Effectiveness of Virtual Game Therapy for Balance and Quality of Life in Parkinson's Patients: A Systematic Review and Meta-Analysis

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Keywords: Parkinson's Diseases, Quality of Life, Virtual Game Therapy.

Abstract: Parkinson's disease is a neurological disorder and one of the degenerative diseases and balance dysfunction and related falls are common symptoms. Many therapies have been found, one of which is virtual game therapy, but more research is needed to find the effectiveness of virtual game therapy, and the optimal duration of intervention. This study aims to assess the effects of virtual game therapy on balance ability and quality of life in parkinson's patients. This study followed the guidelines provided by PRISMA. Study searches were conducted through PubMed, Cochrane, and Embase up to October 31st, 2023. We also use Covidence to screen studies for inclusion and the Cochrane Risk of Bias 2.0 to assess the risk of bias of inclusion studies. Then, we analyzed the data using Review Manager v5.4. Eighteen randomized studies, yielding 786 patients are included. Our study showed the virtual game therapy is significantly increase the balance ability for Berg Balance Scale (BBS) subgroup (Pooled MD = 1.56; 95% CI [0.50,2.62]; P< 0.004; I2 = 34%), and it is significantly increasing the quality of life for Parkinson's Disease Questionnaire (PDQ) subgroup (Pooled MD = -0.85; 95% CI [-1.58, -0.12]; P=0.02; I2 = 39%). Virtual game therapy is highly recommended to give 120 minutes a week for balance outcomes (Pooled MD = 1.94; 95% CI [1.40, 2.49]; P<0.00001; I2 = 0%). The results indicate significant effects on increasing balance ability and quality of life for people with Parkinson's diseases. For optimal balance and quality of life outcomes, we recommend giving virtual game therapy for 120 minutes a week. Future studies need to have more homogenous study designs, high-quality randomized studies, and larger populations.

1 INTRODUCTION

Parkinson's disease is a disease caused by nerve disorders, especially in the substantia nigra area in the brain (Zafar & Yaddanapudi, 2023). Parkinson's disease is a neuro-degenerative disease with 4 cardinal signs such as resting tremor, bradykinesia, rigidity, and postural instability that affect a person's ability to move, speak, and perform daily activities (DeMaagd & Philip, 2015). In the United Kingdom (UK) the incidence of Parkinson's disease per 100.000 person years at risk was 149 in 2006 and 144 in 2016 (Okunoye et al., 2022). Parkinson's disease gets worse over time. Symptoms in Parkinson's patients can have an adverse impact such as often experiencing imbalances in their motor resulting in a decrease in quality of life. Parkinson's disease causes high disability and the need for treatment. Some types of Parkinson's treatment can cause side effects that impact the patient's Quality of Life, so an alternative is needed. One solution that is quite potential to overcome this is virtual game therapy (VGT). VGT has been a promising alternative for improving the balance ability and quality of life of Parkinson's patients. Virtual gaming therapy (VGT) is a form of therapy that uses virtual gaming technology to help improve the balance ability and quality of life of Parkinson's patients. VGT usually engages the patient in games specifically designed to improve the body's balance and coordination abilities. Patients can use motion controllers or motion sensors to interact with the virtual environment and accomplish specific tasks. The mechanism of action of VGT is based on the concept of neuroplasticity, that is, the ability of the brain to adapt and repair itself (Campo-Prieto et al., 2021). VGT can help strengthen nerve pathways involved in balance and coordination of the body, thereby improving the balance ability of Parkinson's

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patients (Wang et al., 2021). In addition, VGT can also help improve motor function, mental health, and quality of life for Parkinson's patients.

2 METHODS

2.1 Research Methodology

Conforming to the guidelines established in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the Cochrane Handbook for Systematic Reviews of Interventions, version 6.3, 2022, we conducted the systematic review and meta-analysis study.

2.2 Eligibility Criteria: Inclusion and Exclusion Criteria

Prior to initiating the literature search, specific criteria for inclusion and exclusion were established to assess the relevance of the data. The inclusion criteria encompassed 1) randomized controlled trial studies, 2) using parkinson's patient 3) studies which given virtual game therapy included virtual exercise therapy as intervention 4) measuring the balance ability outcomes and/or quality of life outcomes, and 5) adherence to the English language. On the other hand, exclusion criteria involved 1) using the virtual game therapy combined with other therapy, 2) using virtual intervention as consultation not as therapy 3) the use of incompatible languages, and 4) unavailability of full-text access. The selection of titles and abstracts from the included papers was performed independently by three reviewers (AA, PMR), with any disagreements resolved through consultation with another author (AAS). The results of inclusion and exclusion criteria are shown in Figure 1.

2.3 Standard of References

We referred to a randomized controlled trial that demonstrated the impact of virtual game therapy on the balance ability and quality of life outcomes for individuals with Parkinson's disease.

2.4 Search Strategy

As illustrated in the first attachment, the literature search encompassed databases such as PubMed, Cochrane, and Embase. The searches were executed between October 30 and October 31, 2023. All terms adhered to the Medical Subject Headings (MeSH) browser. Keywords were incorporated into the search field using Boolean operators, and specific terms were employed following the guidelines of Boolean

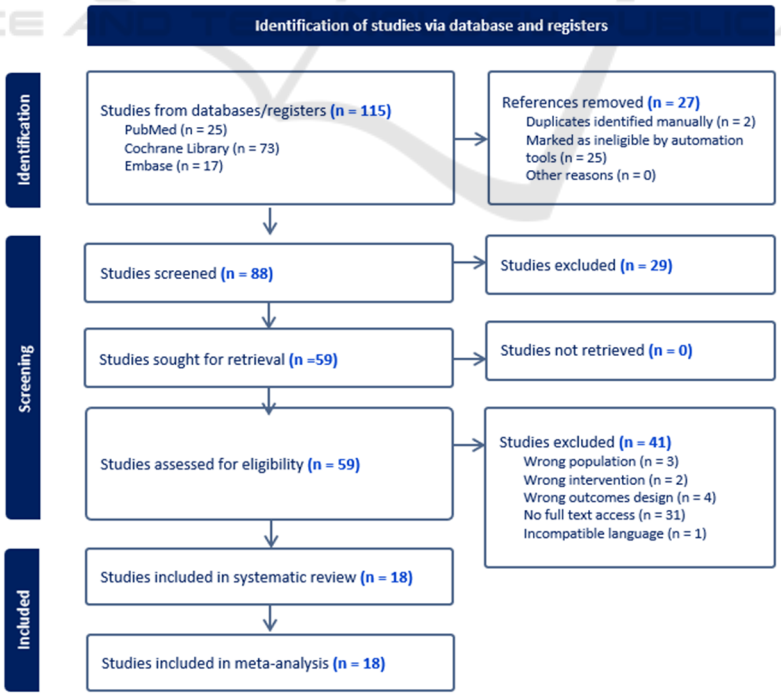

Figure 1: PRISMA flow Diagram

operator keywords, for example, (parkinson disease [MeSH Terms]) AND (game OR games OR virtual) AND (balance OR Quality of Life).

