Original Article

Acceptance, safety, and impact on quality of life of exergame for elderly patients with neurodegenerative diseases: A systematic review and meta-analysis

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Abstract

The aim of this study was to evaluate the efficacy, safety, adherence, and acceptance of exergame in improving the quality of life (QoL) among elderly patients with neurodegenerative diseases. A systematic search was conducted in PubMed, Embase and Scopus for relevant studies up to 16 March 2023. Quality of the included studies were assessed using Cochrane's Risk of Bias tool version 2.0. Meta-analysis using a random effect was conducted on outcomes reported at least by two studies to calculate the standard mean difference (SMD) and its 95% confidence interval (CI). The difference of influence between exergame and conventional therapy was judged based on *Z*- and *p*-values. Heterogeneity was determined by I^2 score. As many as 15 studies were included (n=466 participants) published between 2013–2023. Nine studies had 'high quality' five studies had 'some concerns', and one had 'high risk'. Results from meta-analyses suggests that the exergame does significantly not improve the QoL among patients with Parkinson's diseases. Similarly, no statistically significant difference ($p>0.05$) of QoL improvement among Alzheimer's disease patients receiving exergame intervention. No adverse effects were reported to be associated with the intervention, and in fact, the patients experienced reduced fatigue and fear of falling. Patients in intervention group showed high acceptance and adherence to the therapy, which could be attributed to exergame being enjoyable, easy-to-use, and motivational. In conclusion, despite exergame being highly acceptable and relatively safe, the intervention does not improve the QoL of the elderly patients.

Keywords: Acceptance, elderly, exergame, neurodegenerative, quality of life

Introduction

Neurodegenerative diseases affect millions of people due to the increasing aging rate of the worldwide population [1]. They are characterized by the progressive deposition of specific proteins within district areas of the brain and progressive loss of sensory-motor and cognitive functions [2-4]. Out of many different types of neurodegenerative diseases, Alzheimer's (AD), Parkinson's (PD), Huntington's diseases (HD), and multiple sclerosis (MS) are the most prevalent [5].

In general, these diseases have typical symptoms, namely weakness, fatigue, motor impairment, ataxia, dysphagia, urinary complications, sensory loss, depression, cognitive decline, sleep disorders, and so on [6]. These conditions could be developed into severe symptoms

Received: September 7, 2023 - Accepted: December 31, 2023 - Published online: January 3, 2024

affecting the daily living of the sufferer's [7,8]. Data suggest that patients with neurodegenerative disease present lower levels of health-related quality of life (QoL) in emotional, physical, and social terms than that of the general population [6].

Standard rehabilitation consists of conventional physical training (including aerobic exercise or other exercises that aim to improve muscle strength, physical function, balance control, and flexibility) and cognitive training (completing puzzles, painting, drawing, playing dominoes, crosswords, and playing word games). Unfortunately, conventional rehabilitation is still considered inefficient and provides a long recovery period [9]. The traditional clinical setting for therapy is often expensive and suffers from poor adherence. Thus, experts have suggested the urgency of improving rehabilitation efficacy through innovation and technology.

Exergame is a technology that provides physical and cognitive training simultaneously by combining exercise and gaming activities. Exergame requires its users to engage in physical activities and multiple players interaction, where they can share learning experiences and feel challenged at each difficulty level [10]. Dancing, boxing, bating, running, and puzzle solving through quests are among many other fun and exciting activities the patients could experience when using an exergame. Through gamified techniques, exergame allows patients to receive rehabilitation at home. The gamified therapy performed in the clinic can be installed at the patient's home ensuring the continuity of the rehabilitation [11]. Moreover, all people across generations are interested in playing games [12].

Further, many games have been designed specifically for healthcare services. Different games are tailored for various disorders according to the requirements of the patients. That is, the games are customized individually according to the patients' needs. These exergames are included in the rehabilitation process since they combine the benefits of gaming as well as exercising. The virtual reality games facilitate people to substitute their sedentary screen time with physical activities [13]. Unfortunately, the impacts of exergame on QoL have not been extensively evaluated and summarized in a frame of a comprehensive review. Herein, a systematic review and meta-analysis were performed to evaluate the efficacy of exergame in improving the QoL among patients with neurodegenerative diseases. Safety of exergame and the patients' acceptance toward this technology were also evaluated.

