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Impact of Exergames on the Mental Health of Older Adults: A Systematic Review and GRADE Evidence Synthesis

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Abstract

Exergames, which combine digital games and physical exercise, have become a popular alternative to traditional exercise programs and are increasingly used in the health domains. This study aimed to provide a systematic review to synthesize existing studies on the use of exergames for the mental wellbeing of healthy older adults, aggregating the collected data to identify effect size. We performed a Systematic Review and Grading of Recommendations, Assessment, Development, and Assessment (GRADE) evidence synthesis. We performed the search in the following databases: MEDLINE[®], CINAHL[®], SPORTDiscus, SCOPUS, SciELO, Psychology and Behavioral Sciences Collection, and Cochrane[®] Central Register of Controlled Trials from the first record until October 2021. Randomized controlled trials using exergames as an intervention were included. A total of 10 articles published between 2009 and 2021 were selected. Most studies used the Nintendo Wii[®] as the exergame in the intervention program. Interventions ranged from 6 to 12 weeks, with 8-week programs being most frequent. It was possible to observe a positive effect on mood, the reduction of apathy, anxiety and depression, self-esteem, and affection.

Keywords: Games, Mental health, Exergames, Aging

Introduction

THE PHENOMENON OF an aging population is a reality that has occurred worldwide, not just in Western countries. Almost every country in the world is experiencing an increase in the number and proportion of the elderly population.^{1,2} The 21st century has been described as the first in human history in which the world will no longer be young, leading to drastic changes in the areas of finance, demography, social attitudes, and welfare.¹ As a response to global aging, the framework of active aging has been proposed to improve the quality of life of older adults.^{2,3} The challenge is to ensure a high quality of life for older people in aging societies to help ensure their wellbeing and autonomy.¹

Therefore, research should focus on the preventive side of diseases to reduce the financial burden and increase wellbeing in old age.^{1,4,5} In addition, the importance of physical activity and exercise is highlighted to reduce the risk of sarcopenia, increase performance in activities of daily living, decrease the risk of falls, and prevent cognitive decline and depression.⁶ However, it is known that older adults are often reluctant to participate in physical activities and exercise due to physiological changes and deceleration of all bodily functions associated with aging, generating a vicious circle that results in a negative mood, and a negative perception of quality of life.⁷

Activating the healthy aging process requires stimulation, which can be achieved through interactive rehabilitation programs.³ Geriatric rehabilitation has become increasingly

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important after recent developments in health care technology and the increase in life expectancy.⁷ Given the popularity of videogames, active videogames (exergames) seem to be an ideal platform for managing physical activity interventions and used as a mediator of behavior change, offering accessible, safe, and controlled experiences that can be played at home.⁸ The confluence of psychological and physical aspects of playing an exergame makes it a unique device that has the potential to be a source of entertainment, exercise, and interpersonal bonds.⁹

These resources have been shown to be effective in older adults by increasing attention and memory levels, decreasing levels of depression, improving functionality, and increasing performance in activities of daily living.³⁻⁵

Although previous research has generally proven the usefulness of this technology and all its resources in improving functionality⁴ and cognitive improvements^{5,10} in various pathologies (e.g., Parkinson, Stroke, Depression),¹¹⁻¹³ no review study has examined its implications for mental wellbeing in healthy older adults. However, a growing body of research has confirmed that exergames have an effect on reducing depression symptoms and have extended the posi-

tive effects of exergames to subliminal depression.¹⁴⁻¹⁸ In addition, it is well established that physical activity triggers the release of certain body chemicals (such as β -endorphins or dopamine), resulting in improved mood and a sense of wellbeing,¹⁸ with implications for the quality of life.⁴

Given the emerging phenomenon of an aging society around the world, special attention is needed not only for physical wellbeing but also for the psychological wellbeing of older adults in general,¹⁶ which goes beyond interventions for different disorders and illnesses. Therefore, this study aimed to provide a systematic review to synthesize existing studies on the subject to address the gap in the domain of exergames regarding the mental wellbeing of healthy older adults. In addition, we aimed to aggregate the collected data to discover the size of the effect of exergames on the mental wellbeing of older adults.

Methods

This systematic review study was reported based on the declaration of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA, Fig. 1). According

