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RECEIVED 29 June 2023

ACCEPTED 29 February 2024

PUBLISHED 09 April 2024

CITATION

Hernandez-Martinez J, Ramos-Espinoza F,
Muñoz-Vásquez C, Guzman-Muñoz E,
Herrera-Valenzuela T, Branco BHM,
Castillo-Cerda M and Valdés-Badilla P (2024)
Effects of active exergames on physical
performance in older people: an overview of
systematic reviews and meta-analysis.
Front. Public Health 12:1250299.
doi: 10.3389/fpubh.2024.1250299

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Effects of active exergames on physical performance in older people: an overview of systematic reviews and meta-analysis

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This overview assessed the available body of published peer-reviewed systematic reviews and meta-analyses related to the effects of active exergames compared with active/passive control on physical performance outcomes in older people. The methodological quality and certainty of evidence were assessed using PRISMA, AMSTAR 2, and GRADE. The protocol was registered in PROSPERO (code: CRD42023391694). The main outcomes indicate that 4,477 records, five systematic reviews, and 10 meta-analyses were included. The AMSTAR-2 reported six meta-analyses with high methodological quality, four moderate quality, two systematic reviews with low quality, and three very-low quality. Meta-analysis was performed on balance using the Berg Balance Scale (BBS) and Timed Up-and-Go (TUG) tests, on cardiorespiratory fitness using the 6-min walk test, and on upper and lower limbs muscle strength using the handgrip strength, knee extension, and 30-s chair stand tests. Significant differences in favor of the active exergames groups concerning active/passive groups were reported in BBS (SMD = 0.85; 95% CI = 0.12–1.58; $I^2 = 96%$; $p = 0.02$), TUG (SMD = 1.44; 95% CI = 0.71–2.16; $I^2 = 97%$; $p < 0.0001$), and 30-s chair stand test (SMD = 0.79; 95% CI = 0.33–1.25; $I^2 = 88%$; $p = 0.0008$). However, no significant differences were reported in favor of the active exergames groups in 6-min walk (SMD = 0.93; 95% CI = –0.64 to 2.50; $I^2 = 95%$; $p = 0.24$), handgrip strength (SMD = 0.67; 95% CI = –0.04 to 1.38; $I^2 = 84%$; $p = 0.06$), and knee extension tests (SMD = 0.20; 95% CI = –0.05 to 0.44; $I^2 = 95%$; $p = 0.12$) compared to active/passive control. However, it was impossible to perform a meta-analysis for the variables of walking speed as a fall risk due to the diversity of instruments and the small number of systematic reviews with meta-analysis. In conclusion, interventions utilizing active exergames have shown significant improvements in the static and dynamic balance and lower limb muscle strength of apparently healthy older people, compared to control groups of active/inactive participants, as measured by BBS, TUG, and 30-s chair stand tests. However, no significant differences were found in the 6-min walk, HGS, and knee extension tests.

Systematic review registration: PROSPERO, CRD42023391694.

KEYWORDS

exergaming, virtual reality, physical functional performance, postural balance, muscle strength dynamometer, aged

1 Introduction

The aging process leads to different physical changes in older people, such as a 59% decrease in balance (1), 73% loss of walking speed (2), 35% lower mobility (2), 30% decrease in muscle strength (3), and 80% increased fall risk (4). Elements that together increase frailty and reduce functional independence (5) affect the quality of life in older people (6).

On the contrary, regular physical activity practice has reported improvements of 54% in physical fitness in older people after interventions that include balance, resistance training, and endurance exercises (7), a fact that aligns with international physical activity recommendations that indicate performing between 150 and 300 min of moderate-intensity physical activity or 75–150 min of vigorous-intensity physical activity a week (8), which include at least two weekly sessions of resistance training in older people (9). However, the COVID-19 pandemic has forced a rethinking of physical activity strategies for the general population (10), particularly in older people (11). Thus, performing physical activity in small spaces while maintaining distance and safety in practice has become indispensable (10, 11); in such a context, active exergames are presented as alternatives that meet these requirements and are also entertaining for older people (12, 13).

