INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

VIRTUAL REALITY REHABILITATION VERSUS TASK-ORIENTED TRAINING FOR IMPROVING DYNAMIC BALANCE AND GAIT AMONG PARKINSON'S DISEASE PATIENTS

Original Research

Suneeta Tariq[1], Anum Kabir[2], Hifza Riaz[3]*, Hafiz Muddassir Riaz[4], Bisma Riaz[5], Syed Nasir Ali Shah[6], Aimon Rizwan[7]
[1]DPT, MS-Sports Physical Therapy, Lecturer, CECOS University of IT and Emerging Sciences, Peshawar, Pakistan.
[2]DPT, University of Azad Jammu and Kashmir, Pakistan.
[3]DPT (UHS), MS NMPT (RIU), Riphah International University, Gulberg Campus, Lahore, Pakistan.
[4]Ph.D. Rehabilitation Sciences, Lecturer, Department of Physical Therapy, University of Health Sciences, Lahore, Pakistan; Department of Physical Therapy, The Superior University, Lahore, Pakistan.
[5]DPT, Govt. College University Faisalabad (GCUF), Pakistan.
[6]BSPT, TDPT/M.PHIL, Principal / HOD Physiotherapy, The Sahara College, Narowal, Pakistan.
[7]DPT, MS-PT, Ghurki Trust and Teaching Hospital, Pakistan.
Corresponding Author: Hifza Riaz, DPT (UHS), MS NMPT (RIU), Riphah International University, Gulberg Campus, Lahore, Pakistan, hifzariaz118@gmail.com.
Acknowledgement: The authors sincerely thank all participants and staff involved in this study for their valuable contributions and support.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Gait and balance impairments are prominent issues in patients with Parkinson's disease (PD), significantly affecting their mobility and quality of life. Innovative therapeutic modalities, including virtual reality (VR) rehabilitation and task-oriented training (TOT), have been reported to enhance motor function in PD patients by improving dynamic balance and gait performance. However, limited evidence exists comparing the efficacy of these interventions, necessitating further investigation.

Objective: o compare the effects of virtual reality rehabilitation and task-oriented training on dynamic balance and gait performance among patients with Parkinson's disease.

Methods: A comparative randomized controlled trial was conducted at Allied Hospital, Civil Hospital Faisalabad, and Moeen Physiotherapy Clinic. A total of 28 patients diagnosed with PD (Hoehn and Yahr stages 2–3), aged 50–70 years, were randomly assigned to Group A (VR rehabilitation) or Group B (TOT). Patients with severe dementia or other neurological abnormalities were excluded. Group A received VR-based training sessions, while Group B underwent task-oriented exercises, with both interventions delivered thrice weekly for eight weeks. Outcomes were assessed using the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and Functional Gait Assessment (FGA). Statistical analysis was performed using SPSS version 21, with paired and independent t-tests applied for within- and between-group comparisons.

Results: Group A demonstrated greater improvements across all outcomes. BBS scores increased from 42.6 ± 3.2 to 48.9 ± 2.9 in Group A compared to 42.9 ± 3.3 to 46.3 ± 3.0 in Group B ($p=0.03$). FGA scores improved from 18.8 ± 2.4 to 23.3 ± 2.1 in Group A versus 19.0 ± 2.6 to 21.7 ± 2.4 in Group B ($p=0.04$). TUG times decreased from 14.3 ± 1.7 to 12.0 ± 1.4 seconds in Group A and 14.5 ± 2.0 to 12.9 ± 1.6 seconds in Group B ($p=0.02$).

Conclusion: Both interventions significantly improved balance and gait in Parkinson's patients. However, VR rehabilitation demonstrated superior efficacy, emphasizing its potential as a more effective therapeutic modality.

Keywords: Balance, Gait, Parkinson Disease, Rehabilitation, Task-Oriented Training, Virtual Reality Rehabilitation.