Methods

Search strategies

The literature search was performed for randomized control trials published from January 2008 (the first year of exergames studies exists) through March 2023 on three major scientific literature databases, which are PubMed, EMBASE, and Scopus. It was conducted using the following keywords: "elderly", "neurodegenerative", "Alzheimer's disease", "Parkinson's disease", "Huntington's disease", "Multiple sclerosis", "exergame", "quality of life", "safety", and "acceptance". Detailed keyword combinations used in this study are presented in **Table 1**.

Inclusion criteria

Inclusion criteria that are considerable for eligibility were based on the PICOS (population, intervention, control, outcome, and study design) framework. The population was neurodegenerative patients (Parkinson's disease, Alzheimer's disease, Huntington's disease and multiple sclerosis) over the average age of 60 years. We included studies with investigated exergame-based interventions consisting of augmented reality or virtual reality, where the control group received conventional exercise or no intervention. Outcome measured in this study was QoL, acceptance, and safety. Only randomized controlled trials (RCTs) were included.

Exclusion criteria

The exclusion criteria were as follows: (1) healthy people as the control group; (2) the subject had other neurodegenerative diseases than Parkinson's disease, Alzheimer's disease, Huntington's disease or multiple sclerosis; (3) irrelevant outcome; (4) studies published before 2008; (5) severe sensory impairments (mainly visual, auditory, or color blindness); (6) published in languages other than English; (7) review article, case report, conference proceedings, and abstract,

editorials, or commentaries; (8) no full access to full-text; and (10) the patients had severe cardiac disease, uncontrolled diabetes, a history of stroke, traumatic brain injury, a seizure disorder, and other severe systemic diseases.

Table 1. Search strategy in each database

Database	Search strategy
PubMed	(old OR older OR elderly OR aged OR geriatric OR “older people”) AND (exergame OR exergaming OR “virtual reality” OR “virtual world” OR “video game” OR “active video game” OR “human computer interaction” OR “augmented reality” OR “electronic game” OR “active game play” OR “virtual rehabilitation” OR “augmented rehabilitation” OR wii OR kinect OR “balance board" OR “Dance Dance Revolution” OR “digital exercise”) AND (“quality of life” OR “health-related quality of life” OR “life quality” OR HRQOL OR acceptance OR acceptability OR safety) AND (“alzheimer’s disease” OR alzheimer OR “alzheimer’s dementia” OR “parkinson’s disease” OR “parkinson” OR “huntington’s disease” OR “huntington” OR “multiple sclerosis” OR “demyelinating disease” OR neurodegenerative)
EMBASE	(TITLE-ABS-KEY((old* OR elderly OR aged OR geriatric OR "older people"))) AND TITLE-ABS-KEY((exergam* OR "virtual reality" OR "virtual world"OR "video game" OR "active video game" OR "human computer interaction" OR "augmented reality" OR "electronic game" OR "active game play" OR "virtual rehabilitation" OR "augmented rehabilitation" OR wii OR kinect OR "balance board" OR "dance dance revolution") AND TITLE-ABS-KEY(("quality of life" OR "health related quality of life" OR "life quality" OR HRQOL OR Acceptance OR Acceptability OR Safety)) AND TITLE-ABS-KEY((“Alzheimer’s disease” OR alzheimer OR “alzheimer’s dementia” OR “Parkinson’s disease” OR “parkinson” OR “huntington’s disease” OR “huntington” OR “multiple sclerosis” OR “demyelinating disease” OR neurodegenerative))
SCOPUS	(old*:ti,ab,kw OR elderly:ti,ab,kw OR aged:ti,ab,kw OR geriatric:ti,ab,kw OR 'older people':ti,ab,kw) AND (exergam*:ti,ab,kw OR 'virtual reality':ti,ab,kw OR 'virtual world':ti,ab,kw OR 'video game':ti,ab,kw OR 'active video game':ti,ab,kw OR 'human computer interaction':ti,ab,kw OR 'augmented reality':ti,ab,kw OR 'electronic game':ti,ab,kw OR 'active game play':ti,ab,kw OR 'virtual rehabilitation':ti,ab,kw OR 'augmented rehabilitation':ti,ab,kw OR wii:ti,ab,kw OR kinect:ti,ab,kw OR 'balance board':ti,ab,kw OR 'dance dance revolutions;ti,ab,kw':ti,ab,kw OR 'digital exercise':ti,ab,kw) AND ('quality of life':ti,ab,kw OR 'health-related quality of life':ti,ab,kw OR 'life quality':ti,ab,kw OR hrqol:ti,ab,kw OR acceptance:ti,ab,kw OR acceptability:ti,ab,kw OR safety:ti,ab,kw) AND ('alzheimer disease':ti,ab,kw OR alzheimer:ti,ab,kw OR 'alzheimer dementia':ti,ab,kw OR 'parkinson disease':ti,ab,kw OR parkinson:ti,ab,kw OR 'huntington disease':ti,ab,kw OR huntington:ti,ab,kw OR 'multiple sclerosis':ti,ab,kw OR 'demyelinating disease':ti,ab,kw OR neurodegenerative:ti,ab,kw) AND [2008-2023]/py

