Effectiveness of Virtual Reality versus Conventional Exercise on GaitTraining in Parkinson's Disease: a literature review

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Abstract. Parkinson's Disease (PD) is a degenerative process involving neurodegeneration in the substantianigra with reduced dopamine production in the brain. Parkinson's patients often experience gait disturbances that require physiotherapy intervention. Studies suggested that conventional exercises such as treadmills, graded resistance exercise, Nordic walking, and Dual-task training positively impact Parkinson's patients with walking disorders. On the other hand, recent research showed that virtual reality improves walking problems in PD with a three-dimensional (3D) stimulation experience. Therefore, this research aims to compare the effectiveness of virtual reality with conventional exercise on gait training in Parkinson's cases. In this literature review, as many as eight articles were filtered and reselected; the final selection was five. The results of the review found that four articles mentioned that the provision of virtual reality interventions was found more effective than conventional therapy in improving walking patterns, stride length, walking speed, freezing of gait (FoG), and gait in Parkinson's Disease patients aged between 50 and 71 years old with an average background in European countries stages I-IV Hoehn and Yahr. However, virtual reality is less practical for patients with severe cognitive impairment. In addition, one article mentioned that conventional treadmill therapy coupled with musical beat cues and visual effects had the same effect. Based on these reviews, virtual reality is more effective than conventional therapy and results in faster improvement for Parkinson's patients with walking problems.

Keywords: Parkinson's Disease, Gait Training, Virtual Reality, Conventional Exercise

1. Introduction

Globally, the prevalence of Parkinson's Disease (PD) is rising at an alarming rate, surpassing the growth of any other neurological disorder (Balestrino & Schapira, 2020). PD is recognized as the second most prevalent degenerative nervous system condition [2]. In Indonesia, an estimated ten individuals annually are afflicted by PD, impacting 876,665 out of a total population of 238,452,952. The disease's toll on Indonesia ranks it 12th worldwide and 5th in Asia, with approximately 1100 fatalities attributed to PD each year [10].

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The key symptoms of PD primarily involve disruptions in posture and walking patterns, characterized by an elevated risk of falls due to a rigid, unsteady, and irregular gait, along with diminished walking capacity [2]. These gait disturbances significantly impact daily life quality and autonomy. They are responsible for falls, often occurring in up to 87% of PD cases, which can lead to hospitalization, immobilization, and a loss of confidence [6].

Physiotherapy is a critical aspect of managing gait problems in Parkinson's patients. Research indicates that various therapeutic exercises, including stretching and strengthening routines, enhance motor and cognitive abilities in PD individuals. Aerobic activities also improve physical well-being, and exercises such as ground walking or treadmill training enhance walking stability [14].

Research by Frazzitta G, et al. highlights that conventional treadmill therapy supplemented with audio cues like rhythmic music and visual aids such as dotted lines yield better outcomes for PD patients with gait impairments [4].

Virtual Reality (VR) is a cutting-edge technology offering users a three-dimensional computer-generated simulation or experience through VR devices. This technology enables the creation of lifelike virtual environments, tailored to therapy needs. VR therapy can be personalized to aid in restoring motor function, focusing patients on specific elements, and facilitating the transfer of movement patterns from virtual to real-world scenarios [12]. VR has demonstrated favorable effects on walking speed, stride length, multitasking abilities, and obstacle navigation in comparison to conventional exercise therapy, ultimately enhancing balance and gait in individuals with neurological disorders [9]. Gait disturbances are a hallmark of PD, leading to diminished walking speed, shorter strides, and increased cadence in affected individuals. This literature review aims to provide a comprehensive comparison of the effectiveness of Virtual Reality versus Conventional Exercise in Gait Training for Parkinson's patients.

2. Method

A comprehensive search for evidence was conducted across Pubmed, Google Scholar, and Proquest databases, employing the keywords "Parkinson's disease OR Parkinson's" AND "Virtual Reality" AND "Conventional Exercise OR Conventional Physical Therapy" AND "Gait." This search yielded a total of 16,130 relevant journals based on the specified keywords. Subsequently, 16,040 journals were eliminated due to their lack of relevance to the subject matter and research objectives.

Following the initial screening, a meticulous review of articles was performed in accordance with predetermined inclusion and exclusion criteria. This process resulted in the identification of 18 articles that align with the research objectives. These selected articles were then subjected to a thorough assessment using the JBI Critical Appraisal Tools to

gauge their quality and validity.

Data synthesis was undertaken utilizing a simplified approach. The articles were evaluated based on their adherence to the inclusion criteria, which encompassed the following aspects: (1) Patients diagnosed with Parkinson's disease; (2) Implementation of Virtual Reality as the intervention; (3) Comparison involving Conventional Exercise; (4) Measurement of gait in patients; (5) Publication year within the range of 2009 to 2023; (6) Articles composed in either English or Indonesian languages.