2.5 Data Extraction and Analysis

Attachment 2 has a summary of the studies that were part of this review. Author, year, country, sample size, length of repetition, kind of control, parkinson's grade, changes in balance score, and changes in quality of life score were the data taken out of the chosen studies. RevMen version 5.4 was utilized for conducting the meta-analysis.

2.6 Risk of Bias in Individual Studies (Qualitative Synthesis)

We assessed the quality of the chosen randomized controlled trials using the Risk of Bias Tool for Randomized Trials version 2 (RoB2). This tool comprises five domains and 28 signaling questions pertaining to the randomized process, intervention, outcome data, and reported results. Three independent reviewers (AA, PMR, AAS) conducted the quality assessment, recording results in the domain file bias (.xlsx). The outcomes were then summarized and visualized on the ROBVIS website using a traffic light system. Scores were assigned based on RoB2 judgment algorithms, including low risk, some concerns, and high risk. The indication of study quality is detailed in Table 1.

2.7 Qualitative Data Synthesis (Meta-Analysis)

Quantitative analysis of the acquired data was conducted using Review Manager 5.4.1. (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen). The Mean Difference (MD) and Standard Deviation (SD) for both the intervention and control groups were utilized, considering measurements before and after treatment extracted

Table 1: Randomized Controlled Trial Risk of Bias

from previously conducted studies. The data, categorized as continuous, underwent statistical analysis using the inverse variance method. Additionally, the fixed effect model (FEM) was employed when the level of heterogeneity (I2) was < 50%, while the random effect model (REM) was applied when the level of heterogeneity (I2) was ≥ 50%. Primary outcomes guiding the statistical analysis included MD and SD for the change from baseline using virtual game therapy for Parkinson's patients, highlighting significant impacts on life quality and balance ability. The effects were quantified through standardized mean differences (SMD), with corresponding 95% confidence intervals (CI) for both individual studies and the overall assessment.

3 RESULTS AND DISCUSSION

Gathered from all eligible journals, a total of 786 samples were categorized into an intervention group comprising 405 patients and a control group consisting of 381 patients. Among these, five articles were sourced from Taiwan, while Italy and Brazil each contributed three articles. Furthermore, two articles originated from the Netherlands, and one each from China, Lahore, Belgium, Switzerland, and Turkey. Detailed information for each included journal is presented in the extraction table in Table 2.

Table 2: Summary of Data Extraction

No	Author, Year	Title (Country)	Duration (repetition)	Participants number, n (trial/control)	Type of Control	Grade of Parkinson Diseases	Changes in balance score					Changes in Quality of Life score				
							Trial		Control		Tools	Trial		Control		Tools
							Pre	Post	Pre	Post		Pre	Post	Pre	Post	
1	Feng et al., 2019	Virtual Reality Rehabilitation Versus Conventional Physical Therapy for Improving Balance and Gait in Parkinson's Disease Patients: A Randomized Controlled Trial (China)	45 min (5 days/week for 12 weeks)	28 (14/14)	Conventional physical therapy	2,5-4	30.64±3.91	36.71±4.60	30.07 ± 3.87	32.00 ± 4.82	Berg Balance Scale (BBS)	N/A	N/A	N/A	N/A	N/A
2	Pazzaglia et al.,2020	Comparison of virtual reality rehabilitation and conventional	40 min (3 times/week for 6 weeks)	51 (25/26)	Underwent conventional rehabilitation	NI	45.6 ±7.9	49.2 ±8.1	47.3 ±7.6	48.1 ±7.2	Berg Balance Scale (BBS)	37.7 ±11.4	43.5 ±9.2	41.9 ±12.8	39.2 ±12.6	Mental composite score (SF-36)

		rehabilita-tion in Parkinson's disease: a randomis-ed controlled trial (Italy)														
3	Liao et al., 2015	Virtual Reality-Based Training to Improve Obstacle-Crossing Performance and Dynamic Balance in Patients with Parkinson's Disease (Taiwan)	45 min (2 times/week for 6 weeks)	24 (12/12)	Traditional exercise/Conventional	1-3	N/A	N/A	N/A	N/A	N/A	78.2 ± 23.3	79.0 ± 24.3	84.5 ± 26.0	68.8 ± 20.0	Parkinson's Disease Questionnaire (PDQ 39)
3	Liao et al., 2015	Virtual Reality-Based Training to Improve Obstacle-Crossing Performance and Dynamic Balance in Patients with Parkinson's Disease (Taiwan)	45 min (2 times/week for 6 weeks)	24 (12/12)	Traditional exercise/Conventional	1-3	N/A	N/A	N/A	N/A	N/A	78.2 ± 23.3	79.0 ± 24.3	84.5 ± 26.0	68.8 ± 20.0	Parkinson's Disease Questionnaire (PDQ 39)
4	Kashif et al., 2022	Combined efects of virtual reality techniques and motor imagery on	60 min (3 days/week for 6 weeks)	44 (22/22)	physical therapy treatment	3	38.95± 3.23	46.59± 3.07	40.23 ± 4.61	43.23 ± 4.45	Berg Balance Scale (BBS)	N/A	N/A	N/A	N/A	N/A

		balance, motor function and activities of daily living in patients with Parkinson's disease: a randomized controlled trial (Taiwan)														
5	Pompeu et al., 2012	Effect of Nintendo WiiTM-based motor and cognitive training on activities of daily living in patients with Parkinson's disease: A randomised clinical trial (Brazil)	60 min (2 times/week for 7 weeks)	32 (16/16)	Balance exercise therapy /Conventional	1-2	52.9 ± 4.1	54.4 ± 2.2	51.9 ± 4.6	53.1 ± 3.4	Berg Balance Scale (BBS)	N/A	N/A	N/A	N/A	N/A
6	Yang et al., 2016	Home-based virtual reality balance training and conventional balance training in Parkinson's disease: A randomized controlled trial	50 min (3 times/week for 6 weeks)	23 (11/12)	licensed physical therapist	NI	46.9 ± 6.5	50.3 ± 5.4	46.9 ± 6.6	51.1 ± 5.9	Berg Balance Score (BBS)	29.2 ± 16.3	23.8 ± 15.5	31.7 ± 17.9	26.4 ± 19.1	Parkinson's Disease Questionnaire (PDQ-39)

