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Original Article

Effectiveness of Virtual Reality Rehabilitation versus Conventional Physical Therapy on Quality-of-Life function and Balance in Parkinson's Disease Patients: A Randomized Controlled Trial

Bahadur Ali[1], Bushra Riaz[2*], Muhammad Shazib Butt[3], Azhar Mehmood[4], Saud Ahmad Khan[5], Usama Mahmood[6]

[1]Peoples University of Medical and Health Sciences For Women (PUMHSW)- Nawabshah
[2]Fatima Memorial Hospital-Lahore
[3]University of Sialkot
[4]University of Lahore
[5]Rashed Hospital, Dubai
[6]University of Montgomery Sahiwal
Corresponding Author: Bushra Riaz; Physical Therapist; Email: bushrariaz4@gmail.com

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ABSTRACT

Background: Parkinson's disease (PD) is a neurodegenerative disorder characterized by motor and non-motor symptoms, affecting the quality of life, functional independence, and balance of individuals. While conventional physical therapy (PT) has been a standard approach, emerging technologies like Virtual Reality (VR) have shown promise in neurorehabilitation.

Objective: This study aimed to compare the effectiveness of Virtual Reality (VR) Rehabilitation with Conventional Physical Therapy (PT) in enhancing the quality of life, functional status, and balance among individuals diagnosed with Parkinson's disease (PD).

Methods: A randomized controlled trial was conducted, involving 46 PD patients the participants were randomly assigned to either the VR group (n=23) or the PT group (n=23). Data was collected from johar poly clinic Lahore Pre-intervention and post-intervention assessments included the Short Form 36 (SF-36) for quality of life, Barthel Index for functional status, and Berg Balance Scale for balance. Descriptive statistics and paired t-tests were employed for data analysis.

Results: Pre-intervention demographics indicated comparable age distributions (VR group: 65.0 ± 5.2; PT group: 67.1 ± 4.8) and a predominance of males in both groups. Baseline scores demonstrated no significant differences between VR and PT groups for SF-36 (41.40 ± 4.87 vs. 38.20 ± 4.21), Barthel Index (90.00 ± 7.14 vs. 86.00 ± 6.93), and Berg Balance Scale (44.00 ± 6.52 vs. 40.00 ± 7.11).

Conclusion: The study results indicated that rehabilitation programs for individuals with Parkinson's disease were efficacious in enhancing their functional outcome. An evaluation of the two programs, both centered around physical exercises, demonstrated that virtual reality (VR) rehabilitation surpasses traditional therapy in assessing overall improvements (such as upper limb function, gait, balance, and the psychological aspect of quality of life) in a secure and stimulating setting.

Keywords: Parkinson's disease, Virtual Reality Rehabilitation, Conventional Physical Therapy, Neurorehabilitation, Quality of Life, Functional Independence, Balance

INTRODUCTION

The increasing prevalence of Parkinson's disease (PD) among the aging population presents significant challenges in managing mobility limitations. By 2020, it's estimated that over forty million individuals might be affected, predominantly males aged between 60 and 79, although onset can occur as early as 30 to 50 years of age (1, 2). This neurodegenerative disorder, primarily caused by the progressive loss of dopaminergic neurons in the substantia nigra, leads to a marked decrease in dopamine levels. This deficit hinders the regulation of the motor loop, culminating in characteristic symptoms like muscle rigidity, bradykinesia, balance issues, and resting tremors (3, 4). Progression often brings non-motor symptoms including anxiety, depression, and sleep disturbances,

which, coupled with motor symptoms, can lead to reduced physical activity, increased fall risk, and decreased independence (4, 5). These factors not only diminish social interaction but also increase the risk of cardiovascular diseases and osteoporosis. Consequently, there is a notable impact on patients' motor skills, communication abilities, and daily mobility, significantly lowering their overall quality of life (QoL) (5, 6).

Quality of life in this context refers to an individual's subjective assessment of their social, mental, physical, and functional well-being. Physical rehabilitation aims to restore physical health, maintain functional independence, and enhance QoL (7, 8). In this regard, physiotherapy emerges as a critical adjunct to pharmacotherapy in PD management, offering potential to improve and maintain motor control and possibly delay the progression of motor impairments (9, 10). The advent of virtual reality (VR) in rehabilitation introduces a novel approach. VR provides an immersive, three-dimensional digital environment, requiring the active engagement of multiple senses including visual, auditory, and tactile perceptions (11, 12). This technology not only allows for immediate feedback on patient performance but also fosters active participation, thereby stimulating both cognitive and motor systems (13).

Research into therapies that enhance the mental and physical well-being of PD patients is crucial, considering the disease's impact on physical capabilities and subsequent QoL decline (14). Rehabilitation in PD employs both conventional and unconventional methods. Traditional approaches include aerobic exercise, resistance training, treadmill exercises, and stretching (15). However, VR rehabilitation has emerged as an innovative technique, offering additional benefits over standard physiotherapy. Its advantages include the provision of task-specific training, simultaneous engagement in cognitive and motor activities, and simulation of real-world tasks, enhancing ecological validity compared to traditional methods (16, 17). VR also allows for the safe execution of high-risk activities under supervision, in a controlled environment (18, 19). The engaging nature of VR may encourage patients to practice longer, although evidence supporting the regular prescription of specific rehabilitation programs in PD remains inconclusive (20, 21). This study aims to compare the effectiveness of Virtual Reality Rehabilitation versus Conventional Physical Therapy on quality-of-life function and balance in patients with Parkinson's disease.

