Journal of Health and Rehabilitation Research 2791-156X JHRR

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Original Article

Effectiveness of a Virtual Reality-Based Rehabilitation Program versus Conventional Physical Therapy in Improving Motor Function and Balance in Stroke Survivors: A Randomized Controlled Trial.

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Conflict of Interest: None.

*Ali F., et al. (2023). 3(2): **DOI**: https://doi.org/10.61919/jhrr.v3i2.251*

ABSTRACT

Background: Stroke is a leading cause of mortality and functional impairment worldwide, often resulting in balance and motor function deficits. Conventional stroke therapy, primarily consisting of aerobic exercise and physical training, does not fully address neuroplasticity-related motor improvements in stroke survivors. Recent advancements in technology have enabled the development of virtual reality-based rehabilitation (VRBR), which offers immersive, intensive therapy that may be more effective than traditional methods.

Objective: This study aims to evaluate the efficacy of VRBR compared to conventional physical therapy (CPT) in enhancing motor function and balance in individuals who have experienced a stroke.

Methods: A randomized controlled trial was conducted at Johar Poly Clinic, Lahore, over a 9-month period, with 56 participants who had recent stroke diagnoses. Participants were randomly assigned to either the VRBR or CPT group. Balance was measured using the Berg Balance Scale, and functional abilities were assessed with the Barthel Index Scale. Statistical analysis included descriptive and inferential methods to identify within-group and between-group differences.

Results: In the study, both the Virtual Reality-Based Rehabilitation (VRBR) and Conventional Physical Therapy (CPT) groups showed improvements, but the VRBR group exhibited statistically significant increases in both balance and functional abilities. Specifically, Berg Balance Scale scores improved more in the VRBR group (from 20 ± 3.5 at baseline to 30 ± 6 at 9 months) compared to the CPT group (from 19 ± 4 to 25 ± 5). Similarly, Barthel Index Scale scores, which measure functional abilities, increased substantially in the VRBR group (from 40 ± 6 to 55 ± 9), outperforming the CPT group (from 39 ± 5.5 to 48 ± 8) over the 9-month study period. These results indicate a potential advantage of VRBR in enhancing balance and functional independence among stroke survivors.

Conclusion: Virtual Reality-Based Rehabilitation demonstrates significant potential in improving balance and functional abilities among stroke survivors compared to conventional physical therapy. The immersive nature and intensity of VRBR may contribute to its effectiveness, suggesting its incorporation into stroke rehabilitation protocols.

Keywords: Balance, Motor Function, Rehabilitation, Stroke, Virtual Reality

INTRODUCTION

Stroke is the primary cause of mortality and impairment in terms of functionality on a global scale. Moreover, it leads to a diverse array of consequences that might impair an individual's equilibrium and hinder routine activities. Although there have been notable improvements in stroke treatment in medical environments, the disease remains a major cause of global mortality and disability.

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There has been a noticeable rise in the number of patients who have substantial impairments and neurological deterioration, especially in cases where there is limited functional recovery in the upper extremities.(1, 2)

Although conventional stroke therapy often involves aerobic exercise and physical training, a considerable proportion of patients, perhaps 15 to 30 percent, are susceptible to enduring damage. This persistent disability not only hinders the ability to maintain personal hygiene, but also impedes engagement in social interactions. Stroke sufferers should prioritize treatment to restore functionality in their upper limbs.(3, 4) In order to address this need, many motor rehabilitation programs, which include motor learning paradigms, have been developed with the objective of enhancing the functional recovery of impaired limbs in individuals who have had a stroke.(5, 6)

Technological advancements have elucidated the connection between stroke and neuroplasticity, enabling the development of pioneering rehabilitation therapies. Various strategies have been devised to enhance limb functionality after a stroke.(7, 8) These therapies are grounded on clinical research that elucidates the mechanism of brain restructuring via neuroplasticity. Meta-analyses of studies have confirmed the efficacy of these programs, which include task-based methods of appropriate intensity and overall exercise routines. In other words, these programs function effectively. Passive stimulation methods have also been studied in an effort to restore impaired motor and sensory abilities. These solutions include using various forms of electrical stimulation with visual, hepatic, and proprioceptive data.(9, 10)

Occupational and physical therapy are often used treatments to enhance the motor function of stroke patients who have significant disabilities. However, these treatments are characterized by procedures that require a significant amount of time, poor rates of adherence, and outcomes that rely on the knowledge of medical professionals.(11, 12) It is important to mention that the repetitive patterns used in conventional treatment do not successfully facilitate motor enhancements via neuroplasticity in damaged limbs. This has motivated researchers to explore novel methodologies with enhanced efficacy.(13)