Screening and study selection

Two authors (G.T & M.A) adapted Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines that can be accessed through (http://www.prisma-statement.org) into the process of literature screening and selection of this study. The 404 total studies we searched were imported to Zotero 6 (zotero.org) and duplicates removed were performed automatically. Titles and abstracts of studies were screened to identify potential studies that met the inclusion criteria. The full texts of these studies were retrieved and independently assessed for eligibility. The full texts of these studies were independently retrieved and reviewed for eligibility. Thirteen studies were included to be extracted for the assessment of the QoL, safety, and acceptance. Hand-picked articles that met the criteria were also included in this systematic review. In the end, fifteen studies were concluded and extracted into primary outcomes.

Data extraction

Study data were also extracted by the same reviewer as the screening. The extracted data included QoL, safety and acceptance. We also extracted the relevant study information, including the first author, country/location, age, sample size (male/female), stage of disease (according to Hoehn and Yahr scale), interventions, the duration and length of intervention, the comparison group, assessments, and outcome measures. Any ambiguity (e.g. The different selections or judgment of outcome measures) met by these two reviewers was discussed with the help of the third reviewer (T.F.D).

Outcomes measures

The primary outcome that was assessed in this systematic review was the impact on QoL, safety, and acceptance for using exergame as a beneficial exercise method rather than the conventional one. There are many variants for neurodegenerative QoL measurement tools. For Parkinson's disease, 39-item Parkinson's Disease questionnaire (PDQ-39) and 5-dimension questionnaire developed by EuroQol (EQ-5D) were used. As for the Alzheimer's disease, QoL in Alzheimer's disease (QoL-AD) was used. The tools have different focuses, domains, and ways to measure and interpret the responses. Safety was assessed by a number of adverse events such as falls, muscle soreness, excessive fatigue during the follow-up period, reduction of the fatigue severity scale (FSS), and a specially designed questionnaire. Acceptance defined by the willing of the patient to use and engage with the exergame. The outcomes were described and extracted into tables.

Quality assessment of studies

The two reviewers (M.A.N & G.T) separately evaluated the studies in the same timeline, April 2023. The studies that met the inclusion criteria after systematic screening adopted R.O.B 2.0, which recommended a tool to assess the risk of bias in randomized trials included in Cochrane Reviews. 5 domains were assessed to define the risk of bias.

Data synthesis and analysis

Meta-analysis was only performed for outcomes that are reported in at least two studies. Forest plots were generated on the software developed by Cochrane Collaborations – RevMan version 5.4.1. Mean differences and standard deviation with 95% confidence interval (Cl) and *p*-value were extracted from the study intervention versus control. Meta-analysis using a random effect was carried out on outcomes reported at least by two studies to calculate the standard mean difference (SMD) and its 95% confidence interval (CI). The difference of influence between exergame and conventional therapy was judged based on *Z*- and *p*-values. Heterogeneity was determined by I^2 score. *P*-value <0.05 was considered as statistically significant and I^2 >50% — highly heterogenous.

Results

Search result and study characteristics

The PRISMA flow diagram for the included studies based on the eligibility criteria in this review has been presented in **Figure 1**. As many as 15 studies met the inclusion criteria and were included in this review participated by a total number of 466 patients (59% male) ranging from 10 to 25 participants per group. All of the included studies were randomized clinical trials. Among these studies, the average age of participants ranged from 61 to 81 years old. Studies were conducted in Australia, Italy, Brazil, Taiwan, Switzerland, Hungary, and the United States of America. Summary of the characteristics of the included studies along with their outcomes has been presented in **Table 2**. We included 3 meta-analyses: (1) PDQ-39 QoL of Parkinson's disease consists of 9 studies, (2) EQ-5D QoL of Parkinson's disease consists of 2 studies, and (3) AD-QoL of Alzheimer's disease that consist of 2 studies.

