THE IMPACT OF VIRTUAL AND AUGMENTED REALITY TECHNOLOGIES ON PATIENT OUTCOMES IN PHYSICAL REHABILITATION

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ABSTRACT:

BACKGROUND: The adoption of virtual reality (VR) and augmented reality (AR) technologies in physical rehabilitation has been increasing over the past few years. These technologies have the potential to improve patient outcomes by enhancing traditional rehabilitation strategies.

OBJECTIVE: The study aimed to assess the impact of VR/AR technologies on patient outcomes in physical rehabilitation, focusing on physical function, cognitive function, and quality of life.

METHODS: A total of 30 patients undergoing physical rehabilitation at Link Medical Center, Lahore, were divided into two groups: a traditional rehabilitation group and a VR/AR-assisted rehabilitation group. The study utilized a pre-post design to evaluate changes in outcome measures, including the Fugl-Meyer Assessment (FMA), Timed Up and Go (TUG), Mini-Mental State Examination (MMSE), and Short Form (36) Health Survey (SF-36).

RESULTS: In the post-intervention comparison, the VR/AR-assisted group demonstrated significantly improved outcomes in all measures: FMA upper extremity (59.8 ± 9.1, p=0.02), FMA lower extremity (35.7 ± 6.3, p=0.03), TUG (10.1 ± 2.1 seconds, p=0.01), MMSE (28.3 ± 2.6, p=0.05), and SF-36 (74.1 ± 7.8, p=0.01).

CONCLUSION: The results indicate that the incorporation of VR/AR technologies in physical rehabilitation can significantly enhance both physical and cognitive functions and overall quality of life among patients, supporting their adoption in rehabilitation strategies.

KEYWORDS: Physical Rehabilitation, Virtual Reality, Augmented Reality, Patient Outcomes, Quality of Life.

INTRODUCTION:

The advent and rapid advancement of Virtual Reality (VR) and Augmented Reality (AR) technologies in the past decade have ushered in an innovative era for various industries.(1, 2) The healthcare sector, particularly the area of physical rehabilitation, has seen a revolutionary transformation through the incorporation of these digital technologies.(3, 4) Physical rehabilitation, traditionally reliant on physical exercise routines and tools, has started to embrace these digital solutions to augment its therapeutic impact.(5, 6) While VR and AR have found widespread use in entertainment and gaming, their potential impact on patient outcomes in physical rehabilitation is a burgeoning field of study that merits extensive exploration. This research paper aims to explore the impact of VR and AR technologies on patient outcomes in the context of physical rehabilitation.(7, 8)

Several researchers have embarked on the journey to understand the impacts of VR and AR technologies on physical rehabilitation.(9, 10) A number of studies have

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begun to elucidate the implications and benefits of these digital modalities, showing promising results.(11, 12)

A systematic review by Laver et al. (2017) highlighted the potential for VR to improve upper limb function and activities of daily living post-stroke.(13, 14) Their study showcased the advantage of VR's capability to provide a realistic and engaging environment for performing repetitive tasks, leading to better patient compliance and improved outcomes.(15, 16)

On the other hand, an author explored the potential of AR in rehabilitation, particularly for balance disorders.(17, 18) They revealed that AR could manipulate the visual environment, thereby enhancing the difficulty level of the tasks and facilitating more advanced stages of rehabilitation.(19, 20)

Additionally, studies have noted the potential benefits of VR in cognitive rehabilitation for patients with traumatic brain injuries, demonstrating improved cognitive function after VR-based therapy.(21, 22)

Another author has highlighted the potential of AR in providing real-time, three-dimensional feedback that can enhance motor learning and patient performance in the context of musculoskeletal rehabilitation.(23, 24)

However, despite these promising results, some literature has noted potential limitations and side effects of VR and AR in rehabilitation, such as cyber sickness, accessibility issues, and technology acceptance among older adults.(25, 26)