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disorder characterized by dysfunction in the cerebral basal ganglia, resulting in impairments in motor control, postural stability, and overall mobility. These symptoms significantly diminish the quality of life for patients and present challenges in daily activities. A common and particularly debilitating motor symptom of Parkinson's disease is freezing of gait (FOG), which often manifests in the later stages of the condition. FOG restricts forward movement despite the patient's efforts to walk, increasing the risk of falls and complicating care requirements (1, 2). Current pharmacological interventions for Parkinson's disease have limited effectiveness in addressing FOG, highlighting the need for complementary therapeutic strategies. Physical therapy has shown potential in improving motor function, offering a non-pharmacological approach to managing gait and balance issues in individuals with PD (3). Among emerging therapeutic modalities, virtual reality (VR) has gained significant attention. By providing visual, auditory, and somatosensory cues, VR-based interventions aim to enhance motor function and improve gait performance in patients with Parkinson's disease (4). This innovative technology allows patients to interact with artificial environments while enabling clinicians to monitor progress in real time. VR's external stimulation can improve gait speed and motor performance through neuroplastic adaptations (5). However, the current body of evidence on the efficacy of VR in addressing motor dysfunction in Parkinson's disease remains limited and calls for further investigation (6).

The rapid advancements in artificial intelligence and rehabilitative medicine have expanded the scope of therapeutic interventions. Wearable sensors, for instance, have been shown to objectively detect balancing exercises in PD patients, while VR systems provide immersive environments with real-time feedback to facilitate motor learning and neuroplasticity (7). These features position VR as a promising adjunct to conventional rehabilitation methods, offering an engaging alternative that compensates for sensory deficits and promotes functional recovery (8). Recent studies have explored the use of VR-based "exergaming," demonstrating improvements in balance and functional mobility among older adults and individuals with Parkinson's disease (9). However, many of these studies are observational, involve short intervention durations, and lack robust clinical evidence. Task-oriented training (TOT) is another well-established rehabilitation approach that emphasizes repetitive practice of functional tasks relevant to daily living. Rooted in motor learning theory, TOT involves exercises such as obstacle navigation, sit-to-stand transfers, and adaptive ambulation. Through consistent practice, patients develop motor skills and neural adaptations that enhance coordination and functional performance (10-12). TOT tasks are designed to mimic real-world challenges, with incremental complexity to promote skill acquisition and environmental adaptability (13, 14). Despite its established benefits, the comparative effectiveness of TOT versus VR-based rehabilitation in improving dynamic balance and gait among Parkinson's disease patients remains underexplored.

The objective of this study is to evaluate and compare the efficacy of an eight-week virtual reality-based training program and task-oriented training in improving dynamic balance and gait among individuals with Parkinson's disease. This investigation aims to address critical gaps in the existing literature, providing evidence-based insights to guide clinical decision-making and optimize therapeutic strategies for Parkinson's rehabilitation.

METHODS

The study employed a comparative randomized controlled trial (RCT) design to evaluate the efficacy of virtual reality-based training (VR) and task-oriented training (TOT) in improving dynamic balance and gait performance among patients with Parkinson's disease. A simple random sampling technique was used to recruit participants from Allied Hospital, Civil Hospital Faisalabad, and Moeen Physiotherapy Clinic. The inclusion criteria encompassed individuals aged 50–70 years diagnosed with Parkinson's disease at Hoehn and Yahr stages 2–3, exhibiting gait and balance impairments but capable of walking independently with or without assistive devices. Exclusion criteria included individuals with severe dementia, neurological or musculoskeletal abnormalities, or those who had undergone recent surgery. The calculated sample size was 28 participants, each group (VR and TOT) was having 14 participants.

Group A underwent VR-based sessions, which incorporated immersive and interactive virtual environments to provide visual, auditory, and somatosensory cues aimed at improving motor performance. Each session lasted 45 minutes and was conducted three times per week for eight weeks. Group B engaged in task-oriented training, focusing on functional activities such as stepping over obstacles, gait

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

training, and balance exercises. The duration and frequency of sessions were identical to those of the VR group to maintain consistency. Dynamic balance was assessed using the Berg Balance Scale (BBS) and the Timed Up and Go Test (TUG), while gait performance was evaluated using the Functional Gait Assessment (FGA). Baseline assessments were conducted prior to the intervention, followed by post-intervention evaluations after eight weeks to measure the effectiveness of each training approach. Ethical considerations were adhered to throughout the study. Approval was obtained from the relevant Institutional Review Board (IRB) or ethical committee, and all participants provided informed consent before their inclusion in the study. The study was conducted from February 2023 to October 2023.