		(Taiwan)														
7	Qayyum et al., 2022	Effects of Exer–Gaming on Balance and Gait in Parkinson's Patients (Lahore)	50 min (3 times/week for 8 weeks)	16 (8/8)	Conventional treatment	N/I	14.6 ± 1.06	19.12 ± 0.83	14.87 ± 0.83	16.37 ± 0.74	Dynamic Gait Index (DGI)	N/A	N/A	N/A	N/A	N/A
8	Yuan et al., 2020	Effects of interactive video-game–based exercise on balance in older adults with mild-to-moderate Parkinson's disease (Taiwan)	30 min (3 times/week for 6 weeks)	24 (12/12)	no IVGB exercise intervention during the first 6 weeks	1-3	1.0 ± 3.8*		1.4 ± 6.7*		Berg Balance Score (BBS)	6.7 ± 34.7*		7.9 ± 18.1*		General health 36-Item Short-Form Health Survey (SF-36)
9	Bekkers et al., 2020	Do Patients with Parkinson's Disease with Freezing of Gait Respond Differently Than Those Without to Treadmill Training Augmented by Virtual Reality? (Belgium)	45 min (3 times/week for 6 weeks)	121 (77/44)	treadmill training	2-3	21.50± 5.8	23.51± 5.46	21.00 ± 6.1	22.26 ± 5.46	Mini Balance Evaluation System Test (Mini-BEST)	N/A	N/A	N/A	N/A	N/A

10	Kolk et al., 2019	Effectiveness of home-based and remotely supervised aerobic exercise in Parkinson's disease: a double-blind, randomised controlled trial (Netherland)	30-45 min (3 times/week for 6 months)	130 (65/65)	stretching	1-2	24·3 ±0·6	24·4 ±0·6	24·2 ±0·6	24·5 ±0·6	Mini-Balance Evaluation Systems Test (Mini-BEST)	24·9 ±2·2	26·0 ±2·3	24·0 ±2·2	26·3 ±2·3	Parkinson's Disease Questionnaire 39 summary index score
11	Gandolfi et al., 2017	Virtual Reality Telerehabilitation for Postural Instability in Parkinson's Disease: A Multicenter, Single-Blind, Randomized, Controlled Trial (Italy)	50 min (3 days/week for 7 weeks)	76 (38/38)	in-clinic sensory integration balance training (SIBT)	2,5-3	48.63±6.31	52.37 ± 3.29	45.61 ±7.97	49.82 ± 5.70	Berg Balance Score (BBS)	30.72 ±15.54	24.16 ±14.78	30.53 ±16.04	24.21 ±15.85	Parkinson's Disease Quality of Life questionnaire (PDQ-8)
12	Maranesi et al., 2022	The Effect of Non-Immersive Virtual Reality Exergames versus Traditional Physiotherapy in Parkinson's Disease Older Patients: Prelimin	30 min (2 times/week for 5 weeks)	30 (14/16)	traditional therapy / Conventional	1-3	13.8 ±0.5	14.7 ±0.4	12.4 ±0.7	13.5 ±0.8	POMA (Performance oriented mobility assessment) Balance	31.6 ±0.7	30.1 ±0.6	30.3 ±0.7	30.3 ±0.7	SF-12

		ary Results from a Randomized-Controlled Trial (Switzerland)														
13	Carpinella et al., 2016	Wearable Sensor-Based Biofeedback Training for Balance and Gait in Parkinson Disease: A Pilot Randomized Controlled Trial (Italy)	45 min (3 times/week for 4 weeks)	37 (17/20)	physiotherapy without feedback	2-4	46.0 ± 9.3	50.0 ± 6.2	42.1 ± 10.9	43.8 ± 10.9	Berg Balance Score (BBS)	46.4 ± 22.9	44.6 ± 24.7	61.5 ± 24.1	59.2 ± 23.3	Parkinson's Disease Questionnaire 39 summary index score
14	Santos et al., 2019	Efficacy of the Nintendo Wii combination with Conventional Exercises in the rehabilitation of individuals with Parkinson's disease: A randomized clinical trial (Brazil)	50 min (2 times/week for 8 weeks)	27 (13/14)	Conventional exercise	1-3	43.9 ± 5.3	49.2 ± 4.4	40.5 ± 5.6	45.6 ± 5.4	Berg Balance Score (BBS)	37.1 (24.5 - 45.3) [Median (25-75 percentile)] # ~ 37.1 ± 15.5	29.7 (22.4 - 35.1) [Median (25-75 percentile)] # ~ 29.7 ± 9.4	32.7 (26.7 - 54) [Median (25-75 percentile)] # ~ 32.7 ± 20.1	25.7 (12.6 - 36.2) [Median (25-75 percentile)] # ~ 25.7 ± 17.5	Parkinson's Disease Questionnaire 39 summary index score
15	Ferraz et al., 2018	The Effects of Functional	50 min (3 times/week for 8	42 (22/20)	functional training	2-3	N/A	N/A	N/A	N/A	N/A	44.7 (26.7)	33.9 (25.2)	47.0 (25.1)	41.7 (21.7)	Parkinson's Disease Questi

		Training, Bicycle Exercise, and Exergaming on Walking Capacity of Elderly Patients with Parkinson Disease: A Pilot Randomized Controlled Single-blinded Trial (Brazil)	weeks)													onnaire 39 summary index score
16	Heuvel et al., 2014	Effects of augmented visual feedback during balance training in Parkinson's disease: a pilot randomized clinical trial (Netherlands)	60 min (2 times/week for 5 week)	31 (14/17)	Conventional training	2-3	1.00 (-0.25, 2.00) [center (dispersion)]# ~ 1.00 ± 0.56		-1.00 (-2.00 , 2.00) [center (dispersion)]# ~ -1.00 ± 1.00		Berg Balance Score (BBS)	2.50 (-8.75, 10.00) [center (dispersion)]# ~ 2.50 ± 4.44		0.00 (-5.00, 2.50) [center (dispersion)]# ~ 0.00 ± 1.875		Parkinson's Disease Questionnaire 39 summary index score
17	Shih et al., 2016	Effects of a balance-based exergaming intervention using the Kinect sensor on posture stability in individua	50 min (2 times/week for 8 weeks)	20 (10/10)	Conventional Balance training	1-3	50.9 ± 5.32	53.2 ± 2.86	50.4 ± 4.79	53 ± 1.89	Berg Balance Score (BBS)	N/A	N/A	N/A	N/A	N/A

		ls with Parkinson's disease: a single-blinded randomized controlled trial (Taiwan)														
18	Gulcan et al., 2022	The effects of augmented and virtual reality gait training on balance and gait in patients with Parkinson's disease (Türkiye)	5 min (3 days a week for 6 weeks)	30 (15/15)	Conventional training	1-2	53.0 (48.0 - 55.0) [median (IQR)]# ~ 53 ± 5.20	54.0 (50.0 - 56.0) [Median (IQR)]# ~ 54 ± 4.45	50.0 (39.0 - 54.0) [median (IQR)] # ~ 50 ± 11.12	52.0 (44.0 - 55.0) [median (IQR)]# ~ 52 ± 8.16	Berg Balance Score (BBS)	N/A	N/A	N/A	N/A	N/A
Total				786 (405/381)												