The active exergames can be developed in health, community, and sports centers or a homeroom individually or in groups using a screen (14) through active exergames that involve the movement of the whole body, similar to the real world with or without the use of a controller allowing the movements to be executed within a reduced space and interacting with the game scenario (14). Conversely, the cost to acquire a game console is affordable and ranges from US\$100 to US\$299, while annual healthcare costs amount to US\$2,000 in the United States of America (15) and €2,337 in England, according to the National Health Service of the Kingdom United (16). The most popular consoles and active exergames used by older people are Nintendo Wii® with the Wii sports, Wii balance, and Wii Fit games (17–19); Microsoft's Xbox Kinect® with the Kinect Sports, Adventure, and Your Shape games (18, 19); and Sony's PlayStation Move® with the Sports Champions Move game (13).

Specifically, Wii Fit has demonstrated a 34% increase in lower limb muscle strength, a 23.6% increase in balance, a 35.1% reduction in fall risk, and an 8% lower risk of frailty in Hong Kong in older people compared to patients undergoing a 6-week conventional balance training intervention (20). Similarly, using a 5-week Xbox Your Shape intervention, Yang et al. (21) reported a 14.3% improvement in dynamic balance and a 16% improvement in static balance in Taiwan's older people over a conventional balance intervention. Another study by Hernandez-Martínez et al. (22) reported notable enhancements in physical performance among older Chilean people following an 8-week Xbox Kinect Sports intervention. The researchers observed a 4.1% increase in walking speed, an 8.5% improvement in the timed up-and-go test (TUG), and a remarkable

16% enhancement in lower limb muscle strength. These findings are in line with a study conducted by Yu et al. (23) on Taiwanese older people, who experienced a 15.6% increase in lower limb muscle strength and a 5.4% improvement in cardiorespiratory fitness after engaging in a 10-week intervention utilizing Xbox Kinect Adventure. These results collectively indicate the potential benefits of utilizing Xbox Kinect-based interventions to promote physical fitness and performance among older populations.

The results that active exergames report on the physical functional and physical fitness in older people (23, 24), added to the increase of studies with high-quality design (randomized controlled trials), have allowed the development of several systematic reviews with and without meta-analysis that synthesize this evidence (19, 25–28). However, to the best of our knowledge, a study that condenses all these systematic reviews into a single document has not yet been published. In this sense, the main aim of this overview was to assess the available body of published peer-reviewed systematic reviews and meta-analyses related to the effects of active exergames compared with active/passive controls on physical performance outcomes in older people.

2 Materials and methods

2.1 Protocol and record-keeping

This overview followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines (29). The protocol was registered in PROSPERO (International Prospective Register of Systematic Reviews; code: CRD42023391694).

2.2 Eligibility criteria

The inclusion criteria for this overview were original peer-reviewed systematic reviews and meta-analyses without any language or publication date restrictions, published up to 23 February 2024. Excluded records were conference abstracts, books, book chapters, editorials, letters to the editor, trial records, case studies, and trials. In addition, the population, intervention, comparator, outcome, and study design (PICOS) framework were followed to incorporate studies into an overview (see Table 1).

2.3 Information search process and databases

The search process used seven databases: PubMed, Web of Science (core collection), Scopus, CINAHL, Cochrane Library, MEDLINE, and Psychology and Behavioral Sciences (EBSCO). Medical Subject Headings (MeSH) from the National Library of Medicine of the

TABLE 1 Selection criteria used in the overview.

Category	Inclusion criteria	Exclusion criteria
Population	Older people with a mean age of 60 years or more, according to the World Health Organization WHO (2021), are healthy and without distinction of sex.	People with a mean age of fewer than 60 years old.
Intervention	Systematic reviews and meta-analysis of interventions with active exergames (i.e., Wii sports, balance and fit, Kinect Sports, Adventure and Your Shape, Sports Champions Move) of 2 weeks or more.	Systematic reviews and meta-analyses of interventions that do not use active exergames as an intervention.
Comparator	Systematic reviews with and without meta-analysis with control groups with (other than active exergames) or without supervised physical activity.	Absence of control groups.
Outcomes	At least one physical performance assessment (i.e., handgrip strength, walking speed, fall risk, Berg Balance Scale), pre- and post-intervention.	Lack of reference and/or follow-up data.
Study design	Systematic reviews or meta-analyses with the inclusion of studies using an experimental design (randomized controlled trial and non-randomized controlled trial) with pre- and post-assessments.	Systematic reviews or meta-analyses with cross-sectional, retrospective, and prospective studies.