Statistical analysis was performed using SPSS version 21. Paired t-tests were employed for within-group comparisons, while independent t-tests were used for between-group analyses. The results were interpreted to determine the relative effectiveness of VR and TOT in improving dynamic balance and gait performance in Parkinson's disease patients.

RESULTS

The study included a total of 28 participants, evenly distributed between Group A (VR-based training) and Group B (task-oriented training), with 14 participants in each group. The demographic characteristics of both groups were comparable, as indicated by non-significant differences in age (Group A: 61.4 ± 6.2 years; Group B: 60.7 ± 5.8 years, p=0.78), gender distribution (Group A: 9 males, 5 females; Group B: 8 males, 6 females, p=0.72), baseline Berg Balance Scale (BBS) scores (Group A: 42.6 ± 3.2; Group B: 42.9 ± 3.3, p=0.81), baseline Functional Gait Assessment (FGA) scores (Group A: 18.8 ± 2.4; Group B: 19.0 ± 2.6, p=0.84), and baseline Timed Up and Go (TUG) test results (Group A: 14.3 ± 1.7 seconds; Group B: 14.5 ± 2.0 seconds, p=0.88). Within-group comparisons revealed significant improvements in both groups across all outcome measures after eight weeks of intervention. In Group A, the mean BBS score increased from 42.6 ± 3.2 to 48.9 ± 2.9 ($p<0.001$), FGA scores improved from 18.8 ± 2.4 to 23.3 ± 2.1 ($p<0.001$), and TUG scores decreased from 14.3 ± 1.7 seconds to 12.0 ± 1.4 seconds ($p<0.001$). Similarly, in Group B, the BBS score improved from 42.9 ± 3.3 to 46.3 ± 3.0 ($p<0.001$), FGA scores increased from 19.0 ± 2.6 to 21.7 ± 2.4 ($p<0.001$), and TUG scores decreased from 14.5 ± 2.0 seconds to 12.9 ± 1.6 seconds ($p<0.001$).

Table 1 Demographics

Characteristic	Group A (VR) n=14	Group B (TOT) n=14	p-value
Age (years)	61.4 ± 6.2	60.7 ± 5.8	0.78
Gender (M/F)	9/5	8/6	0.72
Baseline BBS Score	42.6 ± 3.2	42.9 ± 3.3	0.81
Baseline FGA Score	18.8 ± 2.4	19.0 ± 2.6	0.84
Baseline TUG test	14.3 ± 1.7	14.5 ± 2.0	0.88

Table 2 Within-Group Comparisons

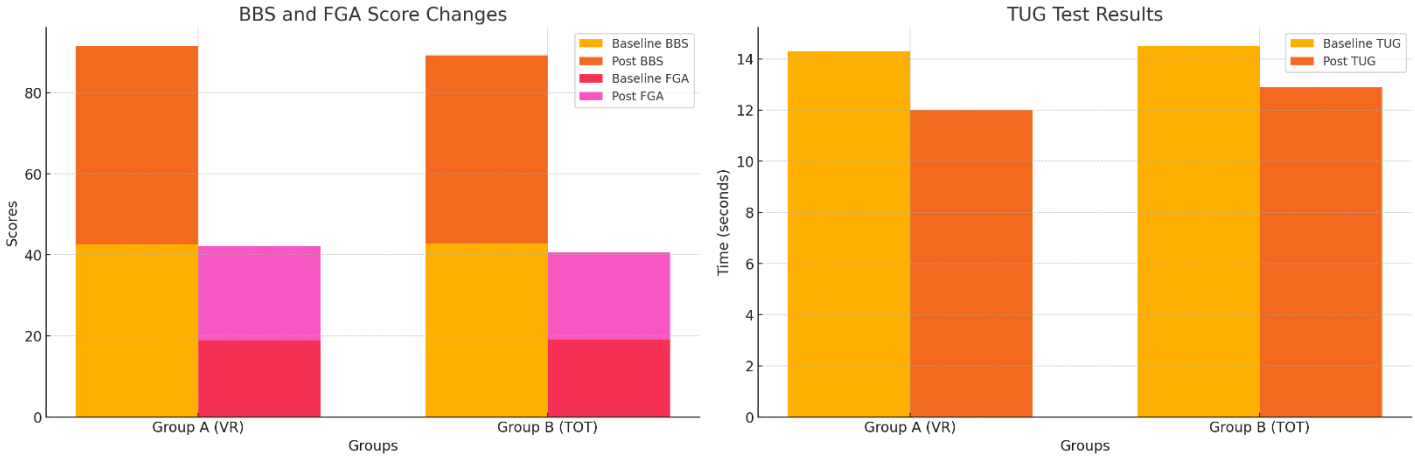
Outcome Measure	Group A (VR) Mean±SD	p-value	Group B (TOT) Mean±SD	p-value
BBS Score Baseline	42.6 ± 3.2		42.9 ± 3.3	
Post-Intervention	48.9 ± 2.9	<0.001	46.3 ± 3.0	<0.001
FGA Score Baseline	18.8 ± 2.4		19.0 ± 2.6	