Quality appraisal

The results from the quality appraisal of the included studies have been presented in **Figure 2**. As many as nine studies were found to have passed all Cochrane's risk of bias criteria, indicating them as high-quality studies [14,15,17–19,22,23,25,26]. Five studies were found to have some concerns [16,21,24,27,28], where three of them were derived from missing outcome data [16,21,24], while two others were because of deviation from the intended intervention and biased measurement [27,28], respectively. A study was marked with a high risk of bias due to missing outcome data [20].

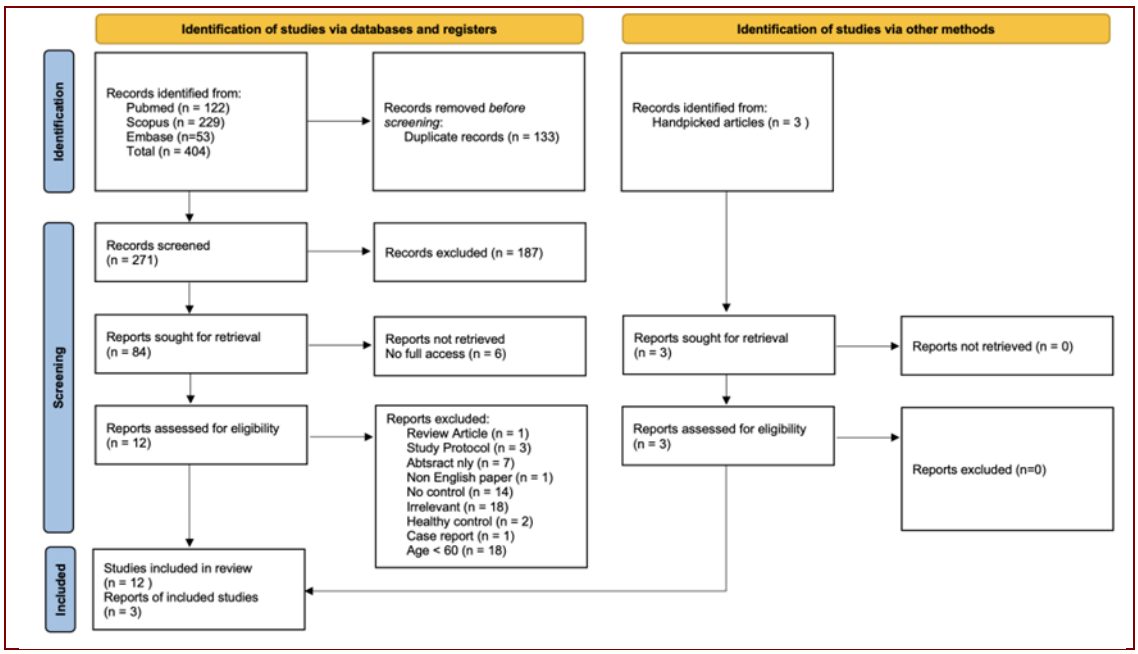

Figure 1. PRISMA flow diagram for the screening and selection process of the published studies