NI = No Information
N/A = No Administered
* = Changes score
# = Transformation to mean (SD) with normally distributed data

Virtual game therapy, also known as exer-gaming, refers to the use of virtual reality (VR) and video game technology as a form of therapy for various health conditions, including Parkinson's disease. This type of therapy includes activities such as virtual-based games, balance-based exergaming, and Wii-based motor and cognitive training. The importance of using virtual game therapy for Parkinson's disease lies in its potential to improve balance, gait, and activities of daily living for individuals with Parkinson's disease. Parkinson's patients often experience impaired balance and a decrease in quality of life due to the progressive nature of the disease. Studies have shown that Parkinson's patients who underwent virtual game therapy exhibited significant improvements in postural stability, balance, and activities of daily living. However, to further validate the effectiveness of virtual game therapy in improving balance and quality of life for Parkinson's patients, a meta-analysis is needed to synthesize and analyze the existing data from multiple studies. This meta-analysis would provide a comprehensive and evidence-based understanding of the effectiveness of virtual reality therapy in enhancing balance and quality of life for individuals with Parkinson's disease, thus guiding future treatment approaches and interventions.

In our review, we divided the meta-analysis into subgroups to provide more specific results depending on the type of outcome. Within outcome types, we had subgroups of balance outcomes and quality of life outcomes. There were sixteen inclusion journals that provided results on the use of virtual game therapy on balance outcomes in patients with Parkinson's disease

(Bekkers et al., 2020; Carpinella et al., 2017; Feng et al., 2019; Gandolfi et al., 2017; Gulcan et al., 2023; Heuvel et al., 2014; Kashif et al., 2022; Kolk et al., 2019; Maranesi et al., 2022; Pazzaglia et al., 2020; Pompeu et al., 2012; Qayyum et al., 2022; Santos et al., 2019; Shih et al., 2016; Yang et al., 2016; Yuan et al., 2020).In the initial subgroup analysis, we examined the efficacy of virtual game therapy for balance outcomes in Parkinson's disease. The meta-analysis revealed significant results for virtual game therapy (Pooled MD = 0.33; 95% CI [0.01, 0.64]; P < 0.00001; I2 = 74%) (Figure 1). Given the high heterogeneity, we further divided the balance outcome subgroup into smaller subdivisions.

Virtual game therapy, a derivative of virtual reality (VR) designed for Parkinson's patients, involves interaction with a computer-simulated environment through gaming. Unlike traditional virtual reality, VGT immerses patients in a game-like setting, replicating either a real or imaginary environment. Developed to enhance the balance ability and quality of life for Parkinson's patients, VGT addresses the primary pathophysiology of the disease—an insufficient level of dopamine in the rain. While pharmacological dopamine replacement therapy is effective, it cannot halt the ongoing functional decline, necessitating additional approaches such as physical therapy.

VGT engages patients in specially designed games to improve balance and coordination using motion controllers or sensors. The underlying mechanism is rooted in neuroplasticity, the brain's capacity to adapt and regenerate. By reinforcing neural pathways related to balance and coordination, VGT contributes to enhancing the balance ability of individuals with Parkinson's disease. This integrated therapy incorporates elements of balance, visual, and auditory cues within a gaming context. Enriched virtual environments provide cues that stimulate active control of the body, ultimately improving somatosensory, vestibular, and visual systems (Gandolfi et al., 2017).

In the first subdivision, we looked at the effectiveness of virtual game therapy for balanced outcomes based on the type of measuring tools. Significant meta-analysis results in the intervention group were obtained from the Berg Balance Scale (BBS) types (Pooled MD = 1.56; 95% CI [0.50,2.62]; $P< 0.004$; $I^2 = 34\%$) (Figure 2).

One of the parameters for measuring balance is the Berg Balance Scale. Berg balance scale was created by Katherine Berg in 1989 and has been used until now and proven to have high validity and reliability to measure balance so that this tool is used to assess static balance and risk of falling in people with Parkinson's disease (Miranda-Cantellops & Tiu., 2023). Berg balance scale consists of 14 tasks which are divided into 3 domains namely sitting balance, standing balance, and dynamic balance. It is an ordinal scale with a score between the range of 0-4. The score of 0 means the patient cannot perform it, and the score of 4 is given when the patient is able to complete the command independently. The maximum score is 56, obtained when the patient is able to follow 14 tasks and complete them independently. The total score range is interpreted and classified into: 0-20 (unable to stand, in a wheelchair), 21-30 (can walk with assistance), 41-56 (independent).

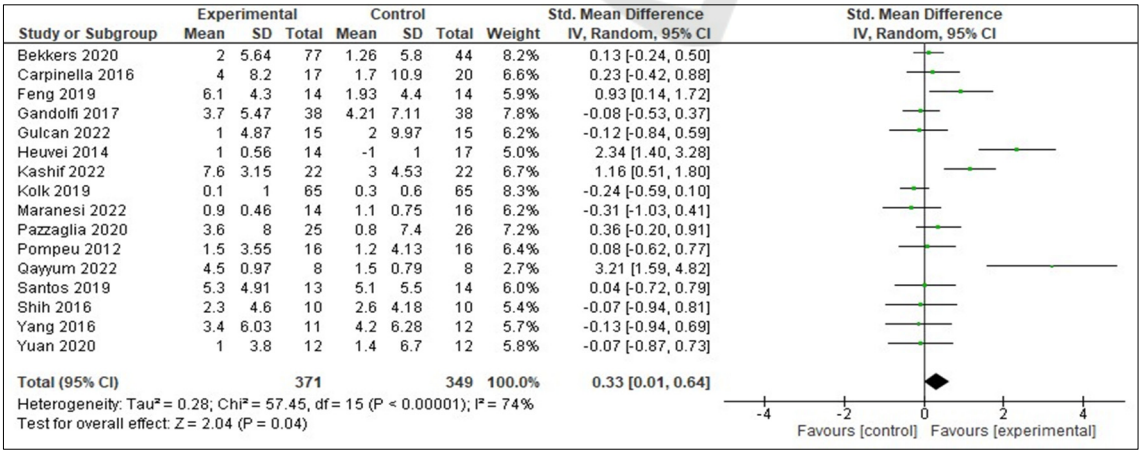

Figure 2: Meta-analysis for balance outcomes.