Conversely, articles were excluded if they met the following criteria: (1) Patients with Parkinson's disease and additional comorbidities; (2) Employment of interventions combining Virtual Reality with other methods; (3) Incorporation of Conventional Exercise alongside other interventions; (4) Publication year predating 2009; (5) Articles not presented in English or Indonesian languages; (6) Research design resembling a literature review.

The search strategy was devised in alignment with the PICO framework, where the population/problem pertained to Parkinson's disease, the intervention encompassed virtual reality, the comparison involved conventional exercise, and the desired outcome was the enhancement of patient gait.

3. Result

Data collection was executed following the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) approach, depicted in Figure 1. A comprehensive evaluation of eight published journals was conducted, uncovering that three of these journals did not adhere to the established inclusion criteria. Subsequently, five journals were chosen for the synthesis of data. The articles that were included and excluded based on the critical appraisal are documented in Table 1. Among these, five journals satisfied the inclusion prerequisites outlined in the research methodology. The ensuing sections outline the findings derived from each of the discussed studies.

The parameter used to assess walking ability involved the implementation of the 6-Minute Walking Test (6MWT). This evaluation necessitated patients to traverse back and forth along a 20-meter corridor, aiming to cover the maximum distance achievable within a span of 6 minutes. The total count of laps completed and the corresponding distance covered were meticulously recorded [7].

Furthermore, gait assessment in individuals with Parkinson's disease also encompassed the option of employing the Functional Gait Assessment (FGA) or the Dynamic Gait Index (DGI). The FGA comprises a series of 10 tasks that progressively challenge patients to walk under complex conditions, such as making turns or walking with closed eyes. Each task is

assigned a score ranging from zero to three, reflecting an individual's inability (zero) or successful completion (three) of the task. According to the FGA, the optimal score achievable is 30, indicative of normal gait functionality [13].

Figure 1.

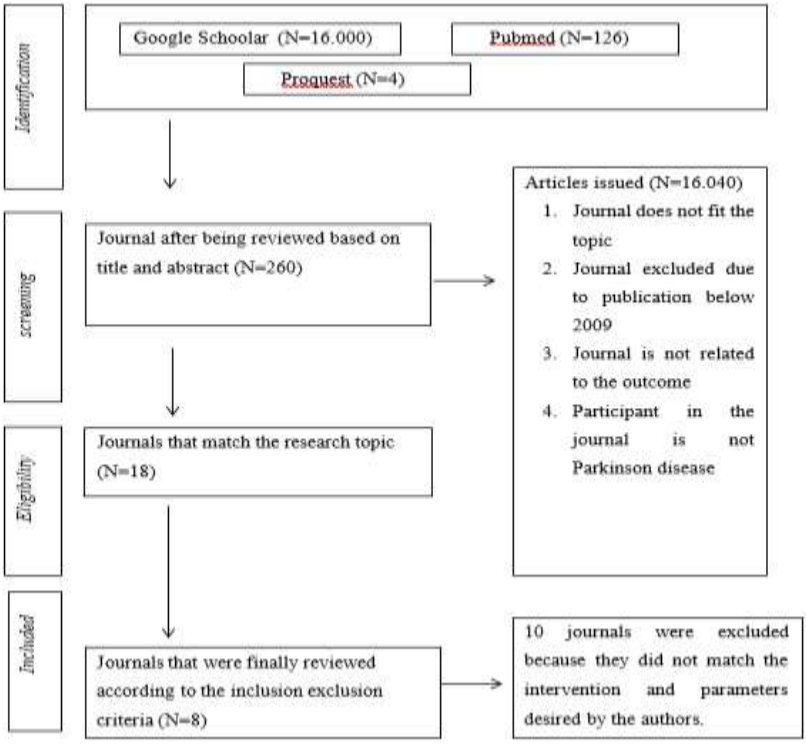

Table 1.

Study	Sample	Age	Intervention	Dosage	Outcome Balance
Pazzaglia C, et al.2020 (Pazzaglia et al., 2020)	T = 51 I = 25 C = 26	Average age 71 years old	I = Virtual reality C = Conventional exercise consists of warm-up body motor coordination	6 weeks, 3 times per week, with 40 minutes/session.	DGI