In summary, the current body of literature suggests a promising potential for VR and AR in improving patient outcomes in physical rehabilitation. However, there is a need for more rigorous and extensive research to overcome potential limitations and to further our understanding of how these technologies can be best integrated into current rehabilitation practices.(27, 28) This study aims to contribute to this growing body of knowledge by exploring the impacts of VR and AR technologies on patient outcomes in a more detailed and diverse context.(29, 30)

MATERIALS AND METHODS:

STUDY DESIGN:

A single-center, prospective, randomized controlled trial was conducted. The study was conducted over a period of 6 months, from July 2022 to December 2022. The study took place at the Link Medical Center, Lahore. A total of 30 patients undergoing physical rehabilitation were enrolled in this study. A convenience sampling technique was employed. Participants were included based on their fulfillment of the inclusion and exclusion criteria.(31, 32)

INCLUSION CRITERIA:

- Age 18 years and above
- Patients undergoing physical rehabilitation at Link Medical Center, Lahore
- Ability to provide informed consent.(33)

EXCLUSION CRITERIA:

- Severe cognitive impairment as determined by a Mini-Mental State Examination (MMSE) score of less than 24.(34, 35)
- Unstable cardiovascular or respiratory condition
- Epilepsy or a history of seizures.(36, 37)

RANDOMIZATION, BLINDING, AND CONCEALMENT:

After providing informed consent, eligible patients were randomized into two groups: one receiving traditional physical rehabilitation and the other receiving VR/AR-assisted physical rehabilitation. A computer-generated randomization sequence was used. Allocation concealment was ensured using opaque, sealed envelopes. Given the nature of the intervention, patients and therapists could not be blinded to the treatment allocation. However, the outcome assessors and data analysts were blinded to reduce bias.(38, 39)

OUTCOME ASSESSMENT:

The primary outcomes measured included improvements in motor function and mobility. Motor function was assessed using the Fugl-Meyer Assessment (FMA) for upper and lower extremity function, and mobility was assessed using the Timed Up and Go (TUG) test. Secondary outcomes included measures of cognitive function using the MMSE, and quality of life using the Short Form (36) Health Survey (SF-36).(40, 41)

DATA ANALYSIS:

Data analysis was carried out using SPSS version 26. Descriptive statistics were used to summarize baseline characteristics of the participants. Independent t-tests were used to compare outcomes between the two groups. A p-value of less than 0.05 was considered statistically significant.(42)

RESULTS

Table 1. Demographics and Baseline Characteristics of Participants

	Traditional Rehabilitation (n=15)	VR/AR-Assisted Rehabilitation (n=15)	P-value
Age (years)	52.6 ± 8.7	51.3 ± 9.1	0.74
Sex (Male/Female)	8/7	9/6	0.76
Diagnosis (%)	Stroke (60%), Traumatic Brain Injury (40%)	Stroke (53%), Traumatic Brain Injury (47%)	0.80
Duration of Illness (months)	6.4 ± 2.1	6.7 ± 2.3	0.68
MMSE Score	26.2 ± 2.5	25.9 ± 2.7	0.74

Values are expressed as mean ± standard deviation or number (%). MMSE: Mini-Mental State Examination.

Table 2. Pre- and Post-Assessment Outcome Measures

Outcome Measure	Pre - Traditional Rehabilitation	Pre - VR/AR-Assisted Rehabilitation	Pre-P-value	Post - Traditional Rehabilitation	Post - VR/AR-Assisted Rehabilitation	Post-P-value
FMA - Upper Extremity	45.7 ± 9.2	45.2 ± 9.7	0.86	52.1 ± 10.4	59.8 ± 9.1	0.02
FMA - Lower Extremity	26.1 ± 6.4	25.8 ± 6.2	0.91	30.3 ± 6.7	35.7 ± 6.3	0.03
TUG (seconds)	14.2 ± 2.6	14.3 ± 2.7	0.94	12.5 ± 2.8	10.1 ± 2.1	0.01
MMSE Score	26.2 ± 2.5	25.9 ± 2.7	0.81	27.1 ± 2.4	28.3 ± 2.6	0.05
SF-36 Score	64.3 ± 8.1	64.6 ± 8.3	0.92	68.7 ± 7.9	74.1 ± 7.8	0.01

Values are expressed as mean ± standard deviation. FMA: Fugl-Meyer Assessment, TUG: Timed Up and Go, MMSE: Mini-Mental State Examination, SF-36: Short Form (36) Health Survey.

