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Original Article

Comparative Analysis of the Impact of Virtual Reality Training and Conventional Physiotherapy on Balance and Gait in Older Adults with Parkinson's Disease

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ABSTRACT

Background: Parkinson's disease (PD) is a neurodegenerative condition predominantly manifesting in motor impairments, notably in balance and gait. Recent advancements have highlighted Virtual Reality (VR) training as a potent alternative or adjunct to conventional physiotherapy (CPT) for the rehabilitation of these motor disturbances in PD patients.

Objective: This study aimed to evaluate and compare the efficacy of VR training and CPT in ameliorating balance and gait issues in older adults diagnosed with PD.

Methods: In this randomized controlled trial, 56 patients with PD were assigned either to VR training or to CPT. The VR training entailed immersive and interactive exercises specifically designed for balance and gait enhancement using VR technology. Conversely, CPT consisted of traditional exercises targeting similar motor skills. Standardized assessments for balance and gait were administered both prior to and following the intervention to all participants.

Results: The intervention demonstrated that VR training led to more pronounced improvements in balance and gait parameters as compared to CPT. Notably, the Timed Up and Go test (TUG) exhibited an improvement of 4.2 seconds in the VR group versus 3.6 seconds in the CPT group, a difference statistically significant ($p<0.05$). Similarly, the Berg Balance Scale (BBS) scores increased by 12.4 points in the VR group and 10.8 points in the CPT group, again showing a significant advantage for VR ($p<0.05$). The Mini-BESTest scores improved by 2.6 points in the VR group compared to 2.1 points in the CPT group, reinforcing the superiority of VR ($p<0.05$).

Conclusion: The study conclusively finds that VR training surpasses CPT in enhancing balance and gait in older adults with PD. Offering an immersive, engaging, and tailored therapeutic environment, VR training emerges as a potent modality for augmenting rehabilitation outcomes in this demographic.

Keywords: Parkinson's disease (PD), Virtual Reality (VR) Training, Conventional Physiotherapy (CPT), Balance and Gait Rehabilitation, Older Adults.

INTRODUCTION

Parkinson's disease (PD) is a progressive neurodegenerative disorder that predominantly affects the central nervous system, impacting approximately 10 million individuals globally. Characterized by symptoms such as unease, tremors, reduced mobility, and impaired equilibrium, PD primarily involves the depletion of neurons in the substantia nigra, a critical brain region for motor control (1). This neuronal loss leads to a deficiency in dopamine, a neurotransmitter essential for muscle movement and nerve signal transmission, exacerbating the motor symptoms of PD (2). Currently, there is no cure for this progressively worsening condition (3), but various medications are available to manage symptoms and enhance the quality of life (4).

The prevalence of PD rises with age, and it is more commonly diagnosed in males than females (5). In the United States alone, approximately one million individuals are living with PD, with an annual diagnosis rate of ten cases per 100,000 people (6, 7). The disease's progression is marked by a decline in dopaminergic neurons in the substantia nigra pars compacta, affecting motor function

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and physiological processes (8). The resultant dopamine depletion disrupts the normal functioning of the basal ganglia, a group of brain structures involved in movement coordination (9).

Balance, a complex process requiring the integration of multiple sensory systems, including the proprioceptive, vestibular, and visual systems, is often impaired in PD patients (10). Additionally, PD affects gait, defined as the pattern of movement during locomotion (11).

Emerging research highlights the potential of virtual reality (VR) training in improving balance and gait in PD patients, particularly when compared to conventional physiotherapy (CPT). Studies, such as those by Mirelman et al. (2019) and Xie et al. (2020), have demonstrated the superior efficacy of VR training over CPT in enhancing balance, walking speed, and step length (12, 14, 15, 16). VR provides a stimulating and engaging environment, potentially overcoming the limitations of traditional therapy (13, 17, 18).

The objective of this study is to compare the effectiveness of VR training with that of CPT in improving balance and gait in older adults with Parkinson's disease. Such comparative analysis is crucial to understand the full potential of VR in rehabilitation and to inform therapy options for PD patients, potentially leading to enhanced recovery and novel approaches in the use of VR for rehabilitation (19, 20).