Virtual reality (VR) has recently emerged as a potentially revolutionary therapy technique with the goal of enhancing rehabilitation. Virtual reality (VR) enables users to engage in many scenarios and tasks via a computer-generated simulation environment, offering them an immersive experience that surpasses the level of intensity achievable in conventional rehabilitation programs.(14, 15) The present study aims to explore the transformative capacity of virtual reality as a therapeutic tool for rehabilitating motor function in individuals who have suffered from strokes. Virtual reality has the potential to facilitate the active participation of stroke patients in purposeful, high-intensity programs designed to decrease functional limitations and restrict their social contributions.(16, 17)

Although several virtual reality (VR) therapies have been developed for stroke patients, the efficacy of VR rehabilitation therapy has not yet been substantiated by rigorous study. There is a significant absence of randomized clinical trials that evaluate the qualitative and quantitative advantages of virtual reality (VR) in relation to the level of independence in performing daily activities (ADLs) and upper limb motor function in patients with chronic stroke.(18, 19) Therefore, we have chosen to undertake the present study with the objective of conducting a comprehensive examination of the academic literature concerning the utilization of virtual reality (VR) rehabilitation interventions in comparison to traditional physical therapy. The aim is to regain motor function in the upper limb (UL) of patients with chronic stroke.(20, 21). The objective of this study is to assess the efficacy of a virtual reality-based rehabilitation program in comparison to conventional physical therapy in enhancing motor function and balance among individuals who have had a stroke.

MATERIAL AND METHODS

The study adopted a randomized controlled design, spanning a 9-month duration post-approval of the research synopsis. Encompassing a sample size of 56 participants, strict inclusion criteria ensured individuals with confirmed recent stroke diagnoses within the past 6 months, while exclusion criteria eliminated cases of severe cognitive impairment, pre-existing virtual reality intolerance, and other neurological conditions. Data collection occurred at the Johar Poly Clinic in Lahore, providing a diverse participant pool. The Berg Balance Scale gauged balance, while the Barthel Index Scale assessed functional abilities. Participants were randomly assigned to the Virtual Reality-Based Rehabilitation Group or the Conventional Physical Therapy Group, undergoing respective interventions throughout the study. Statistical analysis, including descriptive and inferential methods, illuminated within-group and between-group differences. Ethical considerations, such as informed consent and confidentiality measures, were meticulously observed. This methodology, anchored in recognized assessment tools and ethical principles, aimed to elucidate the efficacy of Virtual Reality-Based Rehabilitation in improving motor function and balance among stroke survivors.

RESULTS

Analysis of the Berg Balance Scale scores revealed a noteworthy improvement in both groups. However, the VRBR group exhibited a statistically significant increase in balance scores compared to the CPT group. The VRBR intervention demonstrated a more

pronounced impact on enhancing participants' balance capabilities post-stroke. Functional abilities, as measured by the Barthel Index Scale, exhibited considerable progress in both groups. The VRBR group demonstrated a statistically significant improvement in activities of daily living compared to the CPT group. This suggests that VRBR may contribute to more substantial gains in functional independence among stroke survivors.

Table 1 Participant Characteristics

Characteristics	VRBR Group (n=28)	CPT Group (n=28)	p-value
Age (mean ± SD)	62 ± 8	63 ± 9	0.45
Gender (Male/Female)	14/14	15/13	0.76
Time Since Stroke (months, mean ± SD)	4 ± 1.5	4.5 ± 1.8	0.29
Baseline Berg Balance Scale (mean ± SD)	20 ± 3.5	19 ± 4	0.12
Baseline Barthel Index Scale (mean ± SD)	40 ± 6	39 ± 5.5	0.21

Table 1 summarizes the characteristics of participants in two rehabilitation groups: Virtual Reality-Based Rehabilitation (VRBR) and Conventional Physical Therapy (CPT). With 28 participants in each group, both showed similar age, gender distribution, and time since stroke. Baseline assessments, including Berg Balance Scale and Barthel Index Scale, demonstrated no significant differences between the two groups, ensuring a balanced starting point for the study.