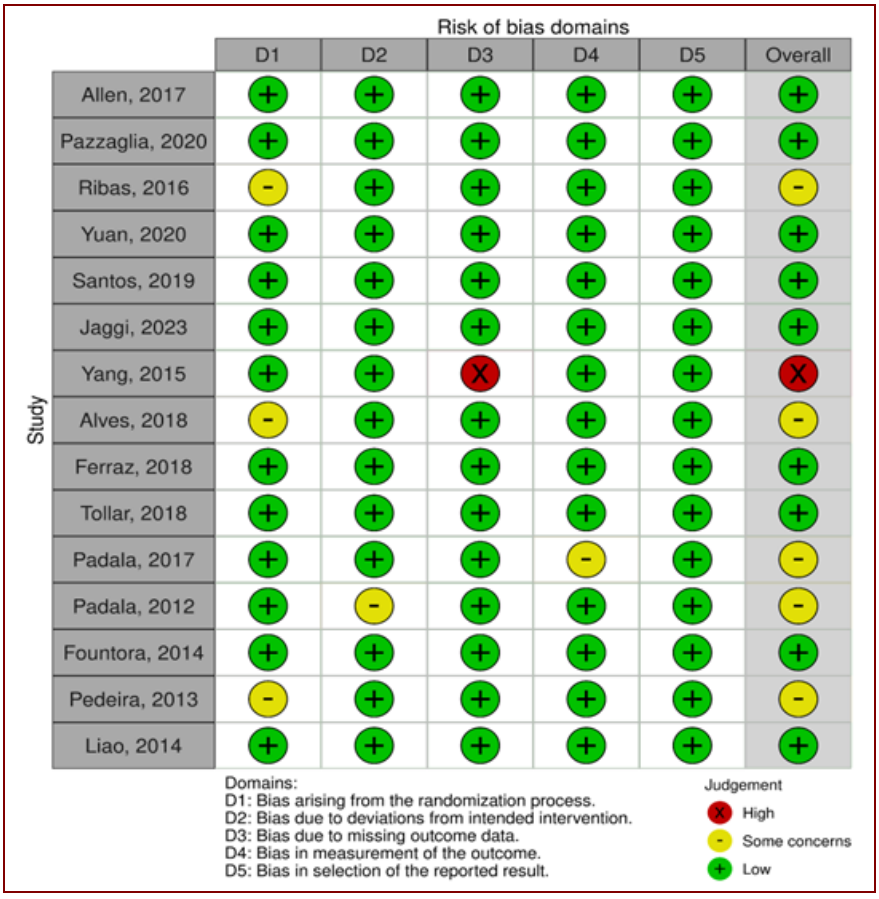

Figure 2. Traffic light plot (a) and summary plot (b) for RoB 2.0 assessment results.

Table 2. Baseline characteristic and the quality of life

Author, year [Ref]	Country	Disease	Characteristic		Treatment		QoL
			Experiment	Control	Experimental	Control	
Allen *et al.*, 2017 [14]	Australia	Parkinson's Disease	n= 19 Age, year: 67.5±7.3 M/F: 12/7 MMSE: 28.8±1.0	n= 19 Age, year: 68.4±8.5 M/F: 11/8 MMSE: 28.6±1.1	Perform the exergames 3x/week for 12 weeks, while on medication	Received usual care, 3x/week for 12 weeks, while on medication	↔
Pazzaglia *et al.*, 2020 [15]	Italy	Parkinson's Disease	n= 25 Age, year: 72±7 M/F: 18/7	n= 26 Age, year: 70±10 M/F: 17/9	VR was performed 40-minute session, 3x/week, 6 weeks	Conventional rehabilitation. 40-minute session, 3x/week, 6 weeks	↑
Ribas *et al.*, 2016 [16]	Brazil	Parkinson's Disease	n= 10 Age, year: 61.70 ± 6.83 M/F: 4/6 Stage: I-III MMSE: 27.5 (1.5)	n= 10 Age, year: 60.20 ± 11.29 M/F: 4/6 Stage: I-III MMSE: 27.5 (0,75)	Exergame, 30-minute session, 2x/week, 12-week period	Conventional Exercise, 30-minute session, 2x/week, 12-week period	↔
Yuan *et al.*, 2020 [17]	Taiwan	Parkinson's Disease	n=12 Age, year: 67.8 ± 5.5 M/F: 2/10 Stage: I-III MMSE: 28.5 ± 1.7	n=12 Age, year: 66.5 ± 8.8 M/F: 9/3 Stage: I-III MMSE: 26.0 ± 2.6	IVGB Training for 30 minute training, 6 weeks	No exercise	↔
Santos *et al.*, 2019 [18]	Brazil	Parkinson's Disease	n=13 Age, year: 61.7 ± 7.3 M/F: 11/2 Stage: I-III	n=14 Age, year:64.5 ± 9.8 M/F: 11/3 Stage: I-III	Nintendo Wii + Conventional Exercise 50 min/day, 2x/weeks for 8 weeks	Conventional exercise, 50 min/day, 2x/weeks for 8 weeks	↑
Jaggi *et al.*, 2023 [19]	Switzerland	Parkinson's Disease	n=21 Age, year: 71.89±9.09 M/F: 12/7 Stage: I-IV MMSE: 27.79±1.55	n=21 Age, year: 72.86±10.14 M/F: 15/6 Stage: I-IV MMSE: 27.57±2.71	Exergame + conventional training, 15 min/session, 5 times/week	Conventional training	NR
Yang *et al.*, 2016 [20]	Taiwan	Parkinson's Disease	n=10 Age, year: 72.5±8.4 M/F: 7/4 Stage: II-III MMSE: 27.5±4.0)	n=10 Age, year: 75.4±6.3 M/F: 7/5 Stage: II-III MMSE: 27.2±2.5	VR balance training, 12 sessions, 2x/week, 6 weeks	Conventional balance, 12 sessions, 2x/week, 6 weeks	↔
Alves *et al.*, 2018 [21]	Brazil	Parkinson's Disease	n=9 Age, year: 58.89±11.16 M/F: 9/0 Stage: I-III MMSE: 27.11±2.8	n=9 Age, year: 61.67±10.74 M/F: 8/1 Stage: I-III MMSE: 25.44±2.29	Nintendo Wii, 2x/weeks, 5 weeks, on medication	No intervention	↑
Alves *et al.*, 2018 [21]	Brazil	Parkinson's Disease	n=9 Age, year: 62.67±13.81 M/F: 8/1 Stage: I-III MMSE: 27.44±2.35	n=9 Age, year: 61.67±10.74 M/F: 8/1 Stage: I-III MMSE: 25.44±2.29	Xbox KinectTM, 2x/weeks,5 weeks, on medication	No intervention	↔