Other considerations for using the berg balance scale as a tool to measure balance in Parkinson's patients are flexible, which can be used in several situations such as before undergoing therapy or after undergoing therapy, cost effectiveness, time saving in several aspects, namely easy to do in several locations, only requires simple equipment, and can be learned with minimal training (Qutubuddin et al., 2005). Berg balance scale is very important, doctors or therapists will understand how the patient's balance ability and whether there is a risk of falling so that this helps in the treatment and rehabilitation plan for people with Parkinson's. Berg balance scale is valid for measuring balance not only as a screening tool but also as an ongoing assessment for patients undergoing intervention (Qutubuddin et al., 2005).

In the second segment, we examined the efficacy of virtual game therapy concerning balance outcomes based on the duration of treatment within a one-week timeframe. Significant meta-analysis findings in the intervention group were observed for a 120-minute therapy duration per week (Pooled MD = 1.94; 95% CI [1.40, 2.49]; P < 0.00001; I2 = 0%). Similarly, significant results were noted in the intervention group for a treatment duration exceeding 180 minutes per week (Figure 3).

Balance, a intricate interplay of sensorimotor control systems, relies on sensory inputs from vision, touch (proprioception), and the vestibular system (movement, balance, spatial orientation). These sensory inputs are intricately connected with motor output. As highlighted by Pazzaglia et al. (2020), a study by Pompeu et al. (2012) underscores two mechanisms contributing to the enhancement of patient balance: (1) the repetition of movements leading to automation, freeing up cognitive resources for other tasks, and (2) the training of simultaneous tasks, resulting in improved management of cognitive resources. Therefore, balance exercise therapy likely brings about improvement through repetitive practice (Pompeu et al., 2012).

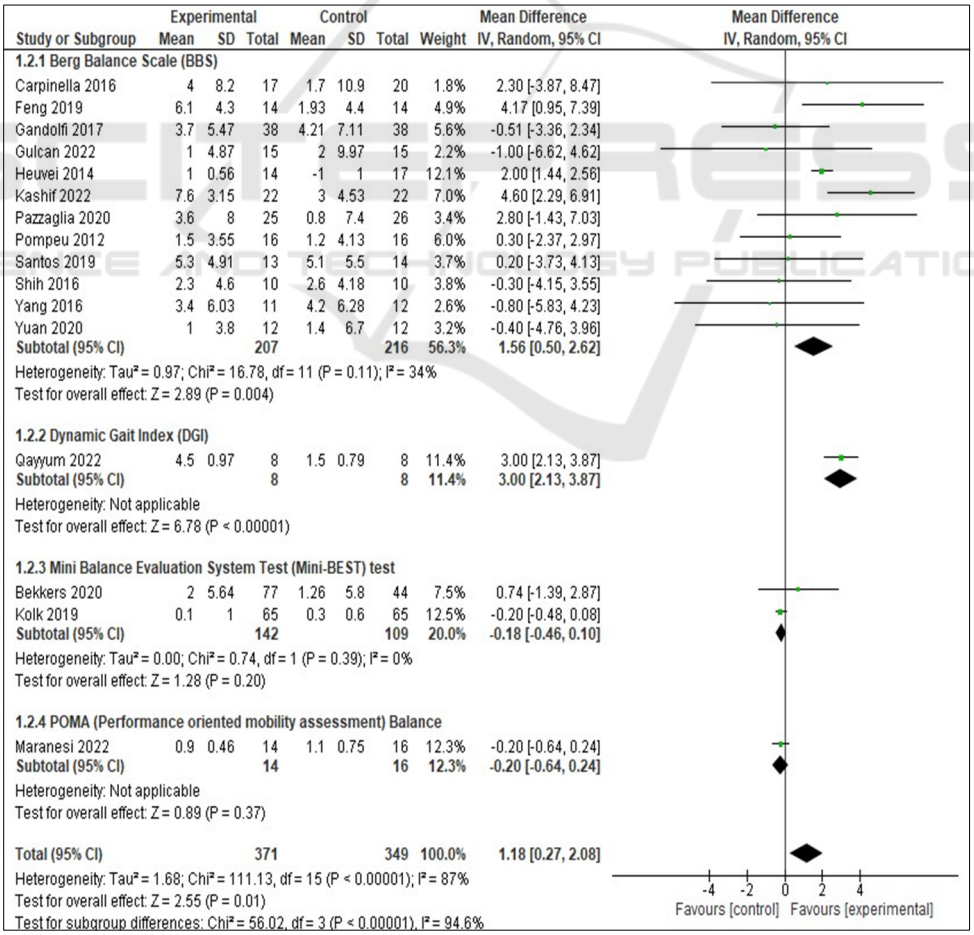

Figure 3: Meta-analysis for balance outcomes based on type of measuring tools

In the second subgroup, we looked at the effectiveness of virtual game therapy for quality of life outcomes in Parkinson's diseases. Insignificant meta-analysis results in a control group (Pooled MD= 0.12; 95% CI [-0.27, 0.51]; $P< 0.00001$; $I^2 = 76\%$) (Figure 4). The heterogenity of the data was very high, so we subdivided into smaller subdivisions.

Parkinson's disease has a progression that varies from one patient to another. The characteristics of Parkinson's disease are characterized by the presence of dominant motor symptoms in the form of dyskinesia and motor fluctuations related to quality of life (Oktariza et al., 2019).