United States of America were used as free language terms related to active exergames, physical performance, and older people. The search string used was as follows: (“exergames” OR “exergaming” OR “active video games” OR “virtual reality” OR “wii” OR “Kinect” OR “play station”) AND (“physical function” OR “physical performance” OR “physical fitness” OR “functionality” OR “functional Independence” OR “functional dependency” OR “functional mobility” OR “health condition” OR “falls” OR “fall risk” OR “risk of fall” OR “falling risk” OR “balance” OR “static balance” OR “dynamic balance” OR “walking speed” OR “gait speed” OR “mobility” OR “strength” OR “muscle strength” OR “upper body strength” OR “lower body strength” OR “muscle power”) AND (“elderly” OR “older adults” OR “older people” OR “older subject” OR “aging” OR “ageing” OR “aged”).

2.4 Study selection and data collection process

Studies were exported to the EndNote reference manager (version X9. Bld.12062, Clarivate Analytics, Philadelphia, PA, United States). Two authors (JHM and PVB) independently searched, removed duplicates, reviewed titles and abstracts, and analyzed full texts. The process was repeated for searches within reference lists and suggestions provided by external experts. Subsequently, potentially eligible studies were reviewed in full text, and the reasons for excluding those not meeting the selection criteria were reported.

2.5 Assessment of methodological quality

The methodological quality of the selected studies was assessed using the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews 2) (30). This instrument is composed of 7 domains, which are as follows: (i) protocol recorded prior to the review; (ii) adequate literature search; (iii) justification of excluded studies; (iv) risk of bias of individual included studies; (v) appropriate meta-analytic methods; (vi) consideration of risk of bias in the interpretation of review results; and (vii) assessment of the presence and likely impact of publication bias. Sixteen items are included to rate the methodological quality of the reviews according to the following confidence criteria (30): (i) high: no critical weaknesses and up to one non-critical (the systematic review provides an accurate and complete summary of the results of

the available studies); (ii) medium: no critical weaknesses and more than one non-critical weakness (although, if there are many, a low confidence could be justified); the systematic review has weaknesses, but no critical flaws, being able to provide an accurate summary of the results of the available studies; (iii) low: up to one critical weakness, with or without non-critical weaknesses: the systematic review may not provide an accurate and complete summary of the available studies; and (iv) critically low: more than one critical weakness, with or without non-critical weaknesses: the systematic review is not reliable. Two authors (JHM and CMV) independently assessed the quality of the reports using PRISMA in a 27-item checklist (29), and a third author (PVB) acted as referee for borderline cases, which were then validated by another author (THV). Each item was assessed according to whether it was reported and received 1 point for full reporting, 0.5 points for partial reporting, and 0 points for not reporting. Less than 15 points indicate relatively severe reporting defects, between 15 and 21 points indicate some reporting defects, and between 21.5 and 27 points indicate a relatively complete report.

2.6 Certainty of evidence

Using the GRADE scale, the degree of certainty of evidence was evaluated, and it was determined whether the studies' degree was high, moderate, low, or very low (31). Due to the inclusion of studies with experimental designs (randomized controlled trials and non-randomized controlled trials), all analyses began with a grade of high certainty and were downgraded if there were issues with consistency, precision, directness of the results, or risk of publication bias (31). Two authors (JHM and CMV) independently assessed the studies, and any discrepancies were resolved through consensus with a third author (PVB). The criteria for downgrading the certainty of evidence were as follows: (i) limitation of included studies: one level of a downgrade if 25% or more of the included articles had a high risk of bias as assessed by AMSTAR-2; (ii) inconsistency: one level of downgrade was applied if there was high heterogeneity ($I^2 \geq 90\%$); (iii) indirectness: One level of downgrade was applied if there were differences between participants, interventions, outcome measures, or indirect comparisons; (iv) imprecision: one level of downgrade was considered if there was a wide confidence interval, crosses the line of no effect, and/or small sample size ($n < 300$); (v) risk of publication bias: one level of downgrade was applied if there was asymmetry in the doi plot.