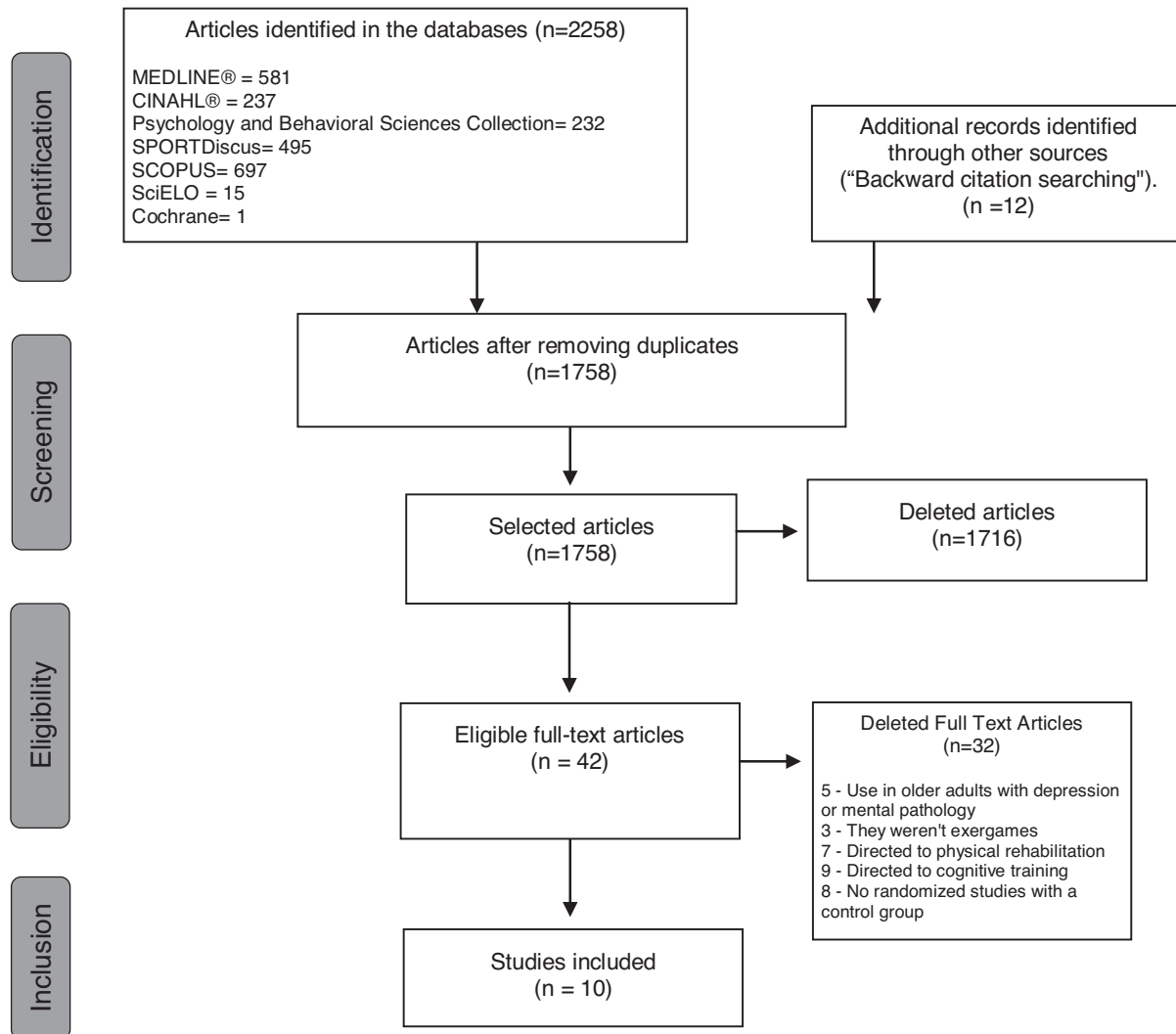


FIG. 1. Process of identification and inclusion of articles—PRISMA diagram flow. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

to the strength and quality of the evidence, the summary of evidence was constructed using the Grading of Recommendations, Assessment, Development, and Assessment (GRADE)¹⁹ approach, produced through the online tool GradePro Guideline Development Tool.

Study selection

To carry out the literature search, the respective descriptors were identified using search syntaxes appropriate to each of the databases: MEDLINE®, CINAHL®, SPORTDiscus, SCOPUS, SciELO, Psychology and Behavioral Sciences Collection, and Cochrane® Central Register of Controlled Trials. In addition, additional studies were searched for in the reference lists of all publications included through “Backward citation searching.” The allocation of all possible descriptors (Supplementary Appendix SA1) integrating older adults, games, and mental health for an extensive search, to which the inclusion and exclusion criteria would later be included, safeguarded the maximum breadth of the search records found.

For the first steps of data selection, the Rayyan QCRI® platform (a Systematic Reviews web application) was used. This resource was crucial for the screening of titles and abstracts.

Two independent reviewers performed the selection of studies and possible disagreements were resolved by consensus with a third reviewer to confirm the eligibility of publications. The search was conducted in October 2021. In terms of population, all publications focused on the use of games in healthy older adults were included. In terms of

intervention, all publications describing and evaluating the use of the game were included. In terms of outcome, only data arising in the context of mental wellbeing were included in the analysis. Only studies with randomized clinical trials (RCTs) were considered in terms of methodology. Articles that did not include specific results from the assessment of mental wellbeing were excluded. Articles referring to the use of memory games were also excluded, as well as articles that addressed the use of exergames in specific disorders, including stroke, depression, Parkinson’s, among others.

Evidence synthesis

The results were evaluated and selected regarding their relevance for inclusion based on the information provided in the title and abstract. Afterward, the selected articles were subject to comprehensive full reading that preceded their integration into the final sample. The table of evidence was built from each included study according to the key question answered.

The evaluation of the quality of each study was carried out using the Cochrane risk of bias tool (Fig. 2), and later, in the aggregation of the outcomes, the results were classified according to the GRADE as “High,” “Moderate,” “Low,” to “Very low.” For the GRADE evaluation, results related only to the mental wellbeing of the elderly were used. These included the psychological health subscale in the quality-of-life questionnaire of the World Health Organization (WHOQOL-BREF); the Mood Rating Scale, Hamilton for Depression Scale (HDSR); the scale to assess apathy, Dementia Apathy Interview and Rating (DAIR); and to assess

	Younbo et al. (2009)	Portela, Correia, Fonseca, Andrade. (2011)	Monteiro-Junior et al. (2017)	Mailliot, Perrot, Hatley, Do. (2014)	Lee, Son, Kim, Yoon. (2015)	Keogh, Power Wooller, Lucas, Whatman. (2014)	Jahoun, et al. (2021)	Gomes et al. (2018)	Eggenberger Wolf, Schumann, Bruhn. (2016)	Cicek, Ozdinler, Tarakci. (2020)
Random sequence generation (selection bias)	+	+	?	?	+	+	+	+	+	+
Allocation concealment (selection bias)	+	?	+	+	?	+	+	+	+	+
Blinding of participants and personnel (performance bias)	?	-	-	+	+	?	+	-	+	-
Blinding of outcome assessment (detection bias)	?	-	+	+	-	?	+	+	-	-
Incomplete outcome data (attrition bias)	+	+	+	+	+	+	+	+	+	+
Selective reporting (reporting bias)	+	+	+	+	+	+	+	+	+	+
Other bias	+	+	+	+	+	+	+	+	+	+

FIG. 2. Risk of bias summary: review authors’ judgments about each risk of bias item for each included study.

anxiety and depression the Goldberg Anxiety and Depression Scale (GADS) and the Depression-15-item Geriatric Depression Scale (GDS-15) (Table 1).

Table 1 illustrates the measurement instruments used by the researchers in their respective surveys.

The WHOQOL-BREF World Health Organization Quality-of-Life Questionnaire investigates the subjective perception of quality of life in older adults.²⁰ It consists of 26 items to evaluate quality of life in four major domains: physical health, psychological health, social relationships, and environmental health.⁷ Responses are scored on a 5-point scale where the maximum score indicates a well-perceived quality of life.²¹ The Hamilton Rating Scale for depression (HRSD) was used to assess the mood of the participants. This scale consists of 21 items, and the maximum score is an indicator of very severe depression.⁷

The Dementia Apathy Interview and Rating (DAIR) scale was used to assess the participants' level of apathy and includes 14 items, where higher scores represent increased apathy.³ On the Goldberg Anxiety and Depression Scale (EADG) a person is considered to have anxiety if they answer yes to four or more items and depression if they give two or more affirmative answers, where a EADG anxiety score >6 indicates the presence of anxiety.^{3,22} The GDS-15 is an assessment tool to diagnose depression in older adults, evaluating degree of satisfaction, quality of life, and feelings; its abbreviated form is widely used in older adults.²³

Short Form 36 Health Survey Questionnaire (SF-36) is a questionnaire that registers the perception of individuals in relation to their own health status and includes the most representative aspects of health. The scores from the eight subscales can be aggregated into two distinct, higher-order summary scores: physical functioning, physical-role functioning, bodily pain, and general health grouped in the physical component higher order; and vitality, social functioning, emotional role, and mental health in the mental component summary.²⁴ Regarding the SF-36 scale, the "Emotional Role" and "Mental Health" subscale values were used,²⁴⁻²⁶ as well as the global Mental score.^{24,25}