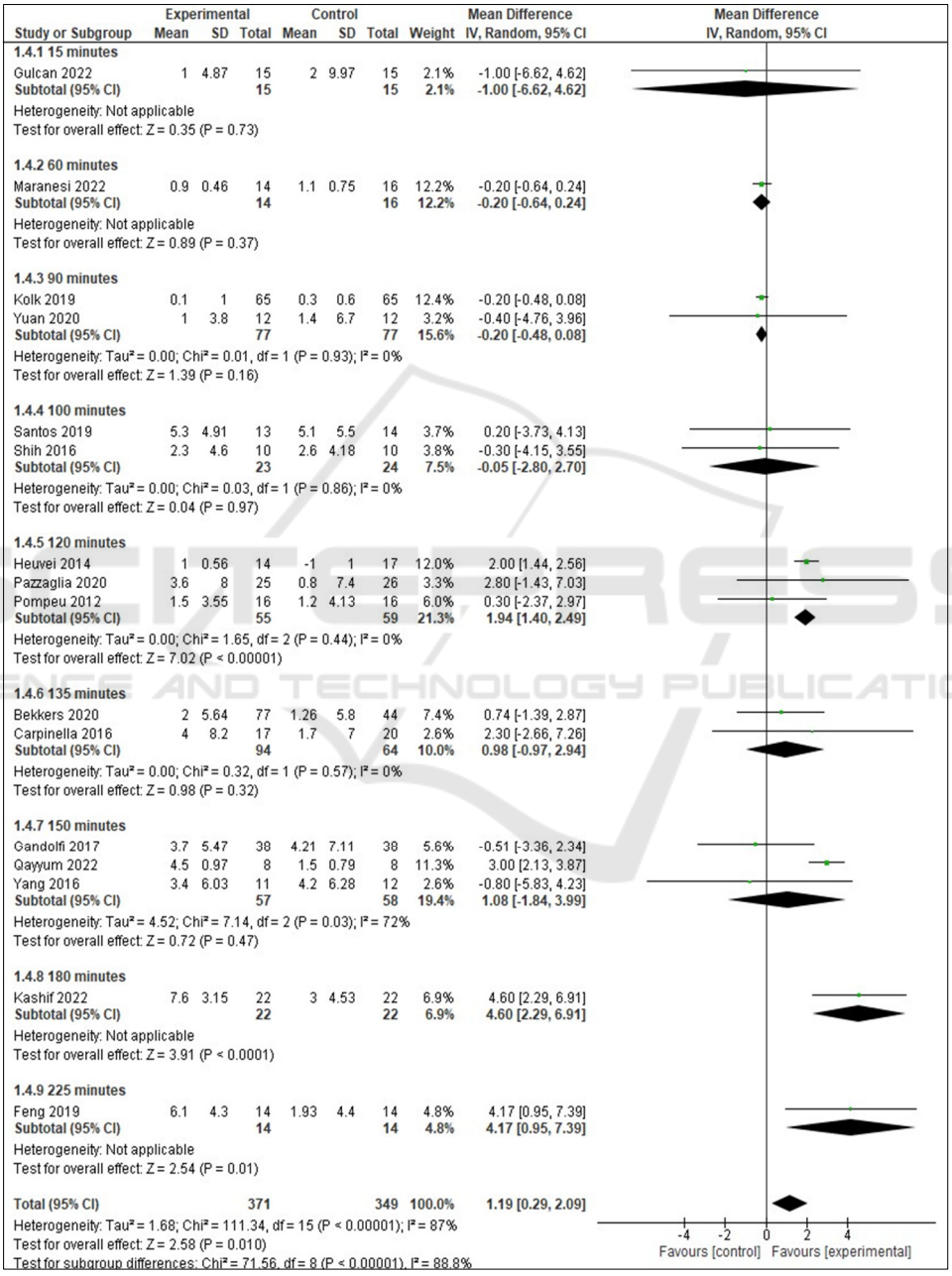

Figure 4: Meta-analysis for balance outcomes based on duration of treatment in 1 week

Virtual game therapy is formed in an entertaining mini games or travel scenes for patients to participate and reward them after completing the tasks in the game. During the use of VGT, this technique involves sensory input, brain assessment and information integration and is effective for neural control. VGT is designed to resemble a game such as completing a mission, during the process of completing the task, the patient can continuously receive feedback, thus encouraging the adjustment of movement patterns to form and restore optimal neural networks. Exercise programs using VGT can involve attractive images as well as beautiful music and positive feedback, which is very different from other conventional therapies. VGT can distract the patient's attention and make the patient psychologically reduce the fear of performing the exercise, thereby achieving a recovery effect. This VGT technology not only provides a training environment similar to the real world and meaningful task- or mission-oriented training for motor therapy, but also measures the patient's functional status before and after rehabilitation, and can improve the patient's quality of life, so that the patient's activities are no longer limited to the house, room, or even just staying in bed. With virtual game-based therapy that is carried out regularly and continuously, it will also gradually improve postural instability, stiffness in gait, and speech difficulties in people with Parkinson's disease. There are no significant side effects in the use of virtual game-based therapy, such as illness or balance problems due to, while stress levels decrease and patients' desire to do VGT therapy at home increases (Bocci et al., 2023).

In the initial section, we examined the efficacy of virtual game therapy on quality of life outcomes, utilizing different measurement tools. The intervention group showed significant meta-analysis results with the Parkinson's Disease Questionnaire (PDQ) (Pooled MD = -0.85; 95% CI [-1.58, -0.12]; P=0.02; I2 = 39%) and the 36 short-form health survey (SF-36) (Pooled MD = –7.94; 95% CI [-14.07, -1.81]; P=0.01; I2 = 0%). Conversely, the control group displayed significant results with the 12 short-form health survey (SF-12) (Pooled MD = 1.50; 95% CI [1.01, 1.99]; P<0.00001) (figure 5).