2.7 Data synthesis

The following data were obtained and analyzed from the selected studies: (i) author and year; (ii) study design (systematic reviews and/or meta-analysis); (iii) baseline health status of the sample; (iv) the number of studies and participants in the intervention and control groups; (v) mean age of the sample; (vi) activities performed in the consoles, active exergames, and control groups; (vii) training volume (total duration, weekly frequency, and time per game); (viii) physical performance data collection instruments; (ix) main outcomes of the systematic reviews and/or meta-analysis; (x) quality assessment; and (xi) PRISMA score.

2.8 Summary measures for meta-analysis

A meta-analysis was performed to explore the effect of different systematic reviews or meta-analyses on the same outcome; this was done using data from systematic reviews or meta-analysis reports included in the overall review. The pooled effect that was calculated is the standardized mean difference (SMD), 95% confidence interval (95% CI), and the inverse variance weighting method with a random effect was used. When only the median and extreme or quartiles were reported in systematic reviews or meta-analyses whose mean and standard deviation (SD) could not be obtained from systematic reviews, neither the mean nor the SD was estimated because the sample size is too small for an accurate estimated value (32). Heterogeneity was quantified by I^2 , where a value >50% indicates substantial heterogeneity (33). Low-quality systematic reviews were excluded from the sensitivity analysis, following the recommendations of previous overviews (33). These were meta-analyzed using RevMan 5.4 following the findings of previous studies (34, 35). Finally, publication bias was measured using Egger's regression asymmetry test to assess small study effects as proposed by Sterne et al. (36). Statistical analyses were performed with StataMP, version 17 (StataCorp, College Station, TX, United States).

3 Results

3.1 Study selection

Figure 1 details the process of searching for systematic reviews and meta-analyses. In the identification phase, a total of 4,477 records were found. Subsequently, duplicates were eliminated, and studies were filtered by selecting title, abstract, and keywords, resulting in 2,106 references. A total of 165 systematic reviews and meta-analysis were included in the next phase of analysis: 24 descriptive systematic reviews, five systematic reviews conducted in people with a mean age less than 60 years, two systematic reviews that reported anthropometric results, 28 systematic reviews of studies with interventions without active exergames, 21 studies that were not systematic reviews (other types of review), 68 systematic reviews of active exergames in patients with cardiac or respiratory neurological pathologies, one review of the study in exergames in older people with balance problems, and one systematic review because the text was inaccessible (the authors of the systematic review were contacted requesting a copy of their manuscript, estimating 30 days as maximum response time). After this process, the total number of systematic reviews and meta-analysis that met all the selection criteria was 15 (17–19, 25–28, 37–44).

3.2 Methodological quality

According to the AMSTAR-2, the mean score of the selected systematic reviews and meta-analysis was 12.6 points; in particular, six meta-analyses obtained a high quality with values between 15 and 16 points (18, 28, 37, 38, 41, 43), four meta-analysis obtained a moderate quality with values between 13 and 14 points (17, 26, 27, 42), two systematic reviews were of low quality with values between 10 and 11 points (19, 44), and three systematic reviews achieved a critically low quality located between 7 and 8 points (25, 39, 40). These results can be seen in Table 2.