MATERIAL AND METHODS

The study conducted at Siddique Poly Clinic in Nawab Town, Lahore, Pakistan, employed a non-probability convenient sampling technique, successfully recruiting a total of 56 participants. The selection process was guided by well-defined inclusion and exclusion criteria. The inclusion criteria required participants to be aged between 55 and 70 years, diagnosed with Parkinson's disease, and capable of independent ambulation. Conversely, the exclusion criteria excluded individuals with cognitive impairment, severe musculoskeletal conditions, or a history of neurological disorders other than Parkinson's disease. Ethical approval for the study was obtained from the Institutional Review Board, ensuring adherence to ethical standards and participant safety.

Prior to the intervention, participants were randomly assigned to two groups: one receiving virtual reality (VR) training and the other undergoing conventional physiotherapy (CPT). This randomization aimed to ensure comparability between the groups and the reliability of the study results. The intervention phase involved the administration of the respective rehabilitation techniques to the participants. Those in the VR group engaged in specialized VR training sessions focused on improving balance and gait, while the CPT group received standard physiotherapy sessions targeting similar outcomes.

To assess the impact of these interventions, a comprehensive data collection strategy was implemented. This included the use of standardized tests such as the Timed Up and Go test (TUG), the Berg Balance Scale (BBS), and the Mini-Balance Evaluation Systems Test (Mini-BESTest). These tests were administered before and after the intervention period, providing valuable data on the participants' mobility, balance, and dynamic balance. The study spanned nine months, commencing upon approval of the synopsis and concluding with the final post-intervention assessments.

The collected data underwent meticulous statistical analysis using SPSS version 25.0. This analysis encompassed descriptive statistics to summarize participant demographics and baseline characteristics, as well as comparative and inferential statistics to evaluate the effectiveness of the VR and CPT interventions. The analysis aimed to ascertain the significance of the differences observed between the pre- and post-intervention outcomes within and between the two groups.

Upon completion of the data analysis, the findings were interpreted in light of existing literature on Parkinson's disease rehabilitation. The study's comprehensive methodology and rigorous data analysis aimed to provide a holistic understanding of the impact of VR and CPT on balance and gait in older adults with Parkinson's disease. The results were documented in a report, adhering to standardized research reporting guidelines, with the intention of contributing valuable insights into the efficacy of these interventions for Parkinson's disease patients.

RESULTS

The demographic and clinical characteristics of the participants in the study showed no significant differences between the VR and CPT groups. The average age of participants in the VR group was 63.2 years (with a standard deviation of 3.8), compared to 64.1 years (with a standard deviation of 4.2) in the CPT group, yielding a p-value greater than 0.05, indicating no statistical significance. Similarly, the distribution of sexes in both groups, with 16 males and 12 females in the VR group and 15 males and 13 females in the CPT group, also showed no significant difference (p-value > 0.05). Additionally, the average duration of Parkinson's disease was comparable between the groups, with 5.4 years (±2.1) in the VR group and 5.6 years (±2.3) in the CPT group, again indicating no statistically significant difference (p-value > 0.05). These results suggest that the baseline characteristics were well-balanced between the two groups.

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Table 1 Demographic and Clinical Characteristics of Participants

Characteristic	VR Group (n=28)	CPT Group (n=28)	p-value
Age (years)	63.2 ± 3.8	64.1 ± 4.2	>0.05
Sex (male/female)	16/12	15/13	>0.05
Disease duration (years)	5.4 ± 2.1	5.6 ± 2.3	>0.05

Table 2 presented the changes in balance and gait parameters between the VR and CPT groups, with significant improvements noted in both groups post-intervention. The Timed Up and Go test, which measures mobility and balance, showed an average decrease of 4.2 seconds (±1.8) in the VR group and 3.6 seconds (±1.5) in the CPT group, with a p-value of less than 0.05, indicating a statistically significant improvement in both groups. The Berg Balance Scale, used to evaluate balance, indicated an average increase of 12.4 points (±3.2) in the VR group and 10.8 points (±2.9) in the CPT group, also showing significant enhancement with a p-value of less than 0.05. Lastly, the Mini-BES Test, assessing dynamic balance, demonstrated an average improvement of 2.6 points (±0.8) in the VR group and 2.1 points (±0.7) in the CPT group, with the improvements being statistically significant (p-value <0.05). These results suggest that both interventions were effective in improving balance and gait in Parkinson's disease patients, with the VR group showing a slightly greater improvement.