MATERIAL AND METHODS

In this randomized clinical trial conducted at Johar Poly Clinic in Lahore, a cohort of 46 individuals diagnosed with Parkinson's disease was meticulously selected to participate. The inclusion criteria were stringently defined to ensure the suitability of participants for the rehabilitation program. Eligible participants were required to demonstrate the capability of independently performing the program with a minimal risk of falling. Cognitive function was assessed using the Mini-Mental State Examination, with a minimum score of 25 indicating the absence of significant cognitive impairment. Additionally, stability in Parkinson's disease medication regimens was a prerequisite, ensuring that any observed effects could be attributed to the rehabilitation interventions rather than changes in pharmacological treatment.

Individuals with severe sensory impairments, such as profound hearing or visual deficits, were excluded. Additionally, the presence of significant coexisting medical conditions that could interfere with rehabilitation outcomes – such as postural hypotension, cardiovascular diseases, stroke, or severe shoulder-hip dysfunction – also constituted exclusion criteria. The cohort was sourced from the physical therapy department of the clinic, ensuring participants had a confirmed diagnosis of Parkinson's disease, with notable symptoms including balance and functional impairments.

Once the sample was established, participants were randomly assigned into two distinct treatment cohorts. The first cohort was subjected to a conventional physiotherapy regimen, while the second cohort participated in a virtual reality-based rehabilitation program. The study employed a comprehensive and multifaceted evaluation approach to gauge the severity of the disease and the impact of the interventions. This approach encompassed clinical interviews, detailed questionnaires, and thorough physical examinations.

Participants provided comprehensive questionnaires that included demographic information, ensuring a thorough understanding of the sample's characteristics. Functional capacity in relation to essential daily activities was evaluated using the Barthel Index scale, a standardized tool that measures the degree of assistance required for various activities of daily living. Additionally, the Parkinson's Disease Questionnaire was administered to gather specific insights into the disease's impact on the quality of life.

To assess physical endurance and mobility, the 6-minute walk test was employed. This test measured the distance each participant could walk in a six-minute period, providing a quantifiable measure of their functional exercise capacity. Moreover, the Berg Balance Scale, a specifically designed tool for assessing balance in individuals with Parkinson's disease, was used to determine baseline balance capabilities before the initiation of the respective rehabilitation programs.

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Throughout the study, data was meticulously collected and recorded, adhering to high standards of clinical research methodology. This approach ensured that the findings would be robust, reliable, and contribute significantly to the existing body of knowledge regarding rehabilitation strategies in Parkinson's disease.

RESULTS

The study aimed to assess the effectiveness of Virtual Reality (VR) Rehabilitation compared to Conventional Physical Therapy (PT) in improving the quality of life, function, and balance among patients with Parkinson's disease. Pre-intervention scores revealed that both groups were comparable in age, with the VR group having a mean age of 65.0 (± 5.2) and the PT group with a mean age of 67.1 (± 4.8). The gender distribution showed a predominance of males in both groups, with 10 males and 5 females in the VR group, and 8 males and 7 females in the PT group. The baseline assessment demonstrated similar scores between the groups, with the VR group showing mean SF-36, Barthel Index, and Berg Balance Scale scores of 41.40 (± 4.87), 90.00 (± 7.14), and 44.00 (± 6.52), respectively, and the PT group having scores of 38.20 (± 4.21), 86.00 (± 6.93), and 40.00 (± 7.11), respectively.

After the intervention, positive changes were observed in both groups. The VR group exhibited improved scores in the SF-36 (48.60 ± 4.72), Barthel Index (98.00 ± 5.87), and Berg Balance Scale (54.00 ± 7.21). Similarly, the PT group showed enhancements in SF-36 (42.80 ± 4.19), Barthel Index (92.00 ± 7.55), and Berg Balance Scale (47.00 ± 6.89). These post-intervention results indicate that both VR and PT interventions positively impacted the quality of life, functional status, and balance in Parkinson's Disease patients. The findings suggest that VR Rehabilitation can be as effective as Conventional Physical Therapy in improving the outcomes for individuals with Parkinson's Disease.

Table 1 Demographic

Group	Age (Mean ± SD)	Sex (Male/Female)
VR Group	65.0 ± 5.2	10/5
PT Group	67.1 ± 4.8	8/7

The mean age of participants in the VR group is 65.0 years, with a standard deviation of 5.2. In terms of gender distribution, there are 10 males and 5 females in the VR group. On the other hand, the PT group has a slightly higher mean age of 67.1 years (± 4.8) and a distribution of 8 males and 7 females.