Outcome Measure	Group A (VR) Mean±SD	p-value	Group B (TOT) Mean±SD	p-value
Post-Intervention	23.3 ± 2.1	<0.001	21.7 ± 2.4	<0.001
TUG (seconds)	14.3 ± 1.7		14.5 ± 2.0	
Baseline				
Post-Intervention	12.0 ± 1.4	<0.001	12.9 ± 1.6	<0.001

Table 3 Between-Group Comparisons

Outcome Measure	Group A (VR) Mean±SD	Group B (TOT) Mean±SD	Mean Difference	p-value
BBS Score	48.9 ± 2.9	46.3 ± 3.0	2.6	0.03
FGA Score	23.3 ± 2.1	21.7 ± 2.4	1.6	0.04
TUG (seconds)	12.0 ± 1.4	12.9 ± 1.6	-0.9	0.02

Between-group comparisons demonstrated that Group A exhibited significantly greater improvements in all outcome measures compared to Group B. Post-intervention, the mean BBS score in Group A was 48.9 ± 2.9 compared to 46.3 ± 3.0 in Group B, with a mean difference of 2.6 (p=0.03). Similarly, the FGA score was higher in Group A (23.3 ± 2.1) than in Group B (21.7 ± 2.4), with a mean difference of 1.6 (p=0.04). The TUG test results indicated a greater reduction in time for Group A (12.0 ± 1.4 seconds) compared to Group B (12.9 ± 1.6 seconds), with a mean difference of -0.9 seconds (p=0.02). These findings suggest that while both VR-based training and task-oriented training were effective in improving dynamic balance and gait among Parkinson's disease patients, VR-based training demonstrated significantly greater improvements across all measured parameters.



DISCUSSION

The current randomized controlled trial demonstrated significant improvements in dynamic balance and gait among individuals with Parkinson's disease following an eight-week intervention of virtual reality-based training (VR) and task-oriented training (TOT). Group A, which underwent VR-based training, exhibited superior outcomes compared to Group B, which received TOT. These findings align with previous research indicating that VR-based interventions enhance motor function, balance, and gait in Parkinson's disease patients by leveraging visual, auditory, and somatosensory stimuli to promote neuroplasticity and functional recovery (15). The Berg Balance Scale (BBS) scores significantly improved from baseline to post-intervention in both groups, with Group A demonstrating a larger increase (42.6 ± 3.2 to 48.9 ± 2.9) compared to Group B (42.9 ± 3.3 to 46.3 ± 3.0, p<0.001). This suggests that VR-based training provides a more immersive and engaging environment for patients to practice balance exercises, reinforcing neural adaptations and improving motor control. These results corroborate findings from earlier studies that highlighted VR as an effective tool for balance rehabilitation in Parkinson's disease patients.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Improvements in the Timed Up and Go (TUG) test were also observed, with Group A showing a greater reduction in time from 14.3 ± 1.7 seconds to 12.0 ± 1.4 seconds compared to Group B, which improved from 14.5 ± 2.0 seconds to 12.9 ± 1.6 seconds ($p<0.001$). These results suggest that VR-based training not only enhances dynamic balance but also improves functional mobility and gait efficiency. Previous research has similarly demonstrated the potential of VR to provide real-time feedback, which may accelerate motor learning and enhance task performance. However, both groups showed improvements, supporting the notion that TOT remains a viable and effective approach for motor rehabilitation, as it focuses on task-specific exercises and functional activities relevant to daily living. Functional Gait Assessment (FGA) scores also improved significantly in both groups, with Group A demonstrating a greater increase (18.8 ± 2.4 to 23.3 ± 2.1) compared to Group B (19.0 ± 2.6 to 21.7 ± 2.4, $p<0.001$). This finding underscores the effectiveness of VR-based interventions in addressing gait-related impairments, as these programs offer immersive scenarios that mimic real-world challenges, thereby enhancing patients' ability to navigate their environments safely. Previous systematic reviews have highlighted the importance of intervention durations exceeding six weeks to achieve meaningful improvements in gait, which aligns with the current study's findings.