Author, year [Ref]	Country	Disease	Characteristic		Treatment		QoL
			Experiment	Control	Experimental	Control	
Ferraz *et al.*, 2018 [22]	Brazil	Parkinson's Disease	n=20 Age, year: 67±0.53 M/F: 10/10 Stage: II-III MMSE: 26.85±0.80	n=20 Age, year: 67.14±1.87 M/F: 11/9 Stage: II-III MMSE: 27±1.07	Kinect, 50-minutes/session, 3x/week for 8 weeks	Functional training, 50-minutes/session, 3x/week for 8 weeks	↑
Tollar *et al.*, 2018 [23]	Hungary	Parkinson's Disease	n=25 Age, year: 70.0±4.69 M/F:12/13 Stage: II-III	n=25 Age, year: 70.6±4.10 M/F:11/14 Stage: II-III	Exergame use Xbox 360 core system,1 hour/ sessions over 5 weeks, three-5-week-long waves	Bicycle ergometer, rode 110-140 m/s, three-5-week-long waves	↔
Pedreira *et al.*, 2013 [24]	Brazil	Parkinson's Disease	n=16 Age, year: 61.1 ± 8.2 M/F: 11/5 Stage: I-III	n=15 Age, year: 66.2 ± 8.5 M/F: 11/4 Stage: I-III	Exergame using Nintendo Wii, 40 minutes/session, 3 days/week for 4 weeks.	Physical therapy program, 40 minutes/session, 3 days/week for 4 weeks.	↑
Liao *et al.*, 2014 [25]	Taiwan	Parkinson's Disease	n=12 Age, year: 67.3±7.1 M/F: 6/6 Stage: I-III MMSE: 29.5±0.7	n=12 Age, year: 64.0 ±30 M/F: 5/7 Stage: I-III MMSE: 29.7±0.6	VR-based Wii Fit exercise + treadmill training, 2 sessions/week, 6 weeks	Fall-prevention education	↑
Fontoura *et al.*, 2017 [26]	Brazil	Parkinson's Disease	n=10 Age, year: 63±7 M/F: 7/3 Stage: I-III	n=10 Age, year: 62±8 M/F: 9/1 Stage: I-III	VR + conventional physiotherapy. 60 minutes/session 2 sessions/week, 5 weeks	Conventional physiotherapy, 60 minutes/session 2 sessions/week, 5 weeks	↑
Padala *et al.*, 2017 [27]	USA	Alzheimer's Disease	n= 15 Age, year: 72.1±5.3 M/F: 10/5 MMSE: 23.3 (2.2)	n=15 Age, year: 73.9±7.1 M/F: 13/2 MMSE: 22.7±2.3	Wii-Fit program, 30 minutes/session, 5 days/week for 8 weeks	Walking exercise, 30 minutes/session, 5 days/week for 8 week	↑
Padala *et al.*, 2012 [28]	USA	Alzheimer's Disease	n=11 Age, year:79.3±9.8 M/F: 3/8 MMSE: 22.6±4.3	n=11 Age, year:81.6±5.2 M/F: 3/8 MMSE: 22.0±4.1	Wii-fit training, 30 minutes/session, 5 times/week for 8 weeks	Walking exercise 30 minutes daily, 5/w, for 8 weeks	↔

M/F, male/female; MMSE, mini-mental state examination; NR, not reported
↔, not significant; ↑, significant

Quality of life among Parkinsons's disease patients based on PDQ-39 score

The results of the random effect meta-analysis of the QoL-based on PDQ-39 have been presented in **Figure 3**. The effect of exergame therapy on QoL was assessed in nine studies [14,15,17–19,22,23,25,26] according to PDQ-39 overall mean score. The effect of exergame therapy on QoL favored the experimental group but was not statistically significant (n= 9, SMD= -0.08, 95%CI: -0.31–0.16, p= 0.53). The I^2 of this analysis was unobservable (0%).