3.3 Certainty of evidence

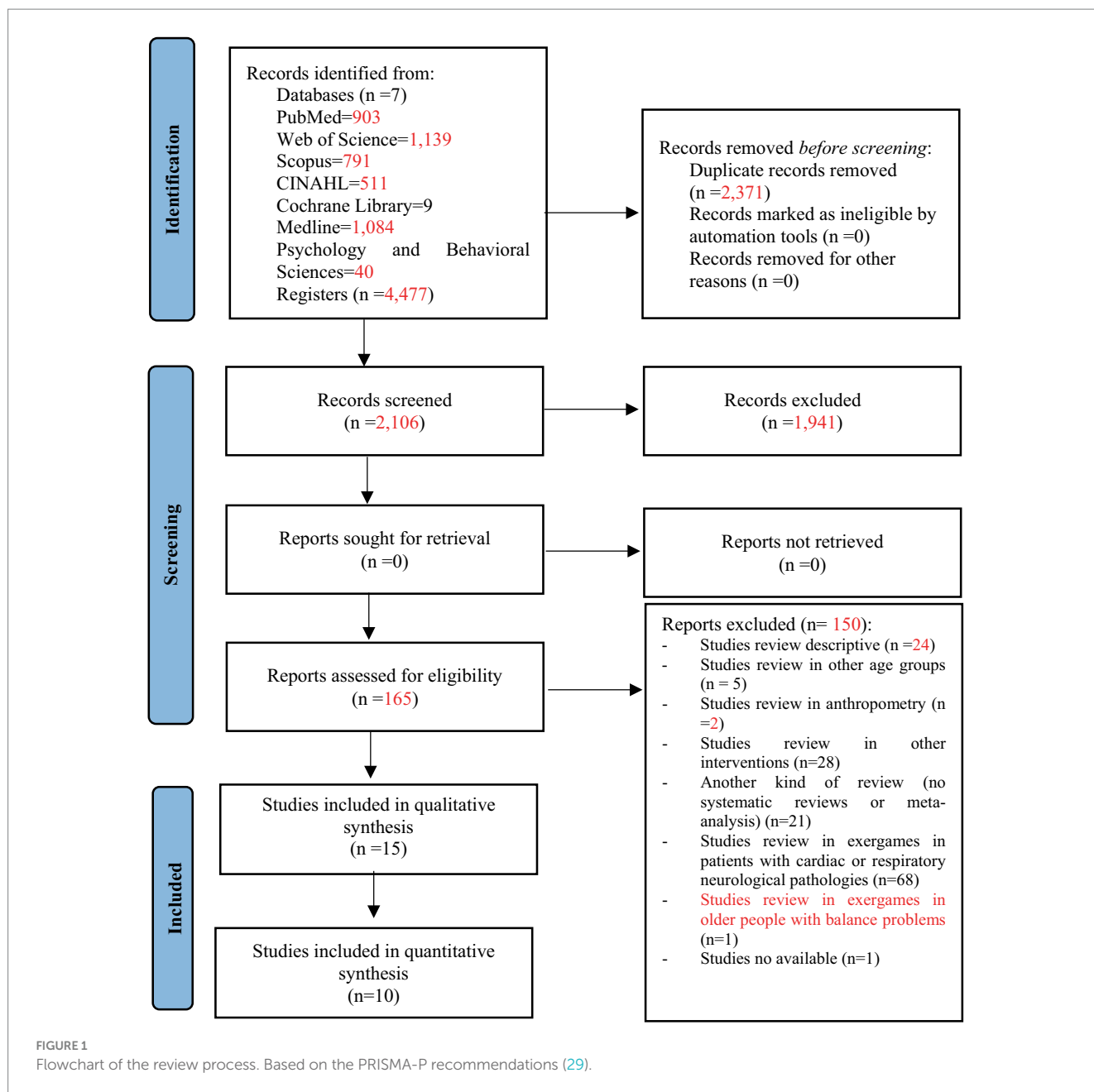
In the certainty of the evidence, it was reported that for the balance variable in the Berg Balance Scale (BBS) and TUG tests, there was a moderate certainty of evidence (18, 26–28, 37, 41, 42), similar to the 30-s chair stand test (27, 37, 41, 42). While in the cardiorespiratory fitness variable through the 6-min walk test (18, 41), a high certainty of evidence was reported. On the contrary, in the direct muscle strength variables through handgrip strength (HGS) (41, 43) and knee extension (41, 43) tests, a very low certainty of the evidence was reported. The certainty of evidence is shown in Table 3; this allows us to recommend using active exergames in variables of balance and muscle strength, such as BBS, TUG, and 30-s chair stand tests in older people.