The Mini-Mental State examination is the most used scale to assess the mental state of individuals, where a score lower than 24 suggests a deficit.²⁰ The Mini-Mental State Exam was used in two studies.^{6,26} The Rosenberg Self-Esteem Scale (SES) is used to measure the level of self-esteem using a 10-item Likert-style questionnaire, where higher scores indicate a more positive self-esteem.⁹ Finally, the Bradburn Affect Balance Scale measures a participants' positive or negative affect level, where higher scores indicate a strong positive affect.⁹

Statistical analysis

We pooled the results and conducted a meta-analysis whenever possible. Standardized mean differences (SMD) between the participants, the intervention group, and the control group, as well as the respective 95% confidence intervals (CIs), were calculated. As we are accumulating data from several studies performed by researchers operating independently, the random-effects model is more easily justified than the fixed effects model,²⁷ especially when considering the methodological heterogeneity between studies. Hence, the random-effects model was used to calculate the pooled effect estimate.

The results of each analysis are presented in a forest plot (Fig. 3), showing the joint effect estimate for each outcome considered, as well as the respective CI. All meta-analysis calculations were obtained using Revman 5.4 software (Cochrane Collaboration, Oxford, England, United Kingdom) using random effects models to account for heterogeneity between individual study effects. To facilitate the presentation of results, all scales were converted upward.

Results

Study selection

The search strategy retrieved 2270 records. After removing the duplicates, 1758 studies were included for the first screening. Following the first screening by title and abstract, applying the inclusion and exclusion criteria, 42 studies were selected for full-text reading. After reading the full-text copies, 32 studies were excluded from this review. Some studies were with older adults with depression or mental pathology, others were not exergames or applied to physical rehabilitation, others were directed at cognitive training, or were not randomized studies with a control group. The limited number of studies found may be related to the challenges of conducting high-quality clinical trials with exergames. At the end of the process, 10 publications met the eligibility criteria and were included for analysis (Fig. 1).

Study characteristics

Table 2 summarizes the characteristics of the 10 studies included in the review, with regard to authors, year, country, study design, objectives, participants, type of game, intervention, measurement instruments, and study results.

A total of 10 articles published between 2009 and 2021 were selected for review.^{3,6,7,9,20-23,28,29} The studies were carried out in very different places, such as Turkey,⁷ Spain,^{3,22} France,²¹ Brazil,^{6,23} Portugal,²⁰ Singapore,⁹ Japan,²⁸ and Columbia.²⁹ Four hundred five older adults participated in all the studies, and most were women ($n=259$). As for exergames used in intervention programs, the Nintendo Wii[®] was the most frequently used.^{3,7,9,20,21,23,28} Interventions ranged from 6 to 12 weeks, with 8-week programs most frequent.^{3,7,22,28,29}

Quality assessment

The risk of bias assessment results for the 10 studies are shown in Figure 2. According to the risk of bias assessment of RCTs by Cochrane, for the seven domains, we can observe that the lower quality of some studies is related to the lack of information regarding the measures used to blind the participants, professionals involved, and evaluators.

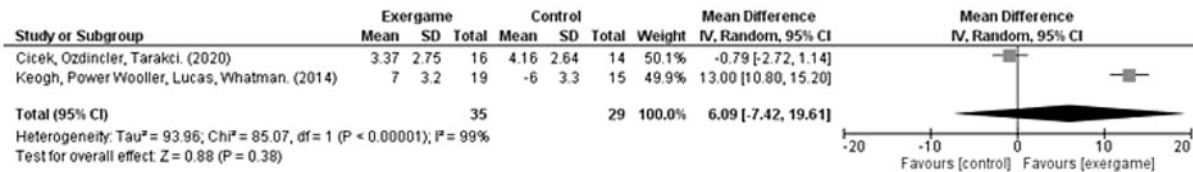
Using the GRADE "summary of findings" table (Table 3), the quality of evidence is seen as mostly moderate and low, essentially due to limitations of the studies related to the risk of bias (detection and performance). The evidence for the different outcomes were mostly classified as moderate to low quality, as the risk of bias and inaccuracy were evaluated to be unclear in some situations. The aspects related to this evaluation included the nondouble blinding of the participants and the evaluation, and the risk of bias arising from the randomization process, different exergames used in the intervention, and poor clarity in the presentation of study results.