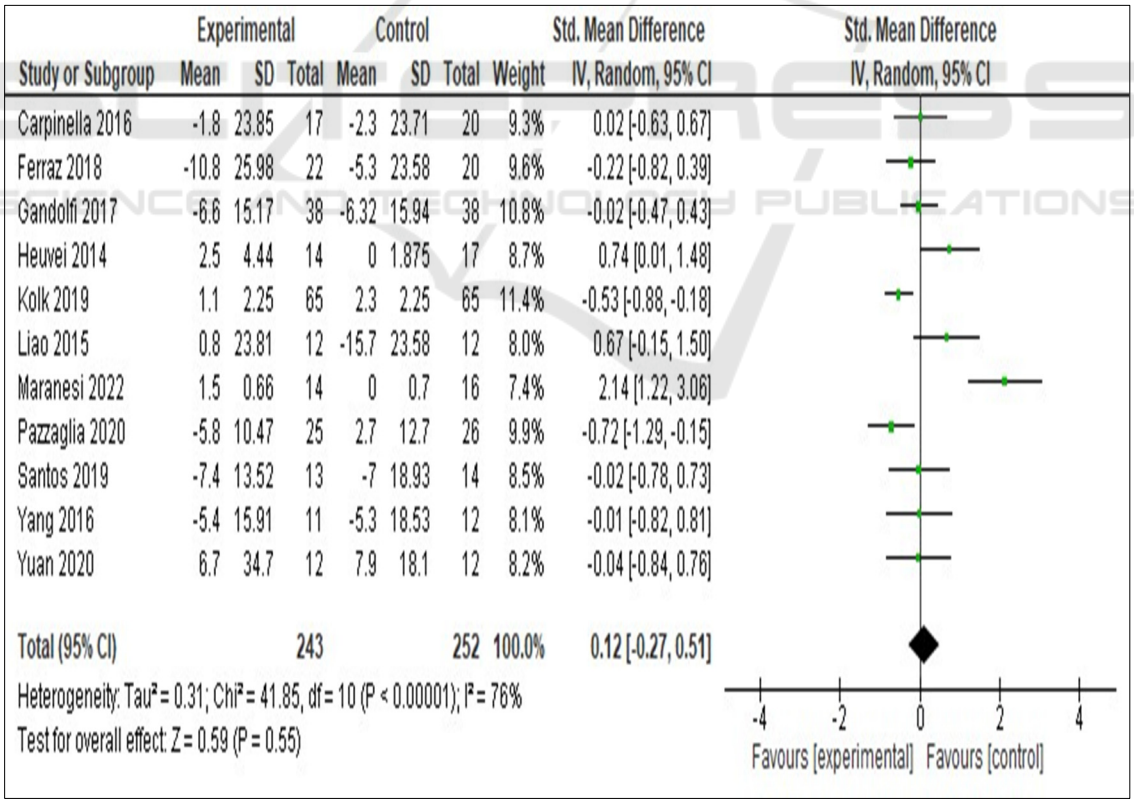

Figure 5: Meta-analysis for quality of life outcomes

The PDQ-39, a widely utilized tool for assessing the quality of life in Parkinson's patients, comprehensively evaluates various life aspects impacted by the disease. Covering mobility, daily activities, emotional well-being, stigma, social support, cognition, communication, and bodily discomfort, the 39-item self-administered questionnaire provides a holistic view of Parkinson's impact on an individual's life.

Validated and reliable, the PDQ-39 is a crucial tool for evaluating health-related quality of life in Parkinson's patients. It quantifies the disease's impact on daily living, offering valuable insights into the subjective experience. Widely employed in clinical trials, research studies, and routine practice, it aids in assessing intervention effectiveness, tracking disease progression, and informing treatment decisions (Al-Khammash et al., 2023).

In the subsequent section, we assessed the impact of virtual game therapy on quality of life outcomes concerning the duration of treatment within a one-week timeframe. Notably, significant meta-analysis findings in the intervention group emerged from a 90-minute therapy session per week (Pooled MD = -1.17; 95% CI [-1.94, -0.40]; P=0.003; I2 = 40%) (Figure 6). The results of this meta-analysis are not clear because significant results in the intervention group were only obtained at 90 minutes a week, and for more than that duration showed insignificant results. This may be because the more repetitions of the duration of therapy resulted in more saturation of patients so as to reduce the quality of life, but it should be noted that there are no studies that support this hypothesis.

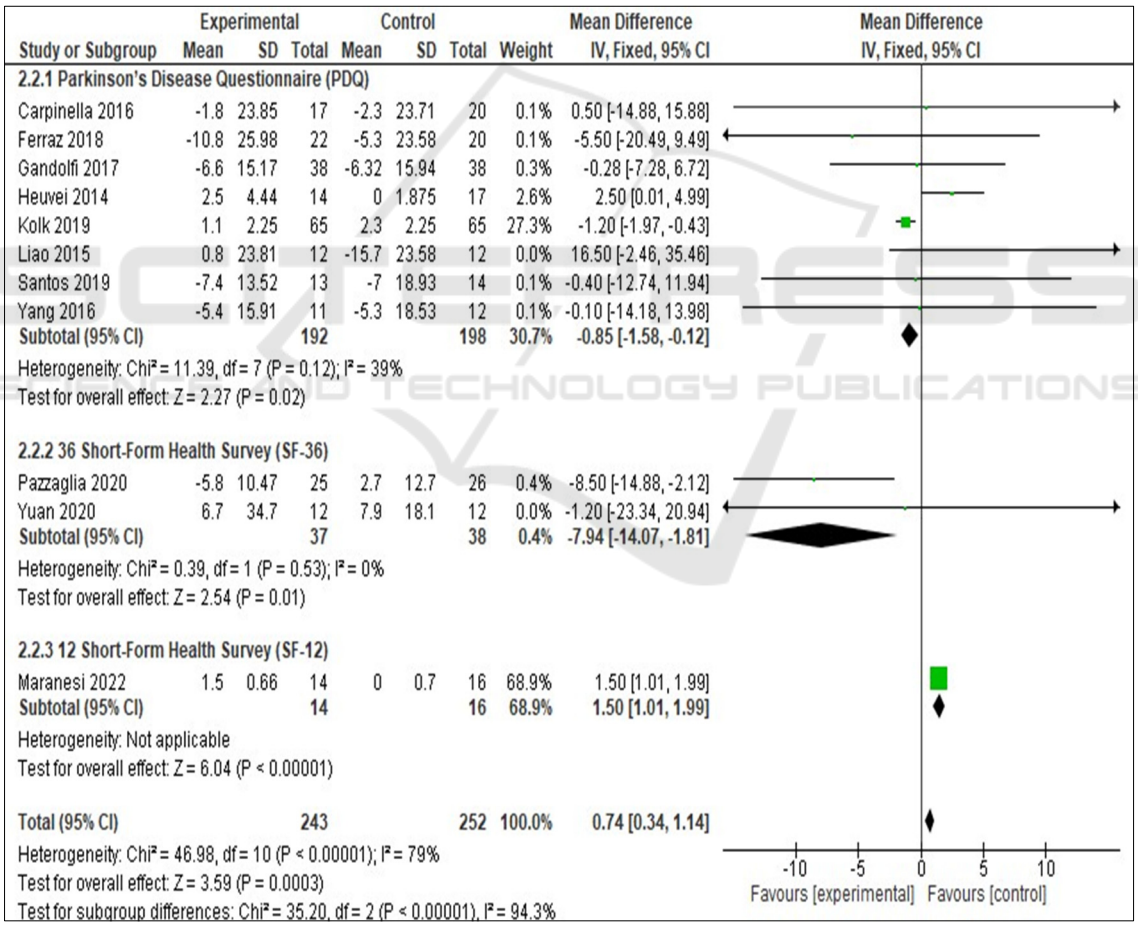

Figure 6. Meta-analysis for quality of life outcomes based on type of measuring tools