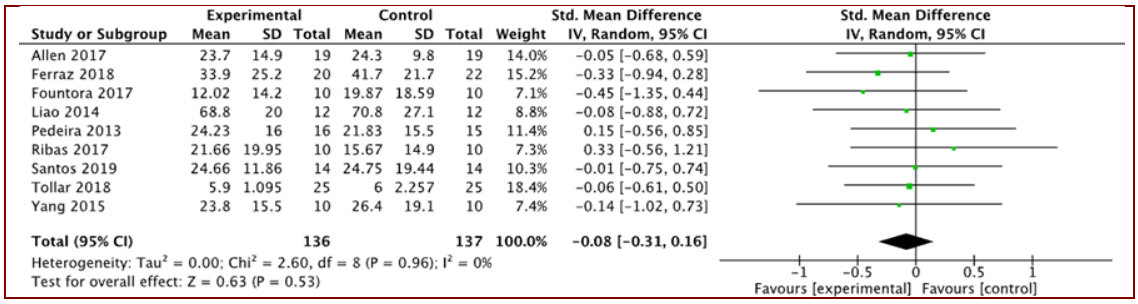

Figure 3. The result of exergame in alleviating quality of life in Parkinson disease patients using PDQ-39 tools

Quality of life among Parkinsons's disease patients based on Euroqol-5D score

The results of the random effect meta-analysis of the quality based on Euroqol-5D only assessed in 2 studies [22,23] and are presented in **Figure 4**. The effect of exergame therapy on QoL favored the experimental group but was not statistically significant (n= 2, SMD= -0.27, 95%CI: -0.79–0.24, p= 0.30). The I^2 of this analysis was no more than 50% (35%).

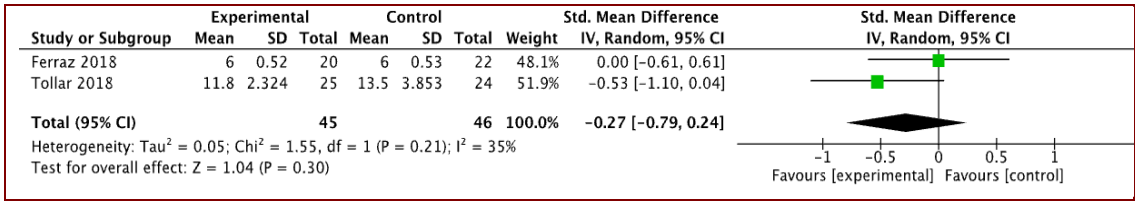

Figure 4. The result of exergame in alleviating quality of life in Parkinson's disease patients using Euroqol-5D tools

Quality of life among Alzheimer's disease patients

The results of the random effect meta-analysis of the quality based on the QoL-AD were only assessed in 2 studies [27,28] and have been presented in **Figure 5**. The effect of exergame therapy on QoL favored the experimental group but was not statistically significant (n= 2, SMD= -0.21, 95%CI: -0.33–0.76, p= 0.44). The I^2 of this analysis was abandoned (0%).

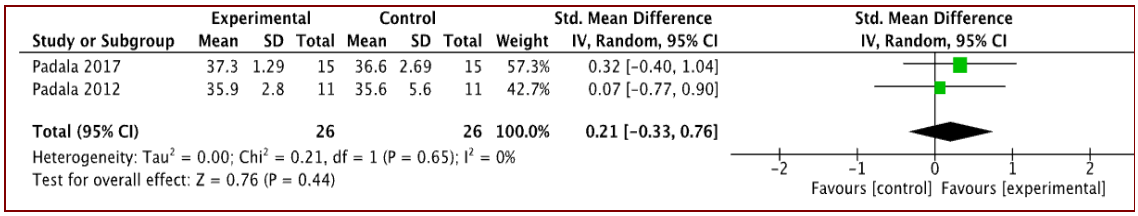

Figure 5. The result of exergame in alleviating quality of life in Alzheimer's disease patients using AD-QoL tools

Safety

Six studies performed the observation on the occurrence of adverse events. All studies reported the absence of adverse events during the intervention [14,16,17,19,25,27].