TABLE 1. MEASUREMENT SCALE

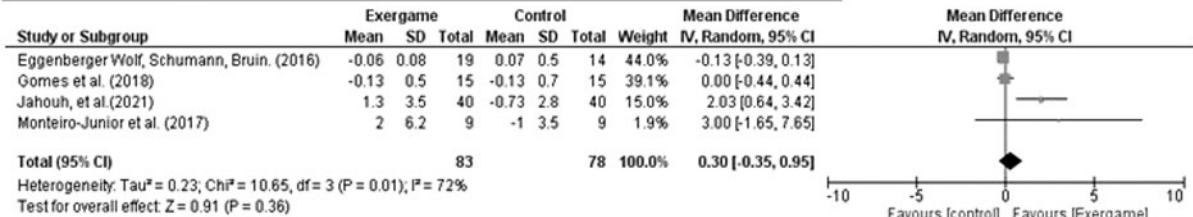
<i>Measures</i>	<i>Scale score</i>	<i>Scale properties</i>
WHOQOL-BREF's	0–100 High score is an indicator of a well-perceived quality of life	This scale is the short 27-question form based on the original 100-question WHOQOL form. The test investigates the subjectively perceived quality of life in the elderly. ⁷ The instrument has five dimensions (General health [three items], Physical health [seven items], Psychological health [six items], Social Relation [three items], and Environmental health [eight items]). The values are then converted into a scale from 0 to 100, where the maximum score is an indicator of a well-perceived quality of life. ^{20,21}
HRSD	0–7 Normal 8–16 Suggests mild depression 17–23 Moderate depression ≥24 are indicative of severe depression; (maximum score 52)	This scale consists of 21 items, but 4 items are not included in the score. Responses are scored on a 0- to 4-point scale. The score is based on the 17-item scale. Scores from 0 to 7 are considered normal, 8 to 16 suggest mild depression, 17 to 23 moderate depression, and scores above 24 are indicative of severe depression; the maximum score is 52 on the 17-point scale. ⁷
DAIR	Rated 0 = no or almost never 3 = Yes, almost always Only items representing a change in behavior are included in the final apathy score	This scale is used to assess the level of apathy. This questionnaire includes 14 items using a four-point scale (0–3). The total score is obtained by adding the score obtained in each completed item and dividing by the number of completed items. Higher scores on this scale represent greater severity of apathy. ³
EADG	The person is considered to have anxiety if they answer affirmatively to four or more items, and depression if they give two or more affirmative answers	This scale is composed of two subscales, one for detecting anxiety and another for detecting depression. Both scales have nine questions; the first four are mandatory, while the remaining five are only formulated if any of the previous questions is answered in the affirmative. The answers to the questions are binary. ²² Higher values indicate a more serious problem (higher 9 score). A person is considered to have anxiety if they answer affirmatively to four or more items, and depression if they give two or more affirmative answers. ³
GDS-15	0–4 Normal 5–8 Indicates mild depression 9–11 Indicates moderate depression 12–15 Indicates severe depression	The GDS-15 is an abbreviated form of the GDS and is used to screen, diagnose, and assess depression in older adults. Of the 15 items, 10 indicate the presence of depression when answered positively, while the others indicate depression when answered negatively. ²³ Scores of 0–4 are considered normal; 5–8 indicate mild depression; 9–11 indicate moderate depression; and 12–15 indicate severe depression. ^{28,29}
SF-36	Scores range from 0 to 100	This scale contains eight subscales. ²⁴ It yields an eight-scale profile of functional health and wellbeing scores, as well as psychometrically-based physical and mental health summary measures (physical functioning; role physical; bodily pain; general health; vitality; social functioning; role emotional; and mental health), two global scores (physical and mental health), and an additional item measuring health transition. ²⁵ The score for each subscale can range from 0 to 100, and a higher score indicates better health. ^{24,26}
MMSE	24 Suggests a deficit 23–21 Mild deficit 20–11 Moderate deficit ≤10 Severe	The Mini-Mental State Exam includes items on orientation, information recording, attention, calculation, memory, language, and construction. It has a total score of 30 points, where <24 suggests a deficit; mild between 23 and 21, moderate between 20 and 11, and severe if <10. ⁶
SES	Score range from 0 to 30 15 and 25 Normal range ≤15 Suggest low self-esteem	This scale was initially designed to measure adolescents' feelings of self-esteem and acceptance, but has since been applied to many other contexts, including older adults. This is a 10-item Likert-style questionnaire consisting of five positive and negative statements each, using a four-point scale (0–3) for each statement. The scale ranges from 0 to 30. Higher scores indicate more positive self-esteem. Scores between 15 and 25 are within the normal range; scores below 15 suggest low self-esteem. ⁹
Bradburn Affect Balance Scale	Positive scored 1 Negative scored 0 Higher scores = strong positive affect	This scale measures the participants' level of positive or negative affect. The 10 statements on the scale can be classified as "YES" or "NO", with 5 statements reflecting a positive affect and the other 5 a negative affect. Positive responses are scored as 1, and negative responses are scored as 0. The score for each of the 10 statements is totaled—higher scores indicate strong positive affect. ⁹

DAIR, Dementia Apathy Interview and Rating; EADG, Goldberg Anxiety and Depression Scale; GDS-15, 15-item Geriatric Depression Scale; HRSD, Hamilton Rating Scale for depression; MMSE, Mini-Mental Status Examination; SES, Self-Esteem Scale, Rosenberg Self-Esteem Scale; SF-36, Short Form 36 Health Survey Questionnaire; WHOQOL-BREF, World Health Organization Quality of Life—BREF.

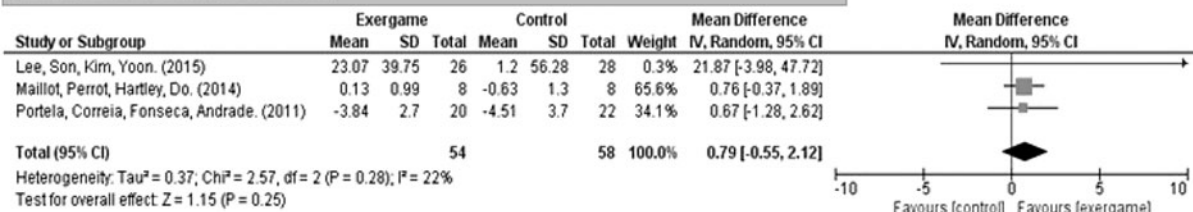
Outcome WHOQOL-BREF's Psychological health



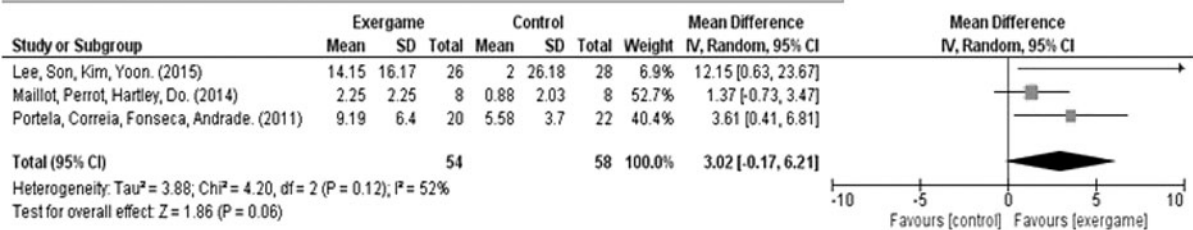
Outcome Anxiety and Depression geriatric Depression Scale (GDS-15)



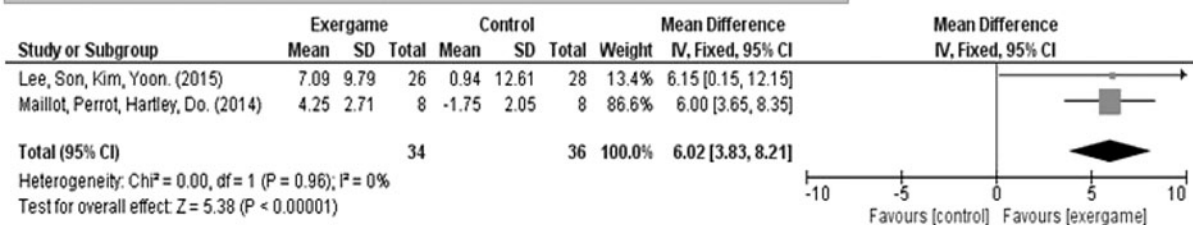
Outcome SF-36 Role Emocional



Outcome SF-36 Mental-health



Outcome SF-36 Mental Score Global



Outcome Mini Mental of State Exam

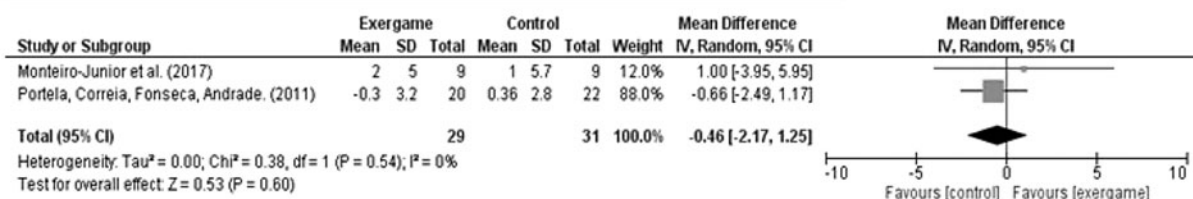


FIG. 3. Exergame outcomes.