One of the key strengths of this study is its randomized controlled design, which minimizes bias and enhances the validity of the findings. The inclusion of validated outcome measures such as the BBS, FGA, and TUG tests further strengthens the reliability of the results. However, the study is not without limitations. The small sample size reduces the generalizability of the findings, and the relatively short intervention period may not capture long-term effects or sustainability of improvements. Furthermore, the study lacked detailed reporting on adherence rates, adverse events, and patient satisfaction, which are critical for evaluating the feasibility of these interventions in clinical practice. Future studies should consider larger sample sizes, longer follow-up periods, and the inclusion of qualitative measures to capture patient-reported outcomes. Additionally, exploring the cost-effectiveness of VR-based interventions compared to traditional therapies could provide valuable insights for healthcare providers and policymakers. While the current study demonstrates the superiority of VR-based training in improving balance and gait, TOT remains a practical and effective approach, particularly in settings where access to VR technology is limited. Combining elements of both interventions may offer an optimized strategy for motor rehabilitation in Parkinson's disease patients.

CONCLUSION

The study demonstrated that both virtual reality-based training and task-oriented training significantly improved balance and gait among individuals with Parkinson's disease. However, virtual reality-based training proved to be more effective, offering enhanced outcomes due to its immersive and interactive approach, which facilitates motor learning and neuroplastic adaptations. These findings underscore the potential of virtual reality as a valuable tool in Parkinson's rehabilitation, providing an innovative and impactful alternative to traditional methods. This research highlights the importance of integrating advanced technologies into therapeutic interventions to optimize patient outcomes and improve quality of life in Parkinson's disease management.

Author Contribution

Author	Contribution
Suneeta Tariq	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Anum Kabir	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Hifza Riaz*	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Hafiz Muddassir Riaz	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Bisma Riaz	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Syed Nasir Ali Shah	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Aimon Rizwan	Contributed to study concept and Data collection Has given Final Approval of the version to be published

REFERENCES

1. Bloem BR Okun MS Klein C. Parkinson's disease. The Lancet. 2021;397(10291):2284-303.

2. Dibble LE Nicholson DE Shultz B MacWilliams BA Marcus RL Moncur C. Sensory cueing effects on maximal speed gait initiation in persons with Parkinson's disease and healthy elders. Gait & posture. 2004;19(3):215-25.

3. Mangone M, Agostini F, de Sire A, et al. Effect of virtual reality rehabilitation on functional outcomes for return-to-work patients with Parkinson's disease: An umbrella review of systematic reviews. NeuroRehabilitation. 2022.

4. Rodríguez-Mansilla J, Bedmar-Vargas C, Garrido-Ardila EM, et al. Effects of virtual reality in the rehabilitation of Parkinson's disease: A systematic review. J Clin Med. 2023;12(15):4896.

5. Ma H-I Hwang W-J Fang J-J Kuo J-K Wang C-Y Leong I-F et al. Effects of virtual reality training on functional reaching movements in people with Parkinson's disease: a randomized controlled pilot trial. Clinical Rehabilitation. 2011;25(10):892-902.