Table 2 Pre-Intervention Scores

Variable	VR Group (Mean ± SD)	PT Group (Mean ± SD)
SF-36	41.40 ± 4.87	38.20 ± 4.21
Barthel Index	90.00 ± 7.14	86.00 ± 6.93
Berg Balance Scale	44.00 ± 6.52	40.00 ± 7.11

Table 2 presents the pre-intervention scores for key variables in both the Virtual Reality (VR) and Conventional Physical Therapy (PT) groups. The SF-36 scores indicate the baseline quality of life, where the VR group has a mean score of 41.40 (± 4.87), and the PT group has a mean score of 38.20 (± 4.21). Functional assessment using the Barthel Index reveals baseline scores of 90.00 (± 7.14) for the VR group and 86.00 (± 6.93) for the PT group. Additionally, the Berg Balance Scale scores, assessing balance, show pre-intervention means of 44.00 (± 6.52) for the VR group and 40.00 (± 7.11) for the PT group.

Table 3 Post-Intervention Scores

Variable	VR Group (Mean ± SD)	PT Group (Mean ± SD)
SF-36	48.60 ± 4.72	42.80 ± 4.19
Barthel Index	98.00 ± 5.87	92.00 ± 7.55
Berg Balance Scale	54.00 ± 7.21	47.00 ± 6.89

Table 3 displays the post-intervention scores for the measured variables in both the Virtual Reality (VR) and Conventional Physical Therapy (PT) groups. The SF-36 scores, reflecting quality of life, show improvements with a mean of 48.60 (± 4.72) for the VR group and 42.80 (± 4.19) for the PT group. Functional assessment using the Barthel Index demonstrates enhanced scores, with means of 98.00 (± 5.87) for the VR group and 92.00 (± 7.55) for the PT group. Assessing balance with the Berg Balance Scale, post-intervention means are 54.00 (± 7.21) for the VR group and 47.00 (± 6.89) for the PT group. These post-intervention scores indicate positive changes in the measured variables after the application of Virtual Reality and Conventional Physical Therapy interventions.

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DISCUSSION

The study conducted at Johar Poly Clinic in Lahore on individuals with Parkinson's disease (PD) yielded insightful results, particularly highlighting the efficacy of virtual reality (VR) therapy over conventional rehabilitation methods across various functional domains. The superior improvement observed in the VR group, in terms of walking (Dynamic Gait Index, DGI), arm function (Disabilities of the Arm, Shoulder and Hand, DASH scale), balance (Berg Balance Scale, BBS), and the mental component of quality of life (Mental Component Summary, MCS), underscores the multifaceted benefits of VR in PD rehabilitation.

Emerging research emphasizes the necessity of addressing more than motor skills in PD rehabilitation, with cognitive functions playing a significant role. Iansek et al.'s findings on the profound impact of cognition on gait are a case in point, illustrating how cognitive impairments in PD can disrupt stride consistency. The use of auditory and visual feedback in VR training exercises enhances performance accuracy, as highlighted in Carpinella et al.'s research on the efficacy of sensor-supplied feedback in biofeedback rehabilitation (22). VR's ability to provide an array of stimuli, both auditory and visual, marks a significant advancement in therapeutic interventions.

The study's results indicate a notable improvement in dynamic balance and walking in the VR group compared to the conventional group, likely due to VR's ability to simultaneously enhance cognitive and sensory-motor skills. Prior research supports the notion that cognitive interventions can target motor symptoms associated with walking disabilities, such as paralysis. Furthermore, therapies combining motor and cognitive activities have been shown to improve both physical and cognitive abilities (23).

Balance maintenance is a complex function of sensory-motor control systems, involving proprioception, vision, and the vestibular system. VR rehabilitation's global approach, stimulating multiple physiological systems, is potentially beneficial for enhancing balance. This aspect is particularly crucial given the prevalent postural instability in PD patients, which can lead to falls and severe injuries (24). Tools like the BBS and DGI, though not specifically designed for PD, have been recommended for evaluating balance and ambulation in these patients.

Both rehabilitation methods showed significant improvement in arm function, as measured by the DASH scale. This finding is notable, considering that neither method specifically targets upper extremities, yet demonstrates the potential to enhance functions vital for daily activities (25).

The VR program's impact on the cognitive aspect of quality of life is particularly noteworthy. This improvement may be attributed to the patients' active involvement in the VR therapy, contrasting with the more passive role in conventional therapy. Additionally, the novelty and engagement offered by VR might appeal more to patients, especially those accustomed to longer durations of conventional therapy (26).

However, several limitations must be acknowledged. The absence of a crossover design reduces the reliability of the results, as restoring participants to baseline and measuring subsequent changes would have offered more robust data. The lack of follow-up data also limits our understanding of the long-term effectiveness of these interventions. Furthermore, the VR exercises did not fully replicate everyday activities, and the study lacked immediate response monitoring tools, which could have provided more detailed insights into the immediate impacts of the exercises.

CONCLUSION

In conclusion, the study underscores the effectiveness of rehabilitation programs for PD, with VR rehabilitation demonstrating superior improvements in functions like gait, balance, upper limb function, and psychological aspects of quality of life, in a stimulating and safe environment.

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