TABLE 2. STUDIES INCLUDED IN THE REVIEW (N=10)

<i>Authors (year), country</i>	<i>Study design</i>	<i>Aim of the study</i>	<i>Participants</i>	<i>Game type</i>	<i>Intervention</i>	<i>Control group</i>	<i>Measures</i>	<i>Outcomes</i>
Cicek et al. (2020), Turkey	Randomized control trial	Evaluate the effectiveness of interactive videogames on mobility, general mood, and quality of life and compare them with physical activity approaches in older adults.	30 Older adults: Control group (8 women and 6 men), Experimental group (9 women and 6 men)	NWFP™	30-Minute exercise program using "Nintendo Wii Fit Plus" 2 times a week for 8 weeks.	Activity program consisting of an exercise bike and a treadmill with the same duration.	HRSD WHOQOL-BREF's	Although there was a significant change in the Hamilton depression score for the intervention group ($P < 0.005$), the differences between groups were not significant. The quality-of-life subtest scores (WHOQOL-BREF) showed a positive improvement in the Intervention Group and the Exercise Group, but the differences within and between the groups were not statistically significant.
Jahouh et al. (2021), Spain	Randomized control trial	Determine the impact and effectiveness of the use of the Wii® game console on improving performance of basic and instrumental Activities of Daily Living (ADLs), as well as its relationship with cognitive impairment levels and mood in institutionalized older people.	80 Older adults (23 women and 17 men) Experimental group (22 women and 18 men)	Nintendo Wii Fit®	20 Rehabilitation sessions (45 minutes), developed over 8 weeks, consisting of different activities with the Nintendo Wii Fit videogame console.	They continued with their conventional methods, treatments, and therapies provided by nursing homes, such as physiotherapy, occupational therapy, and gym sessions.	DAIR Depressive symptoms assessed with GDS EADG	Statistically significant differences were observed in the percentage of change in psychological variables during the study. Specifically, when compared with the control group (DAIR, GDS-15, EADG).

(continued)

TABLE 2. (CONTINUED)

<i>Authors (year), country</i>	<i>Study design</i>	<i>Aim of the study</i>	<i>Participants</i>	<i>Game type</i>	<i>Intervention</i>	<i>Control group</i>	<i>Measures</i>	<i>Outcomes</i>
Maillot et al. (2014), França	Randomized control trial	Determine whether exergame training in physically simulated sports activity improved balance assessed by clinical measures, functional fitness, and HRQoL in older adults.	16 Older adults living independently (12 women, 4 men) divided into two groups (8 in training group and 8 in control group)	Nintendo Wii®	Completed two exergame sessions per week over a 12-week period, resulting in a total training time of 24 hours.	Control group participants pledged not to modify their lifestyles and not start playing video exergames or engaging in any other new physical activity throughout the 14-week study.	SF-36	The results showed that the improvement was only significantly greater in the intervention group than in the control group for global mental score.
Monteiro-Junior et al. (2017), Brasil	Randomized control trial	Investigating the effect of virtual reality-based physical exercise with exergames (GPhysEx) on cognitive functions, physical performance, depressive symptoms, and fear of falling.	18 Older adults: Control group (6 women and 3 men), Experimental group (6 women and 3 men)	Exergame GPhysEx	GPhysEx performed six exercises with exergames 35/40 minutes. The workout was planned to have 12 and 16 sessions twice a week (7 weeks).	Performed the same six exercises as GPhysEx, although without virtual reality stimulation.	Depressive symptoms assessed with GDS MMSE	There was no significant difference in global cognition (MMSE) and in the assessment with the GDS.
Portela et al. (2011), Portugal	Randomized control trial	To assess the impact of using Nintendo Wii in the elderly.	65 Older adults (40 women and 25 men), 3 groups	Nintendo Wii	Wii without physiotherapist supervision (Group A; $n=23$), Wii without supervision (Group B; $n=20$) over 15–20 sessions 50 minutes each.	Geriatric Gymnastics (Group C; $n=22$) over 15 sessions 50 minutes each.	SF-36 MMSE	In the assessment with the SF-36 scale, there were significantly better results in the mental health intervention group ($P=0.023$).

(continued)

TABLE 2. (CONTINUED)

<i>Authors (year), country</i>	<i>Study design</i>	<i>Aim of the study</i>	<i>Participants</i>	<i>Game type</i>	<i>Intervention</i>	<i>Control group</i>	<i>Measures</i>	<i>Outcomes</i>
Eggenberger et al. (2016), Spain	Randomized control trial	To investigate whether exercise and virtual game training induces functional brain plasticity during challenging treadmill walks and causes associated changes in cognitive executive functions.	33 Older adults: Control group (9 women and 5 men), Experimental group (12 women and 7 men)	Exergame Intervention DANCE	The 8-week intervention included three 30-minute sessions per week.	Treadmill walking protocol for 8 weeks.	Depressive symptoms assessed with GDS	Baseline values showed no significant difference between groups in the GDS ($P=0.104$).
Gomes et al. (2018), Brazil	Randomized control trial	Evaluate the feasibility, safety, and acceptability of playing NWFP interactive videogames, and the functional outcomes (postural control, gait, cognition, mood, and fear of falling) in frail and prefrail older adults.	30 Older adults: (2 men and 28 women), Control group ($n=15$), Experimental group Control group ($n=15$)	Nintendo Wii	The intervention participants performed 14 training sessions, lasting 50 minutes each, twice a week (7 weeks).	Control group participants received a book with information and illustrations describing the benefits and risks of physical activity.	Depressive symptoms assessed with GDS	There was no significant effect on the GDS-15. The lack of positive results in changes in depression in the GDS-15 may be related to the ceiling effect of the GDS at baseline, as the participants did not have depression before starting the intervention.

