersive environments by simulating real world tasks like grasping objects, walking etc. and aiding neural recovery. When combined with treadmills, VR can improve balance, self-efficacy related to falls and improve gait pattern. VR also helps Stroke survivors learn new motor skills by providing immediate feedback on their movements.

Peng *et al.* found that stroke survivors who received VR based balance training showed

significant improvements in postural control and gait parameters compared to those undergoing traditional therapy.[16] Similarly, Irene suggested a higher effect of immersive VR in improving balance and reducing the risk of falls, as well as the perception of visual verticality in stroke patients.[17]

In another research, Cho *et al.* studied the effects of a Virtual Walking Training program using a projector screen in front of a treadmill and found stroke patients to have significantly improved on BBS (Berg Balance Scale) with scores improving from baseline to postintervention (36.71 ± 2.28 to 40.85 ± 1.67 scores, p value < 0.05), along with the control group, but overall, the VR group showed significantly greater improvement in-between group scores on the BBS.[18] Lee *et al.*[65] who studied augmented reality postural control training on chronic stroke patients reported *post hoc* analysis results to be significant for improvement on the TUG (Timed Up and Go) for both the intervention group (p = 0.007) and the control group (p = 0.038).[19]

Virtual Reality in Parkinsons

VR can simulate environments where patients practice balance and coordination exercises by challenging patients to navigate obstacles or maintain balance, which can help improve their stability and coordination. One of the reasons why VR-based rehabilitation is particularly effective in improving balance function in patients with PD is because it challenges the patient's balance through game-based VR program that incorporate activities requiring weight shifting and balance maintenance.[20,21]

Therefore, VR-based rehabilitation effectively improves balance in patients with PD because it provides a high level of immersion, customized training, immediate feedback, and motivation through a game-like experience. These advantages make it a powerful tool for rehabilitation and a promising avenue for future research on PD treatment.[22]

Virtual Reality in Spinal Cord Injury

In Spinal cord injury patients, VR systems can create engaging tasks that challenge the patient's motor skills, promoting neuroplasticity and muscle retraining. VR can simulate walking or other movements, helping patients practice these actions in a controlled environment. It also helps in pain management, balance & coordination. Virtual environments can provide exercises to help improve cognitive functions, such as attention and memories as well. The impact of VR on people's multisensory perception, movements, attitudes, and even modulations of socio-cognitive aspects of their behavior may influence every phase of their rehabilitation treatment, from the acute to chronic stages.[23] VR system helps in characterizing movements not only related to strength but also in kinematic performance required for smooth and harmonious patient movements, as well as other functional and clinical variables.[24] A typical setup creates an interactive virtual moving system, where patients can see their own body aligned with the avatar's body, reproducing the same movements in real time and creating the illusion that they are controlling the avatar's movement and speed, for example, when grasping objects or walking along a path.[23]

DISCUSSION

While conventional rehabilitation approaches are effective for many, they are often perceived as monotonous, slow, and exhausting by some users. VR has shown its effectiveness in reducing motor, sensory & cognitive impairments and improving the quality of life. This is attributed to their innovative approach, flexibility, real-time feedback, and user-friendly interface. VR is perceived as more responsive and interactive by stroke survivors due to its closer resemblance to physical reality.[25]

In a VR system, the complexities of the real world are simulated in a controlled environment.[26] Moreover, VR provides an environment where patients can repeat the same exercises with enough motivation to perform a large number of exercises, which is the cornerstone in rehabilitation.[27] Other advantages of VR include performance feedback, individual setup and ease of adjustment.[28] It also provides an interactive session for facilitated home-based exercise therapy in rehabilitation due to enjoyment of therapy, reduced perception of pain, and improved movement. Neural plasticity is fundamental to Virtual reality.

According to Sokołowska, the dynamic interplay between sensory inputs, motor

responses, and cognitive engagements triggers a cascade of neuroplastic changes, altering synaptic connections, neural circuitry, and functional brain networks.[29] These neuroplastic adaptations serve as the foundation for learning, memory formation, and the acquisition of new skills within the VR landscape.

Some of the limitations of VR include high upfront costs of VR systems and its accessibility in lower income healthcare settings, need for specialized training for both therapists and patients to effectively use VR and motion sickness in which some patients may experience discomfort while using VR, limiting its use for certain populations.

CONCLUSION

VR is one of the most innovative technologies which can transform rehabilitation for diverse disorders.It can augment conventional Physiotherapy treatment by fostering motor and cognitive recovery in patients as it provides tailored target specific goals.

Conflict of Intestate

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