3.4 Studies characteristics

The characteristics of systematic reviews and meta-analyses analyzed in the overview indicated that 12 systematic reviews and meta-analyses were randomized controlled trials (17, 18, 25, 26, 28, 37–42, 44) and three systematic reviews and meta-analysis were non-randomized controlled trials (19, 27, 43). A total of 290 studies were analyzed in the selected systematic reviews and meta-analysis, totaling 15,832 participants with a mean age of 75.2 years (17–19, 25–28, 37–44). In general, older people who participated in the active exergames were apparently healthy (17, 18, 25–28, 37, 39, 41), pre-frail, and frail (19, 40, 44), which was determined by bone mineral densitometry and functional physical performance (19, 40, 44) and who participated in active exergames through the system with Xbox Kinect 360 (18, 19, 25, 26, 37, 38, 43), Nintendo Wii (17–19, 25, 27, 28, 37–44), and Play Station Movie (17, 18). The reviews analyzed report active control groups, specifically those that participated in traditional physical activity (17–19, 25, 26, 28, 37–42, 44), inactive control groups (no physical activity) (27, 28, 38, 41, 43), or who killed the basic activities of daily living (17, 18, 25, 41). More information about this topic is presented in Table 4.

3.5 Active exergames dosage

The dosage of the interventions with active exergames was diverse, ranging from 2 to 26 weeks with a frequency of one to five sessions per week with a duration of 30–60 min per session with moderate-to-vigorous intensities ranging from three to six in the 10-point rating of perceived exertion (RPE) (17–19, 25–28, 37–44).



3.6 Outcomes of overview

The results of systematic reviews and meta-analyses were synthesized. First, we qualitatively summarized the results of the systematic reviews and meta-analysis that reported the individual effects of different types of active exergames on physical performance in older people, then extracted data from the meta-analysis to better explain the effects of active exergames. Only 10 systematic reviews and meta-analyses qualified for meta-analysis that presented moderate and high methodological qualities.

3.7 Fall risk

Only four systematic reviews reported the fall risk measured through Tinetti's falls efficacy scale (25), falls efficacy scale (19, 25, 44),

short falls efficacy scale-international (19), efficacy scale-international, and iconographical fall efficacy scale (26). The individual results from systematic reviews indicate significant improvements in the groups with active exergames. However, conducting a meta-analysis was impossible due to the diversity of instruments and the small number of systematic reviews with meta-analysis; these findings cannot be confirmed.

3.8 Walking speed

Two reviews reported walking speed measures assessed through functional gait assessment (17, 38) and gait speed test (17). The individual results from systematic reviews indicate significant improvements in the groups with active exergames. However, conducting a meta-analysis was impossible due to the diversity of

TABLE 2 Methodological quality.

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Did the review report contain an explicit statement that the review methods were established prior to the review, and did the report justify any significant deviations from the protocol?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
3. Did the review authors explain their selection of the study designs for inclusion in the review?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Continued)

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunnen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
4. Did the review authors use a comprehensive literature search strategy?	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Did the review authors perform study selection in duplicate?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Did the review authors perform data extraction in duplicate?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Did the review authors provide a list of excluded studies and justify the exclusions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Did the review authors describe the included studies in adequate detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Continued)

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (16)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunnen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies included in the review?	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
10. Did the review authors report on the funding sources for the studies included in the review?	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No
11. If meta-analysis was performed, did the review authors use appropriate methods for the statistical combination of results?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No

(Continued)

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunnen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
13. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
14. Did the review authors provide a satisfactory explanation for and discussion of any heterogeneity observed in the review results?	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No

(Continued)

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunnen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (20)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
15. If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Total score	8	14	15	14	15	10	16	7	14	8	15	15	13	15	11
Methodological quality rating	Critically low	Moderate	High	Moderate	High	Low	High	Critically low	Moderate	Critically low	High	High	Moderate	High	Low

TABLE 3 GRADE assessment for the certainty of evidence.