(continued)

TABLE 2. (CONTINUED)

<i>Authors (year), country</i>	<i>Study design</i>	<i>Aim of the study</i>	<i>Participants</i>	<i>Game type</i>	<i>Intervention</i>	<i>Control group</i>	<i>Measures</i>	<i>Outcomes</i>
Younbo et al. (2009), Singapore	Randomized control trial	Examined the impact of playing Nintendo Wii games on the psychological and physical wellbeing of seniors in a long-term care facility.	45 Older adults: Control group ($n = 20$), Experimental group Control group ($n = 25$)	Nintendo Wii	Activity sessions, with the Wii lasting 1.5 hours each, took place three times a week.	Activity sessions with traditional games instead of Wii last 1.5 hours three times a week (6 weeks).	SES Bradburn Affect Balance Scale (6 weeks)	Elderly individuals in the Wii condition scored significantly higher on self-esteem and affect.
Keogh et al. (2014), Japan	Randomized control trial	Examined whether the Nintendo Wii Sports could significantly improve the functional ability, physical activity levels, and quality of life.	34 Older adults: Control group (13 women and 2 men), Experimental group (17 women and 2 men)	Nintendo Wii sports	Participants in the intervention group selected the frequency, duration, and type of games they wanted to play for 8 weeks.	During the 8-week intervention, control group participants received no additional treatment and carried out their normal activities of daily living.	WHOQOL-BREF's	Significantly greater improvements in psychological quality of life (assessed by WHOQOL-BREF) were observed for the intervention group than the control group ($P = 0.012$).
Lee et al. (2015), Colombia	Randomized control trial	Studied the effect of exergame on HRQoL in older women.	54 Older women: Control group ($n = 28$) Experimental group ($n = 26$)	Xbox 360	60-Minute exercise program three times a week for 8 weeks with virtual reality game.	60-Minute exercise program three times a week for 8 weeks.	SF-36	Within-group analysis for SF-36 revealed an increase in emotional role ($P = 0.007$) and mental health ($P < 0.001$).

HRQoL, health-related quality of life; NWFP, Nintendo Wii Fit Plus; SF-36, Short Form 36 Health Survey Questionnaire.

TABLE 3. GRADE EVIDENCE: PROFILE OF INCLUDED STUDIES

Certainty assessment		No. of patients			Effect						
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Exergame	Control	Absolute (95% CI)	Certainty	Importance
Outcome WHOQOL-BREF's Psychological health (assessed with: WHOQOL-BRIEF's)											
2	Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	35	29	MD 6.09 higher (7.42 lower to 19.61 higher)	⊕⊕⊕ Moderate	Important
4	Anxiety and Depression-GDS-15 Randomized trials	Serious ^b	Serious ^c	Not serious	Not serious	None	83	78	MD 0.3 higher (0.35 lower to 0.95 higher)	⊕⊕⊕ Low	Important
3	SF-36 Role Emotional Randomized trials	Serious ^a	Not serious	Not serious	Serious ^d	None	54	58	MD 0.79 higher (0.55 lower to 2.12 higher)	⊕⊕⊕ Low	Important
3	SF-36 Mental health Randomized trials	Serious ^a	Not serious	Not serious	Serious ^d	None	54	58	MD 3.02 higher (0.17 lower to 6.21 higher)	⊕⊕⊕ Low	Important
2	SF-36 Mental Score Global Randomized trials	Not serious	Not serious	Not serious	Not serious	None	34	36	MD 6.02 higher (3.83 higher to 8.21 higher)	⊕⊕⊕ High	Critical
2	Mini-Mental of State Exam Randomized trials	Serious ^e	Not serious	Not serious	Serious ^d	None	29	31	MD 0.46 lower (2.17 lower to 1.25 higher)	⊕⊕⊕ Low	Important
1	Self-esteem SES Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	25	20	MD 0.63 higher (0.33 higher to 0.93 higher)	⊕⊕⊕ Moderate	Critical
1	Affect-Bradburn Affect Balance Scale Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	25	20	MD 1.42 higher (0.48 higher to 2.36 higher)	⊕⊕⊕ Moderate	Critical
1	Humour-HRSD Randomized trials	Serious ^a	Not serious	Not serious	Not serious	None	16	14	MD 1.3 higher (0.82 higher to 1.78 higher)	⊕⊕⊕ Moderate	Critical
1	Apathy-DAIR Randomized trials	Serious ^f	Not serious	Not serious	Not serious	None	40	40	MD 4.55 higher (3.92 higher to 5.18 higher)	⊕⊕⊕ Moderate	Critical
1	Anxiety and Depression-EADG Randomized trials	Serious ^f	Not serious	Not serious	Serious ^g	None	40	40	MD 1.3 higher (0.28 higher to 2.32 higher)	⊕⊕⊕ Low	Critical

^aNot blinding participants and outcomes assessment-Risk of bias.^bNot blinding outcomes assessment-Risk of bias.^cDifferent exergames used in the intervention.^dLow clarity in the results of one study.^eNot blinding participants-Risk of random errors.^fRisk of bias arising from the randomization process.^gDifferent intervention intensity.

CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Assessment; MD, mean difference; SF-36, Short Form 36 Health Survey Questionnaire.

Table 3, using the meta-analysis of pooled data, allowed us to identify the outcomes for the construction of the GRADE evidence profile of the included studies. However, not all results of the studies included in this review could be compared and included in the meta-analysis presented in Figure 3. Regarding the results presented, the comparisons between the interventions were not statistically significant. High and moderate heterogeneity values were observed in the following outcomes: WHOQOL-BREF's scale ($I^2=99\%$), GDS anxiety and depression ($I^2=72\%$), and SF-36 Mental-Health ($I^2=52\%$).

Exergames in mental health

Two of the studies investigated the impact of exergames on quality of life through the WHOQOL_BREF's scale. Concerning the psychological dimension, only one of them reports a significant positive association,⁷ which was not evidenced in the other study.²⁸ In this context, the difference in grouped means was 1.79 (95% CI, -2.33 to 5.90; $P=0.39$). The GRADE of evidence was categorized as moderate quality.

Four of the studies assessed the impact of exergames on anxiety and depression measured using the GDS anxiety and depression scale.^{3,6,22,23} The difference in grouped means was 0.30 (95% CI, -0.35 to 0.95; $P=0.36$). The GRADE of evidence was categorized as low quality. Two of these studies reported a significant positive association,^{3,6} which was not found in the other two studies.^{22,23}

Regarding the impact of exergames on the perception of older adults of their own health status, as assessed using the SF-36 scale, our meta-analysis did not show a significant SMD in the three studies for the results of "Emotional role" scale (0.79; 95% CI, -0.55 to 2.12; $P=0.25$) and the "Mental Health" scale (3.02; 95% CI, -0.17 to 6.21; $P=0.06$) at the end of the intervention.^{20,21,29}

However, a different result was obtained with the aggregation of two of the studies for the conjugation of the global mental score. Of note, data from one of the previous studies were not available on this topic.²⁰ There were also no significant SMDs for the Mini-Mental of State Exam (-0.46; 95% CI, -2.17 to 1.25; $P=0.60$). The GRADE of evidence was categorized as low quality.