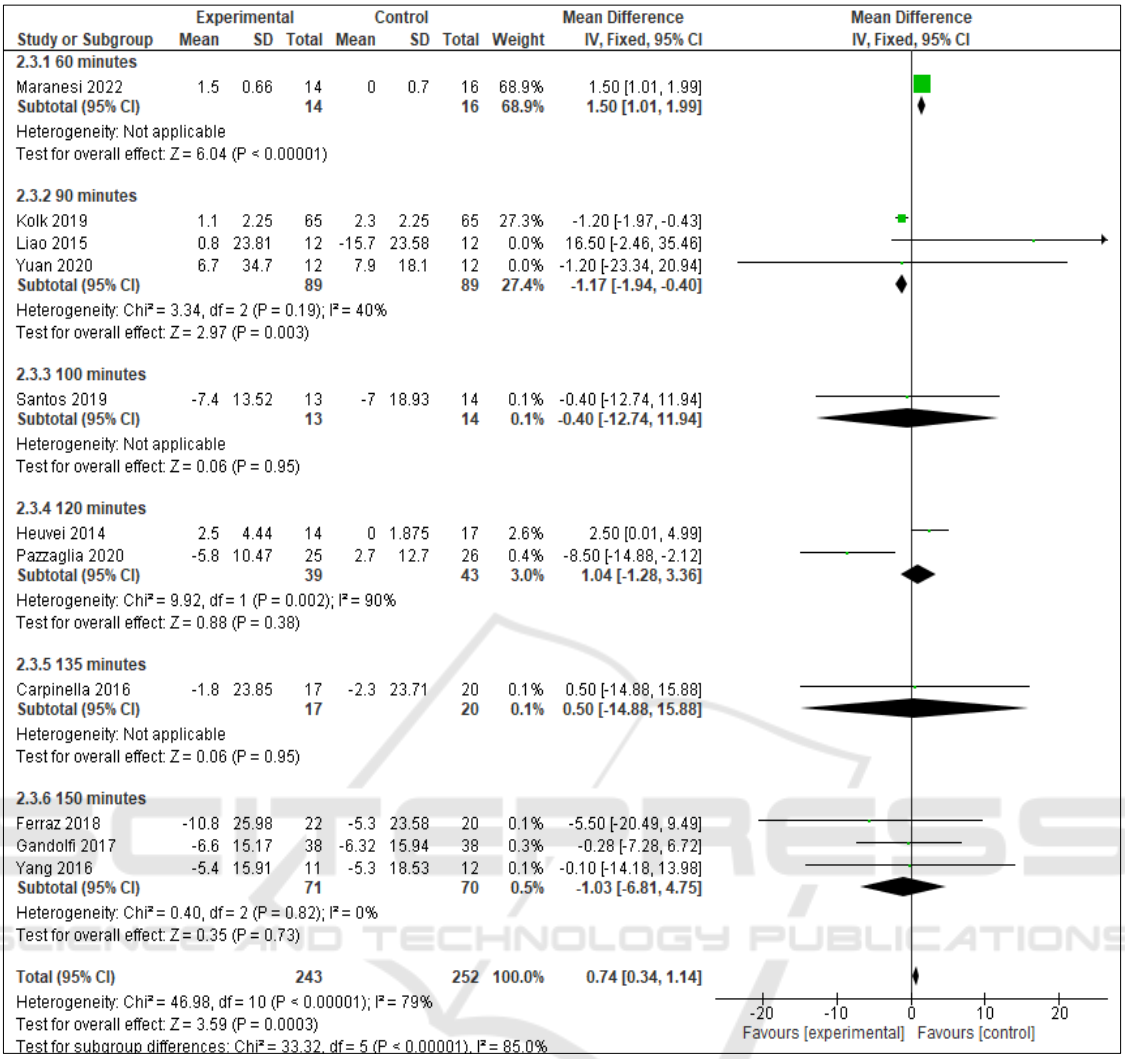

Figure 7. Meta-analysis for quality of life outcomes based on duration of treatment in 1 week

4 CONCLUSIONS

4.1 Conclusion

The objective of this systematic review and meta-analysis was to assess the efficacy of virtual game therapy for individuals with Parkinson's disease. The examination of randomized controlled trials revealed substantial enhancements in both balance and quality of life when compared to control interventions. These study outcomes add valuable insights to the current understanding of treatment options for Parkinson's patients, emphasizing the potential effectiveness of virtual game therapy as a viable treatment approach. Other findings found in our study are: 1) virtual game therapy is the most effective therapy for increasing the balance ability, 2) virtual game therapy is the most effective therapy for increasing the quality of life, 3) virtual game therapy is more effective for increasing balance ability if the treatment given for 120 minutes in 1 week, or like 30 minutes (4 times/week) or 60 minutes (2 times/week).

4.2 Suggestion

Future research should focus on comparing different durations of intervention in virtual game therapy to prove the results of our meta-analysis. More randomized controlled trials with low risk of bias is needed for more good quality of analysis. Future studies need to examine the effects of virtual game therapy for Parkinson's patients with more

homogenous study designs, and also a larger population.

4.3 Strength and Limitation

This is an updated research to discuss virtual game therapy and its correlation to balance and quality of life outcomes for Parkinson's patients while previous studies looked at 2022 and only assessed balance outcomes. Here we added 4 recent articles that make this study more updated. We assessed comprehensively and successfully recommended an effective time for virtual game therapy administration. Due to variations in our journal (table 2) such as sample size, duration of treatment, and scales used, we decided to divide this meta-analysis into several subgroups and subsections. The drawback of this study is that the large number of journals included in the inclusion has some risk of bias issues in various domains.

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APPENDIX

First Appendix: Study Selection

Keywords:

PubMed

No.	Search	Result
#1	Parkinson disease[MeSH Terms] filters: Randomized Controlled Trial, in the last 10 years	1.171
#2	Game OR games OR virtual filters: Randomized Controlled Trial, in the last 10 years	3.588
#3	Balance OR quality of Life filters: Randomized Controlled Trial, in the last 10 years	31.196
#4	((parkinson disease[MeSH Terms] AND ((y_10[Filter]) AND (randomized controlled trial[Filter]))) AND (game or games or virtual AND ((y_10[Filter]) AND (randomized controlled trial[Filter])))) AND (balance or Quality of Life AND ((y_10[Filter]) AND (randomized controlled trial[Filter])))	25

	AND ((y_10[Filter]) AND (randomized controlled trial[Filter]))	

Total : 25

Cochrane

No.	Search	Result
#1	MeSH descriptor: [Parkinson Disease] explode all trees	6.251
#2	Game OR games OR virtual	38.826
#3	Balance OR quality of life OR QOL	199.948
#4	Randomized controlled trial OR randomised controlled trial OR randomized clinical trial OR randomised clinical trial	1.036.178
#5	#1 AND #2 AND #3 AND #4	73

Total : 73

Embase

(parkinson disease[MeSH Terms] AND (game OR games OR virtual) AND (balance OR Quality of Life)

Total : 17