Acceptance and adherence

Acceptance was associated with exergame being enjoyable, easy-to-use, and motivational [14]. Low attrition was observed in an RCTs which was associated with easy-to-use characteristic of the exergame [19]. The adherence rate was high as reported in three studies [14,19,27], where some studies reported the adherence rate of 97% [19] and 80% [27]

Discussion

Exergame is a new technological invention that has been lately designed for medical purposes. This gaming technology has recently been used to treat patients with PD and other neurologic disorders [24]. It combines video-game-based training with augmented virtual reality (VR) and is intended to be engaging and challenging, therefore stimulating motivation and increasing exercise adherence [29]. Further advantages of exergaming are the possibility to adapt to the level of exercise difficulty and to provide online visual and/or verbal feedback during the exercise. All these aspects are important to optimize motor learning in individuals with neurologic disorders.

In this present systematic review, fourteen studies assessing the QoL were included. Twelve of which reporting about Parkinson's disease and the other two – Alzheimer's disease [14,15,24–28,16–23]. Most of Parkinson's disease studies used PDQ-39 and EQ-5D. While the tools for assessing the QoL in Alzheimer's patients used QoL-AD. The tools have different focuses, domains, and approaches in measuring and interpreting the responses. PDQ-39 was designed to measure the impact of Parkinson's disease in various aspects that affect the individual's life involving eight different domains which are mobility, activities of daily living, emotional well-being, stigma, social support, cognition, communication, and bodily discomfort. The higher score of PDQ-39 indicates, the lower QoL [30]. Additionally, EQ-5D assesses only five domains consisting of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The higher score of EQ-5D indicates the better QoL [31]. Equally important, QoL-AD evaluates five domains including physical health, mood, functional abilities, social support, and financial resources with a higher score suggesting a better QoL.

In this present meta-analysis, we found that exergame did not significantly improve the QoL as compared to control. According to the individual study employing, significant improvement of QoL among elderly with neurogenerative diseases was reported in 8 studies [15,18,21,22,24–27], while the insignificant results were reported in the other 5 studies [14,16,17,23,28]. We also noticed the presence of probable bias deriving from the imbalance baseline in two studies [16,24]. Previously, a meta-analysis was carried out to assess the improvement of QoL among elderly with neurogenerative diseases [32]. As a comparison, we included more studies than the previous meta-analysis [32]. Our present meta-analysis results are in accordance with the previous meta-analysis. [32]. Moreover, the results of our meta-analysis are also in accordance with a study that assessed the QoL on different neurological diseases [33].

There were six studies that reported the safety of using an exergame, for instance, fall, muscle soreness, fatigue, and so on [14,16,17,19,25,27]. All the studies revealed that there were no adverse events found when using the exergame as a rehabilitation. There were no adverse events reported within the studies whether using exergame with sitting up, walking, or moving methods. One of the included study witnessed that exergame had a lower value of fatigue in Parkinson's disease than conventional rehabilitation, and enhanced the confidence level of patients for avoiding falls while intervention [16]. Participants also felt a reduction in fear of falling during the intervention, where the console can be set with safety settings [27].

High adherence rate was found in three studies means that they are comfortable doing the task of exergames, [14,19,27], even some of them doing more than the prespecified task as order and low attrition indicates high acceptability for people with a neurodegenerative disorder. Through open-ended and close-ended interviews, it was revealed that participants felt the exergame was easy, safe, well-integrated, enjoyable, easy to learn, and motivated to complete the next task. However, studies reported that some patients had difficulties in following the exergame therapy, such as having insufficient space at home for the exergame [14]. In another study, the patients complained about the complexity, cumbersome, and need for technical support for the exergame therapy [19].

This present study is the first in reporting the pooled results from studies participated by elderly population. As limitations, the data acquired are limited and cannot be used to infer a conclusion for the whole neurodegenerative disease. For example, there are studies reporting Parkinson's disease and Alzheimer's disease, multiple sclerosis, and Huntington's Disease but were excluded because the participants >60 years old. Moreover, the limitation in data is also contributed by the small sample size of the included studies.

Conclusions

Exergames are not significantly different from conventional rehabilitation in improving the QoL. However, exergame is still considered a promising modality in rehabilitating patients with neurodegenerative disease attributed to its easy-to-use and entertaining nature. Moreover, the exergame was found to have high acceptance and safety for the elderly to use. To ensure maintaining the interest of its users, we recommend the game developer improve the visualization, game scenarios, and movement variety. We also highly suggest further research to develop an exergame that requires minimum space, so it will not burden participants living in small houses. Investigation with a larger sample size is highly recommended in the future.

Ethics approval

Not required.

Acknowledgments

None.

Competing interests

All the authors declare that there are no conflicts of interest.

Funding

This study received no external funding.

Underlying data

All data underlying the results are available as part of the article and no additional source data are required.

How to cite

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