At the end of follow-up (Table 3), there was a significant SMD for outcomes resulting from individual studies, namely for self-esteem (SES $P<0.001$),⁹ affect (Bradburn Affect Balance Scale $P<0.001$),⁹ humor (Hamilton Scale for Depression $P<0.001$),⁷ apathy (Apathy Interview and Rating $P<0.001$),³ and anxiety/depression (EADG-GADS $P=0.01$).³

Discussion

This study aimed to bring together existing studies on the use of exergames for the mental wellbeing of healthy older adults and identify the size of the effect of this intervention. Although previous reviews have synthesized the effects of exergames in older adults,^{5,10-12} the present study specifically focused on the benefits on mental health in older adults who do not have any associated disorder or illness. Indeed, research into exergames for older adults has broadened, and is designed to consider the emotional and psychological aspects of games, going beyond physical involvement, improving emotional involvement, and thereby enhancing psychological wellbeing.⁹

Exergames are widely available and can be done at home, reducing environmental barriers to exercise, reinforcing exercise maintenance, increasing activity satisfaction, and counteracting the diminished enjoyment of exercise.¹⁷ What reinforces its growing popularity in this population group is demonstrated in this study, with 10 included studies published from 2009 to 2021. Research in this domain is still unclear but is important for opening the discussion on how exergames can promote the wellbeing of the elderly.

Studies have shown that interventions with exergames can improve several functions in the elderly, reporting improvements in clinical parameters such as cognition, motor function, and balance.^{30,31} The use of exergames should also be considered an important way to protect older adults by promoting mental health in healthy aging.⁷ Active videogames are a viable and well-accepted intervention that can encourage older adults to engage in physical activity actively and improve their wellbeing.³²

Although our findings did not demonstrate the positive impact of exergames on all outcomes analyzed, it was possible to observe a positive effect on mood,⁷ a reduction in apathy,³ reduced anxiety and depression,³ and improved self-esteem⁹ and affection.⁹ This is in line with the results of other authors, who reported that exergames have a greater effect size in participants with depression or related mental disorders than in participants without depression-related illnesses.¹⁵

Exergames can be used and defended in clinical and nonclinical populations to promote the mental health of older adults.^{5,17} This type of intervention can be a complementary tool in the rehabilitation of older adults who may not be motivated to practice conventional exercises.³² In addition, it can be difficult to convince older adults to exercise, and therefore, new and different approaches are needed to attract their attention and increase adherence as much as possible.⁷

For health care professionals, the prescription of an exergame with minimal supervision can be used to achieve therapeutic goals, and it is recommended that older adults play exergames with their family and friends as a regular physical activity.⁵ Moreover, health professionals play a vital role in promoting improvements in lifestyle and promoting healthy aging.³²

On the other hand, this review showed that the Nintendo Wii was the most frequently used exergame in the included studies. Other studies also refer to it, highlighting it as one of the most accessible and most used for older adults.^{15,23} Moreover, Nintendo's Wii Sports games have been recommended for health purposes and are rated as having a high level of fun, an aspect that should be integrated into the development of health games.¹⁵

Commercial exergame gaming systems such as Nintendo Switch and Xbox Kinect are popular, fun, and interactive and can be used in any context.^{5,11,15} However, exergames with devices developed by research teams are not designed as a commercial product and often lack entertainment, fun, and interaction, making them less interesting.⁵ Therefore, more importance should be placed on the user's play experience from a health perspective and inspire researchers and designers in the specific domain of exergames in health.¹⁵

This review allowed us to identify that exergames can be used to promote mental health of older adults, and highlights the practical implications of game design that should prioritize the user's playful experience. Moreover, research that

documents the impact of this intervention focusing on mental wellbeing, in addition to the physical domain, remains scarce and requires further research and studies.

Now and in the future, society must seek to maximize the number of people who achieve a positive aging trajectory. An important element of this ambition is access innovative personalized interventions that promote optimal functional levels and a healthy lifestyle, particularly with recourse to exergames.³² Our study is important to encourage the access to and use of alternative physical activity tools in different environments, investigating the use of exergames in addition to functional mobility parameters, namely in mood, quality of life,⁷ wellbeing, mental health, promoting active aging. Due to the multimodal nature of the activity, exergames provide an effective tool for the remediation of age-related problems.²⁵

The quality of this review was enhanced by the comprehensive search strategy, precisely defined criteria for evaluating the search results, and the use of two independent reviewers for decision making on eligibility and assessments and methods of analysis. Despite these strengths, the review had some limitations that should be considered for the generalization of the results. First, the limited number of studies identified. In addition, the variability in study characteristics and outcome measures, in particular the large variability of assessment instruments for identical outcomes, made the meta-analysis difficult. Another limitation is related to some studies focusing on assessments other than the mental domain. The main conclusions must be interpreted with caution due to the variability in the size of some samples, the difference in the intervention time, and differences in the type of exergame used.

Key Findings

- Although the results have not demonstrated the positive impact of exergames on all outcomes, it was possible to observe a positive effect on mood, reducing apathy, anxiety, and depression, and improving self-esteem and affection.
- Exergames should continue to be integrated as an attractive method for the mental wellbeing of healthy older adults by promoting active aging.
- High-quality clinical trials, including groups with larger samples and less risk of bias, should be carried out.

Conclusion

In summary, this systematic review and evidence synthesis from GRADE support the effectiveness of using exergames for the mental wellbeing of older adults. It was possible to observe a positive effect on mood, reduced apathy, anxiety, depression, and improved self-esteem and affection. However, there is a need for more robust clinical trials that assess the effectiveness of the exergame only in this domain. Nonetheless, the potential of these technologies could help motivate and challenge older adults to increase their physical activity and improve their mental health. This will be an important challenge to be brought together, thinking about new remote intervention resources for a paradigm shift toward hybrid care.

Authors' Contributions

All authors have agreed on the final version of the article and have met at least one of the criteria: contributions

to conception, data collection, analysis, and interpretation, and drafting the article or critically revising.