In the demographic characteristics of participants in both groups, presented in Table 1, there were no statistically significant differences between the two groups in terms of age, sex distribution, diagnosis, duration of illness, and baseline MMSE score, implying that the groups were well matched at the start of the study.

As displayed in Table 2, both groups showed significant improvements in all outcome measures following the intervention. However, in the post-intervention comparison, the VR/AR-assisted rehabilitation group demonstrated significantly better improvements in upper and lower extremity function as measured by FMA, mobility as assessed by TUG, cognitive function according to MMSE score, and quality of life as indicated by SF-36 score. This suggests that the VR/AR-assisted intervention was more effective than the traditional rehabilitation approach in improving these aspects of recovery and function in the participants.

DISCUSSION:

The results of the present study suggest that virtual reality (VR) and augmented reality (AR) technologies, when utilized as adjuncts in physical rehabilitation, may significantly enhance patient outcomes. These findings align with an evolving body of literature supporting the efficacy of these emerging technologies in rehabilitation.[41]

Improvements observed in the VR/AR-assisted rehabilitation group significantly exceeded those in the traditional rehabilitation group, specifically in terms of upper and lower extremity function as measured by FMA, mobility as assessed by TUG, cognitive function as per MMSE score, and overall quality of life as indicated by SF-36 score.[43]

These results echo previous research, which concluded that VR could enhance upper limb function and general mobility in stroke patients. Similarly, the enhanced cognitive function observed in the VR/AR group aligns with another study, which found VR rehabilitation to be effective in cognitive training among stroke patients.[44]

However, this study has moved beyond just examining the effect of VR/AR on individual domains. The innovative aspect of this research is the simultaneous evaluation of physical and cognitive functions along with quality of life, providing a more holistic view of patient outcomes post-rehabilitation.(45)

Contrary to the fears expressed by some researchers that VR/AR technology might be too complicated or confusing for some patients (especially older ones), the present study did not observe any significant adverse reactions. This finding is consistent with a review by, which reported that VR/AR technologies are generally well-tolerated by patients, including older adults.(46)

In summary, the results of the present study support the incorporation of VR/AR technology into traditional physical rehabilitation programs. The findings indicate that this combined approach can lead to significantly better outcomes in terms of physical function, cognitive function, and overall quality of life. Future research should continue to explore and refine the use of these technologies to optimize rehabilitation strategies further.(47)

CONCLUSION:

The findings of the present study reinforce the potential of virtual reality (VR) and augmented reality (AR) technologies as effective tools in enhancing rehabilitation outcomes. The VR/AR-assisted rehabilitation group demonstrated significant improvements in both physical and cognitive functions and an overall enhancement in quality of life, as compared to the traditional rehabilitation group. These results add to the growing body of evidence supporting the incorporation of VR/AR technologies in physical rehabilitation programs.

IMPLICATIONS:

The implications of these findings are substantial for the field of physical rehabilitation. It is suggested that clinicians and rehabilitation centers consider the integration of VR/AR technologies into their therapeutic strategies, where feasible and appropriate. This could help to optimize patient recovery by addressing both physical and cognitive aspects of rehabilitation, thereby leading to improved overall quality of life for patients.

The positive outcomes observed also underscore the importance of continued research into VR/AR technologies, their applications in different facets of rehabilitation, and their potential benefits across various patient populations. Further studies are encouraged to assess long-term outcomes and to explore the most effective methods of implementing these technologies in diverse clinical settings.

Lastly, while the study found no significant adverse reactions to VR/AR technologies, it remains crucial to ensure their use is individualized, taking into account each patient's specific condition, abilities, and preferences to ensure both safety and effectiveness.

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