6. dos Santos Mendes FA Pompeu JE Lobo AM da Silva KG de Paula Oliveira T Zomignani AP et al. Motor learning retention and transfer after virtual-reality-based training in Parkinson's disease–effect of motor and cognitive demands of games: a longitudinal controlled clinical study. Physiotherapy. 2012;98(3):217-23.

7. Robles-García V Corral-Bergantiños Y Espinosa N García-Sancho C Sanmartín G Flores J et al. Effects of movement imitation training in Parkinson's disease: a virtual reality pilot study. Parkinsonism & related disorders. 2016;26:17-23.

8. Mirelman A Maidan I Herman T Deutsch JE Giladi N Hausdorff JM. Virtual reality for gait training: can it induce motor learning to enhance complex walking and reduce fall risk in patients with Parkinson's disease? Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2011;66(2):234-40.

9. Li R, Zhang Y, Jiang Y, Wang M, Ang W, Lau Y. Rehabilitation training based on virtual reality for patients with Parkinson's disease in improving balance, quality of life, activities of daily living, and depressive symptoms: A systematic review and meta-regression analysis. Clin Rehabil. 2021;35(10):1089–102.

10. Feng H, Li C, Liu J, Wang L, Ma J, Li G, et al. Virtual Reality Rehabilitation Versus Conventional Physical Therapy for Improving Balance and Gait in Parkinson's Disease Patients: A Randomized Controlled Trial. Med Sci Monit. 2019;25:4186–92.

11. Di Biagio L Andrenelli E Sordoni E Monsù A Ceravolo M Capecci M. Gait and balance training in advanced Parkinson's disease: Comparative study of three methods. Annals of Physical and Rehabilitation Medicine. 2014;57(SUPPL 1):e362.

12. Monticone M Ambrosini E Laurini A Rocca B Foti C. In-patient multidisciplinary rehabilitation for Parkinson's disease: a randomized controlled trial. Movement Disorders. 2015;30(8):1050-8.

13. Capecci M Andrenelli E Hibel M Latini L Grugnetti M Pennacchioni M et al. The role of training intensity in outpatient rehabilitation of people with Parkinson's disease: A retrospective cohort study of disability progression with 4-month follow-up. Annals of Physical and Rehabilitation Medicine. 2018;61:e255-e6.

14. K P Suganthirababu P Srinivasan V Kumar P S D Kumaresan A et al. Effect of Task Specific Training on Activities of Daily Living and Functional Balance Among Parkinson's Disease Patients: A Pilot Study. Indian Journal of Physiotherapy & Occupational Therapy - An International Journal. 2024;18:126-31.

15. Feng H Li C Liu J Wang L Ma J Li G et al. Virtual Reality Rehabilitation Versus Conventional Physical Therapy for Improving Balance and Gait in Parkinson's Disease Patients: A Randomized Controlled Trial. Medical science monitor : international medical journal of experimental and clinical research. 2019;25:4186-92.

16. Lei C Sunzi K Dai F Liu X Wang Y Zhang B et al. Effects of virtual reality rehabilitation training on gait and balance in patients with Parkinson's disease: a systematic review. PloS one. 2019;14(11):e0224819.

17. Wang B Shen M Wang Y-x He Z-w Chi S-q Yang Z-h. Effect of virtual reality on balance and gait ability in patients with Parkinson's disease: a systematic review and meta-analysis. Clinical rehabilitation. 2019;33(7):1130-8.

18. Rodríguez-Mansilla J Bedmar-Vargas C Garrido-Ardila EM Torres-Piles ST González-Sánchez B Rodríguez-Domínguez MT et al. Effects of virtual reality in the rehabilitation of Parkinson's disease: a systematic review. Journal of Clinical Medicine. 2023;12(15):4896.

19. Wu J Zhang H Chen Z Fu R Yang H Zeng H et al. Benefits of virtual reality balance training for patients with Parkinson disease: systematic review meta-analysis and meta-regression of a randomized controlled trial. JMIR Serious Games. 2022;10(1):e30882.

20. Soke F Guclu-Gunduz A Kocer B Fidan I Keskinoglu P. Task-oriented circuit training combined with aerobic training improves motor performance and balance in people with Parkinson′ s Disease. Acta Neurologica Belgica. 2021;121(2):535-43.