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Supplementary Material

Supplementary Appendix SA1

References

1. Khan HTA. Population ageing in a globalized world: Risks and dilemmas? *J Eval Clin Pract* 2019; 25:754–760.
2. Xu X, Li J, Pham TP, et al. Improving psychosocial wellbeing of older adults through exergaming: The moderation effects of intergenerational communication and age cohorts. *Games Health J* 2016; 5:389–397.
3. Jahouh M, González-Bernal JJ, González-Santos J, et al. Impact of an intervention with Wii video games on the autonomy of activities of daily living and psychological-cognitive components in the institutionalized elderly. *Int J Environ Res Public Health* 2021; 18:1570.
4. Xu W, Liang H-N, Baghaei N, et al. Health benefits of digital videogames for the aging population: A systematic review. *Games Health J* 2020; 9:389–404.
5. Yen H-Y, Chiu H-L. Virtual reality exergames for improving older adults' cognition and depression: A systematic review and meta-analysis of randomized control trials. *J Am Med Dir Assoc* 2021; 22:995–1002.
6. Monteiro-Junior RS, Figueiredo LFS, Maciel-Pinheiro PT, et al. Virtual reality-based physical exercise with exergames (PhysEx) improves mental and physical health of institutionalized older adults. *J Am Med Dir Assoc* 2017; 18:454.e1–454.e9.
7. Cicek A, Ozdincler AR, Tarakci E. Interactive video game-based approaches improve mobility and mood in older adults: A nonrandomized, controlled trial. *J Bodyw Mov Ther* 2020; 24:252–259.
8. Soltani P, Figueiredo P, Vilas-Boas JP. Does exergaming drive future physical activity and sport intentions? *J Health Psychol* 2021; 26:2173–2185.
9. Younbo J, Koay J, Ng S, et al. Games for a better life: Effects of playing Wii games on the well-being of seniors in a long-term care facility. In *Proceedings of the Sixth Australasian Conference on Interactive Entertainment. Association for Computing Machinery*, 2009; 5:1–6. <https://dl.acm.org/doi/10.1145/1746050.1746055> (accessed October 3, 2021).
10. Soares VN, Yoshida HM, Magna TS, et al. Comparison of exergames versus conventional exercises on the cognitive skills of older adults: A systematic review with meta-analysis. *Arch Gerontol Geriatr* 2021; 97:104485.
11. Skjæret N, Nawaz A, Morat T, et al. Exercise and rehabilitation delivered through exergames in older adults: An integrative review of technologies, safety and efficacy. *Int J Med Inform* 2016; 85:1–16.
12. Santos P, Scaldaferrri G, Santos L, et al. Effects of the Nintendo Wii training on balance rehabilitation and quality of life of patients with Parkinson's disease: A systematic

- review and meta-analysis. *NeuroRehabilitation* 2019; 44: 569–577.
13. Garcia-Munoz C, Casuso-Holgado MJ. Effectiveness of Wii Fit Balance board in comparison with other interventions for post-stroke balance rehabilitation. Systematic review and meta-analysis [in Spanish]. *Rev Neurol* 2019; 69:271–279.
 14. Li J, Erdt M, Chen L, et al. The social effects of exergames on older adults: Systematic review and metric analysis. *J Med Internet Res* 2018; 20:e10486.
 15. Li J, Theng YL, Foo S. Effect of exergames on depression: A systematic review and meta-analysis. *Cyberpsychol Behav Soc Netw* 2016; 19:34–42.
 16. Li J, Theng YL, Foo S, Xu X. Exergames vs. traditional exercise: Investigating the influencing mechanism of platform effect on subthreshold depression among older adults. *Aging Ment Health* 2018; 22:1634–1641.
 17. Rosenberg D, Depp CA, Vahia IV, et al. Exergames for subsyndromal depression in older adults: A pilot study of a novel intervention. *Am J Geriatr Psychiatry* 2010; 18: 221–226.
 18. Li J, Theng YL, Foo S. Play mode effect of exergames on subthreshold depression older adults: A randomized pilot trial. *Front Psychol* 2020; 11:552416.
 19. Pollock A, Farmer SE, Brady MC, et al. An algorithm was developed to assign GRADE levels of evidence to comparisons within systematic reviews. *J Clin Epidemiol* 2016; 70:106–110.
 20. Obad AS, Abdulwali FK, Alaidroos HAH, et al. Relationship between shortage of basic life needs and quality of life of medical students in Yemen: A study utilizing validity and reliability of WHOQOL-BREF questionnaire. *J Family Med Prim Care* 2021; 10:1466–1472.
 21. Keogh JW, Power N, Wooller L, et al. Physical and psychosocial function in residential aged-care elders: Effect of Nintendo Wii Sports games. *J Aging Phys Act* 2014; 22: 235–244.
 22. Reivan-Ortiz G, Pineda-Garcia G, Parias BDL. Psychometric properties of the Goldberg Anxiety and Depression Scale (GADS) in Ecuadorian population. *Int J Psychol Res* 2019; 12:41–48.
 23. Erazo M, Fors M, Mullo S, et al. Internal consistency of Yesavage Geriatric Depression Scale (GDS 15-item version) in Ecuadorian older adults. *Inquiry* 2020; 57:1–6.
 24. Lee M, Son J, Kim J, Yoon B. Individualized feedback-based virtual reality exercise improves older women's self-perceived health: A randomized controlled trial. *Arch Gerontol Geriatr* 2015; 61:154–160.
 25. Maillot P, Perrot A, Hartley A, Do M-C. The braking force in walking: Age-related differences and improvement in older adults with exergame training. *J Aging Phys Act* 2014; 22:518–526.
 26. Portela F, Correia RJ, Fonseca J, Andrade JM. Wiithery on seniors—Effects on physical and mental domains. In 2011 IEEE 1st International Conference on Serious Games and Applications for Health (SeGAH), 2011: 1–5. <https://ieeexplore.ieee.org/document/6165441> (accessed October 3, 2021).
 27. Spineli LM, Pandis N. Fixed-effect versus random-effects model in meta-regression analysis. *Am J Orthod Dentofacial Orthop* 2020; 158:770–772.
 28. Eggenberger P, Wolf M, Schumann M, de Bruin ED. Exergame and balance training modulate prefrontal brain activity during walking and enhance executive function in older adults. *Front Aging Neurosci* 2016; 8:66.
 29. Gomes GCV, Simões MDS, Lin SM, et al. Feasibility, safety, acceptability, and functional outcomes of playing Nintendo Wii Fit Plus™ for frail older adults: A randomized feasibility clinical trial. *Maturitas* 2018; 118:20–28.
 30. Zeng N, Pope Z, Lee JE, Gao Z. A systematic review of active video games on rehabilitative outcomes among older patients. *J Sport Health Sci* 2017; 6:33–43.
 31. Chao YY, Scherer YK, Montgomery CA. Effects of using Nintendo Wii™ exergames in older adults: A review of the literature. *J Aging Health* 2015; 27:379–402.
 32. Suleiman MN, García LR, Albendín GL, et al. Effects of active video games on physical function in independent community-dwelling older adults: A systematic review and meta-analysis. *J Adv Nurs* 2022; 78:1228–1244.

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