Outcome	Review design	Risk of bias in individual review	Risk of publication bias	Inconsistency	Indirectness	Imprecision	Certainty of evidence
Balance							
BBS	4 RCT and 1 RCT/NRCT with 82 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate
TUG	4 RCT and 1 RCT/NRCT with 98 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate
Cardiorespiratory fitness							
6-min walk test	2 RCT with 40 studies	low	Not assessed	Moderate	Low risk	Moderate	High
Upper limb muscle strength							
HGS	1 RCT and 1 NRCT with 69 studies	High	Not assessed	High	Moderate	High	Very low
Lower limb muscle strength							
Knee extension test	1 RCT and 1 NRCT with 69 studies	High	Not assessed	High	Moderate	High	Very low
30-s chair stand test	3 RCT and 1 NRCT with 66 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate

BBS, berg balance scale; TUG, timed up and go; HGS, handgrip strength; RCT, randomized controlled trial; NRCT, non-randomized controlled trial.

instruments and the small number of systematic reviews with meta-analysis; these findings cannot be confirmed.

3.9 Berg balance scale

Static balance was measured through the Berg Balance Scale (BBS) score. Five systematic reviews with meta-analysis analyzed the effect of active exergames on this measure (26–28, 41, 42), with 493 participants in the active exergames groups and 488 participants in the control groups. The results of the meta-analysis suggested that the active exergames significantly improved BBS score compared to control groups (SMD = 0.85; 95% CI = 0.12–1.58; $I^2 = 96%$; $p = 0.02$), with high-level heterogeneity and using a fixed-effects model (Figure 2).

3.10 Timed up-and-go test

Dynamic balance was measured using TUG. Five systematic reviews with meta-analysis were pooled for meta-analysis (18, 27, 28, 37, 41), with 675 participants in the active exergames groups and 678 participants in the control groups. Results indicate that active exergames significantly reduced time in TUG compared to control

groups (SMD = 1.44; 95% CI = 0.71–2.16; $I^2 = 97%$; $p < 0.0001$), with high-level heterogeneity using a fixed-effects model (Figure 3).

3.11 6-min walk test

Cardiorespiratory fitness was measured through the 6-min walk test. Two systematic reviews with meta-analysis were detected for meta-analysis (18, 41), with 122 participants in the active exergames groups and 111 participants in the control groups. The results indicate that the active exergames did not significantly differ in the 6-min walk test when compared to control groups (SMD = 0.93; 95% CI = –0.64 to 2.50; $I^2 = 95%$; $p = 0.24$), with high-level heterogeneity using a fixed-effects model (Figure 4).

3.12 Handgrip strength








The HGS test measured maximal upper limb muscle strength. Two systematic reviews with meta-analysis were detected for meta-analysis (41, 43), with 161 participants in the active exergames groups and 144 participants in the control groups. The results indicate that the active exergames did not significantly differ in HGS when compared to control groups (SMD = 0.67; 95% CI = –0.04 to 1.38;





TABLE 4 Systematic reviews and meta-analysis reporting outcomes in active exergames on physical performance.