Study	Sample	Age	Intervention	Dosage	Outcome Balance
			exercises, balance exercises, start and stop exercises, walking exercises, and cool down.		
Lei C, et al. 2019 (Lei et al., 2019)	T = 555 I = 277 C = 278	No age limit	I = Virtual reality sports games and visual feedback C = Conventional exercise	4-12 weeks, 2-5 times per week, 30 minutes-1 hour each session	6MWT, DGI
Imbimbo I, et al.2021 (Imbimbo et al., 2021)	T = 30 I = 15 C = 15	60-70 years old	I = Virtual reality in patients with good cognition C = Virtual reality in serious cognitive patients	6 weeks, 2 times per week, with 40 minutes/session.	6MWT
Feng H, et al.2019 (Feng et al., 2019)	T = 28 I = 14 C = 14	50-70 years old	I = Virtual reality C = Conventional exercise consisting of warm-up, weight-bearing transfer, walking exercise, and cool down.	12 weeks, 5 times per week, 45 minutes/session.	FGA
Frazzitta G, et al. 2009 (Frazzitta et al., 2009)	T = 40 I = 20 C = 20	Average age 71 years old	I = Conventional treadmill exercise with tapping music and visuals C = Conventional exercise with music beats and visuals	4 weeks, every day for 20 minutes/session	6MWT

T: Total sample; I: Intervention Group; C: Control Group; DGI: Dinamic Gait Index ; 6MWT: 6 Minute Walking Test ; FGA: Functional Gait Assesment

4. Discussion

4.1 Effect of Virtual Reality on Gait Training

Out of the examined articles, four of them present compelling evidence that the introduction

of virtual reality yields noteworthy enhancements. One study conducted by Pazzaglia C et al. encompassed 51 participants, with 25 in the intervention group and 26 in the control group. This study compared rehabilitation using virtual reality to conventional physical exercise and revealed a significant rise in Dynamic Gait Index (DGI) scores within the intervention group. The utilization of virtual reality led to more pronounced enhancements in walking and dynamic balance (as indicated by DGI) compared to conventional therapy. This could be attributed to the fact that virtual reality stimulates sensory-motor and cognitive functions.

Likewise, research undertaken by Lei C et al. unveiled superior performance in gait and balance among Parkinson's disease patients receiving virtual reality intervention. The impact of VR technology on dynamic gait index (DGI) scores was reported in three studies involving 130 participants. Furthermore, seven studies involving 347 participants highlighted the positive influence of VR technology on walking speed. An additional four trials encompassing 166 participants demonstrated VR's effect on improving walking patterns and stride length. Additionally, this study substantiated that virtual reality enhances hand movements and diminishes arm injuries in patients, who could seamlessly adhere to the intervention without encountering adverse effects.

In contrast, Imbimbo I et al. conducted a six-week investigation involving 30 patients afflicted by idiopathic PD. Their findings indicated that patients with intact cognitive function exhibited improved gait, while those with cognitive decline experienced deterioration. Virtual reality was deemed comparatively less effective due to the varying backgrounds and interaction styles of patients with their environment. The study underscored the pivotal role of stimuli and perception in influencing patient responses, potentially affecting mood and the treatment's effectiveness.

In a study by Feng H, et al., both the experimental group (comprising 14 patients) and the control group (consisting of 14 patients) showcased enhancements in walking ability, as evidenced by significant improvements in Functional Gait Assessment (FGA) scores. Following 12 weeks of therapy, the experimental group, which received VR intervention, exhibited superior outcomes compared to the control group that underwent conventional treatment.

4.2 Effect of Convention Exercise on Gait Training

Based on one of the articles reviewed in a study conducted by Frazzitta G et al, conventional treadmill therapy with audio cues such as musical rhythms and visuals such as dotted lines can provide better results in PD patients with gait and FoG disorders than conventional therapy. With an exercise dose of 20 minutes per session performed daily for 4 weeks, conventional treadmill therapy with audio and visual cues can provide the same effect as VR exercise.

Effectiveness of auditory and visual cues in rehabilitation treatment of gait disturbance in Parkinson's Patients is well known. Auditory cues provide an external rhythm, which can compensate for the damaged internal rhythm of the basal ganglia. Patients with Parkinson's disease do not lose the ability to produce healthy step patterns but have difficulty in activating the motor control system. Visual cues help to fill in the gaps in the motor circuitry by providing visual data on the appropriate stride length. Visual cues generate optic flow that can activate the visual-motor pathways of the cerebellum.

5. Conclusion

This review of literature establishes that utilizing Virtual Reality (VR) intervention is not only more efficient but also accelerates the pace of improvement among individuals with Parkinson's disease facing walking difficulties, in comparison to traditional exercise approaches. It is important to note, however, that patients exhibiting severe cognitive impairment should refrain from engaging in VR interventions. VR exercises can be categorized into immersive, semi-immersive, or non-immersive experiences, encompassing games designed to target balance enhancement and walking activities, all tailored to suit the specific requirements of each patient. Crucially, the presence of a physiotherapist is imperative to ensure the safety of patients throughout their exercise sessions.

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