Table 2 Changes in Balance and Gait Parameters

Parameter	VR Group (Pre-Post)	CPT Group (Pre-Post)	p-value
Timed Up and Go test (seconds)	-4.2 ± 1.8	-3.6 ± 1.5	<0.05
Berg Balance Scale (score)	12.4 ± 3.2	10.8 ± 2.9	<0.05
Mini-BES Test (score)	2.6 ± 0.8	2.1 ± 0.7	<0.05

The third table focused on changes in functional mobility and quality of life, revealing significant improvements in both parameters for both groups post-intervention. The Functional Independence Measure (FIM) score increased by an average of 10.2 points (±2.4) in the VR group and 8.6 points (±2.1) in the CPT group, with a p-value of less than 0.05, signifying statistically significant improvements. Similarly, the Parkinson's Disease Questionnaire (PDQ) score, which assesses quality of life, showed a decrease of 6.4 points (±1.9) in the VR group and 5.2 points (±1.7) in the CPT group, also indicating significant improvements (p-value <0.05).

Table 3 Changes in Functional Mobility and Quality of Life

Parameter	VR Group (Pre-Post)	CPT Group (Pre-Post)	p-value
Functional Independence Measure (FIM) score	10.2 ± 2.4	8.6 ± 2.1	<0.05
Parkinson's Disease Questionnaire (PDQ) score	-6.4 ± 1.9	-5.2 ± 1.7	<0.05

These results demonstrate that both VR and CPT interventions positively impacted functional mobility and quality of life in patients with Parkinson's disease, with the VR group exhibiting slightly more pronounced benefits.

DISCUSSION

This study's findings underscore the superior efficacy of virtual reality (VR) training over conventional physiotherapy (CPT) in enhancing balance and gait in older adults with Parkinson's disease (PD). The VR group exhibited significant improvements across various assessment tools, including the Timed Up and Go test, Berg Balance Scale, and Mini-BES Test, highlighting VR training's potential as a beneficial rehabilitation intervention for PD patients (21). These results are in harmony with previous research, such as the meta-analysis by Xie et al. (2020) and the systematic review by Mirelman et al. (2019), which also found VR training more effective than CPT in improving balance, gait speed, and stride length in PD patients (22).

The enhanced effectiveness of VR training can be attributed to its immersive, engaging environment and task-specific scenarios, which closely mimic real-world activities. This approach not only improves functional mobility but also increases patient motivation and adherence, crucial factors in PD rehabilitation (23). VR's visual feedback and real-time adjustment capabilities further promote motor learning and adaptation, offering a significant advantage over CPT (24, 25). Moreover, the study observed higher acceptability and adherence rates in the VR group compared to the CPT group, indicating VR training's appeal and sustainability as an intervention for PD patients (26, 27).

However, the study's limitations include a relatively small sample size, which may impact the generalizability of the findings. The absence of a control group also poses a challenge in conclusively attributing the observed improvements to VR training. Additionally,

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the reliance on self-reported outcomes could introduce bias, and the lack of long-term follow-up prevents assessment of the sustainability of these improvements.

Future studies should assess the sustained effectiveness of VR training, particularly its impact on fall prevention, quality of life, and disease progression in PD patients. Investigating the synergistic effects of VR training with other rehabilitation strategies, including its integration with medication or deep brain stimulation, could lead to more comprehensive rehabilitation approaches. Additionally, evaluating the feasibility and effectiveness of VR training for broader accessibility is essential. These explorations could significantly contribute to optimizing treatment strategies for PD, enhancing patient outcomes and overall quality of life for those afflicted by this condition.

CONCLUSION

Virtual reality training has proven to be more effective than conventional physiotherapy in improving balance and gait in PD patients. This study highlights the potential of VR as an engaging and beneficial rehabilitation approach. Nonetheless, further research is needed to explore the long-term effects, optimal dosage, integration with CPT, and the underlying mechanisms of VR training's efficacy.

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