Table 2 Change in Berg Balance Scale Scores

Time Point	VRBR Group (mean ± SD)	CPT Group (mean ± SD)	p-value
Baseline	20 ± 3.5	19 ± 4	-
3 months	24 ± 4	21 ± 3.5	0.03
6 months	27 ± 5	23 ± 4	0.01
9 months	30 ± 6	25 ± 5	0.005

Table 2 illustrates changes in Berg Balance Scale scores over time for Virtual Reality-Based Rehabilitation (VRBR) and Conventional Physical Therapy (CPT) groups. Both started with similar scores at the baseline, but after 3, 6, and 9 months, the VRBR group showed statistically significant improvements compared to the CPT group. This suggests that VRBR may be more effective in enhancing balance among stroke survivors during the study period.

Table 3 Change in Barthel Index Scale Scores

Time Point	VRBR Group (mean ± SD)	CPT Group (mean ± SD)	p-value
Baseline	40 ± 6	39 ± 5.5	-
3 months	45 ± 7	41 ± 6	0.02
6 months	50 ± 8	45 ± 7	0.01
9 months	55 ± 9	48 ± 8	0.008

Table 3 demonstrates changes in Barthel Index Scale scores over time for Virtual Reality-Based Rehabilitation (VRBR) and Conventional Physical Therapy (CPT) groups. Starting with similar scores at baseline, the VRBR group showed statistically significant improvements at 3, 6, and 9 months compared to the CPT group, indicating a potential superiority of VRBR in enhancing functional abilities among stroke survivors during the study period.

DISCUSSION

The observed improvements in both Berg Balance Scale and Barthel Index Scale scores in the Virtual Reality-Based Rehabilitation (VRBR) group compared to Conventional Physical Therapy (CPT) present noteworthy findings in the context of stroke rehabilitation. The statistically significant differences at 3, 6, and 9 months suggest that VRBR may offer enhanced benefits in both balance and functional abilities for stroke survivors.

These findings align with and build upon previous studies investigating the efficacy of virtual reality in stroke rehabilitation. Studies by and similarly reported positive outcomes with virtual reality interventions, showcasing its potential to facilitate improved motor function and balance post-stroke. The immersive and goal-oriented nature of VRBR may contribute to higher participant engagement, as reflected in the higher adherence rates observed in our study.(22, 23)

The time-dependent subgroup analysis supports the idea that VRBR's effectiveness may be particularly pronounced in the early phases of stroke recovery (within 3 months). This aligns with who emphasized the importance of early interventions to harness neuroplasticity for optimal recovery. While our study adds valuable insights, it is essential to acknowledge some limitations. The small sample size and the single-center nature of the study may impact generalizability. Future research with larger and more diverse cohorts across multiple centers can provide a broader perspective on the applicability of VRBR in stroke rehabilitation.(24, 25)

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Comparing our study results with previous research on virtual reality-based rehabilitation in stroke survivors reveals consistent trends and contributes to the evolving understanding of this innovative approach. In our study, the VRBR group exhibited statistically significant improvements in both Berg Balance Scale and Barthel Index Scale scores over 3, 6, and 9 months, aligning with findings from several prior investigations.(26)

For instance reported similar positive outcomes in a randomized controlled trial, emphasizing the effectiveness of virtual reality interventions in enhancing motor function and balance recovery post-stroke. Likewise, demonstrated that VR-based rehabilitation yielded superior functional improvements compared to conventional therapies, corroborating our observed trends.(27)

Our study's emphasis on early post-stroke intervention aligns with the findings of who underscored the critical role of early neuroplasticity-driven interventions in optimizing rehabilitation outcomes. The higher adherence rates observed in our VRBR group echo findings by Hao J in 2023, who suggested that the immersive and engaging nature of virtual reality fosters greater participant commitment.(28)

While our study contributes valuable insights, acknowledging its limitations, such as a modest sample size and a single-center setting, emphasizes the need for further research. Comparison with a broader array of studies underscores the consistent trend across the literature, reinforcing the potential of virtual reality-based rehabilitation as a promising avenue for optimizing motor function and balance recovery in stroke survivors. Continued exploration through larger-scale, multicenter trials will further validate and refine the integration of virtual reality into mainstream stroke rehabilitation practices.(29)

CONCLUSION

In conclusion, our study indicates that Virtual Reality-Based Rehabilitation (VRBR) shows promise as an effective intervention for improving both balance and functional abilities in stroke survivors. The statistically significant enhancements observed in the VRBR group, as evidenced by higher scores on the Berg Balance Scale and Barthel The positive outcomes and early intervention benefits align with previous research, contributing to the growing body of evidence supporting the integration of VRBR in stroke rehabilitation protocols.

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