References	Study design (SR and/or MA)	Baseline health status of the sample	Number of studies and participants in the intervention and control groups	The mean age of the sample	Activities performed in the consoles and active exergames and control groups	Training volume (total duration, weekly frequency, and time per game)	Physical performance data collection instruments	Main outcomes of the systematic reviews and meta-analysis	Quality assessment	Meta-analysis	PRISMA score
Chen et al. (26)	RCT	Older people, apparently healthy	20 (795; EG: 423; CG: 372).	EG: age 73.2 ± 5.3 years; CG: 73.8 ± 5.4 years.	EG: Xbox 360 Kinect. CG: Physical therapy exercises.	6/20 wk.; 2/3 wk. of 30/90 min.	BBS; FES-1 and Icon-FES	BBS↔; FES-1↑; Icon-FES↑	The Cochrane risk-of-bias tool	Yes	27
Fang et al. (37)	RCT	Older people, apparently healthy	16 (632; EG: 318; CG: 318).	EG: age 72.8 ± 7.0 years; CG: age 72.1 ± 6.5 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	6/15 wk.; 2/3 wk. of 30/50 min.	TUG and 30-s chair stand	TUG↓; 30-s chair stand↑	PEDro	Yes	25
Corregidor-Sánchez et al. (17)	RCT	Older people, apparently healthy	14 (Both groups: 491).	Both groups: age 77.2 ± 6.5 years.	EG: Nintendo Wii and Play Station movie. CG: traditional physical exercise or daily activities.	2/24 wk.; 1/5 wk.; no reported min.	FGA and GST.	FGA↔; GST↑	Not reported	Yes	27
Janhunen et al. (38)	RCT	Older people, apparently healthy	58 (Both groups: 3,774)	Both groups: age 74.3 ± 6.8 years	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/26 wk.; 2/3 wk. of 11/90 min.	FGA↑	FGA↑	The Cochrane Risk of Bias 2 tool	Yes	26
Laufer et al. (39)	RCT	Older people, apparently healthy	7 (285; EG: 126; CG: 159).	EG: age 71.5 ± 26.3 years; CG: age 76 ± 21.9 years.	EG: Nintendo Wii. CG: traditional physical exercise or daily activities.	6/20 wk.; 1/3 wk. of 30/60 min.	TUG	TUG↓	PEDro	No	13
Taylor et al. (42)	RCT	Older people, apparently healthy	18 (1,263; EG: 704; GC: 559).	EG: age 78.3 ± 10; GC: age 75 ± 8 years.	EG: Nintendo Wii. CG: traditional physical exercise or no intervention	3/20 wk.; 2/3 wk. of 40 min.	BBS	BBS↑	The Cochrane collaboration's risk of bias tool	Yes	22
Pacheco et al. (28)	RCT	Older people, apparently healthy	12 (1,423; EG: 704; GC: 719).	EG: age 76 ± 6 years; 719 GC: age 76 ± 5 years.	EG: Nintendo Wii. CG: traditional physical exercise or no intervention	4/16 wk.; 2/3 wk. of 30/70 min.	BBS and TUG	BBS↑; TUG↑	The Cochrane Handbook for Systematic reviews of interventions	Yes	26
Suleiman-Martos et al. (41)	RCT	Older people, apparently healthy	22 (Both groups: 1,208).	Both groups: age 74.9 ± 6.1 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or no intervention.	3/24 wk.; 2/3 wk. of 15/120 min.	BBS; TUG; 6WMT; HGS; Knee extension and 30-s chair stand.	BBS↑; TUG↓; 6MWT↑; HGS↑; Knee extension ↔ and 30-s chair stand↑	The Cochrane risk-of-bias tool	Yes	25

(Continued)

TABLE 4 (Continued)

References	Study design (SR and/or MA)	Baseline health status of the sample	Number of studies and participants in the intervention and control groups	The mean age of the sample	Activities performed in the consoles and active exergames and control groups	Training volume (total duration, weekly frequency, and time per game)	Physical performance data collection instruments	Main outcomes of the systematic reviews and meta-analysis	Quality assessment	Meta-analysis	PRISMA score
Zheng et al. (44)	RCT	Older people; frail and pre-frail.	7 (243; EG: 171; CG: 72).	EG: age 80.0 ± 6.2 years; CG: age 83.1 ± 5.0 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/15 wk.; 2/3 wk. of 20/50 min.	FE	FES↔ 	The Cochrane Collaboration's tool for assessing the risk of bias	No	21
Afridi et al. (25)	RCT	Older people, apparently healthy	10 (Both groups: 442).	Both groups: age 65.8 ± 4.9 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	8/12 wk.; 2/3 wk. of 30/60 min.	Tinetti's falls efficacy scale and FES	Tinetti's falls efficacy scale↔; FES↑ 	Not reported	No	12
Corregidor-Sánchez et al. (18)	RCT	Older people, apparently healthy	18 (Both groups: 772).	Both groups: age 71.1 ± 6.8 years.	EG: Nintendo Wii, Play Station movie, and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/24 wk.; 2/3 wk. of 20/50 min.	TUG and 6WMT	TUG↓; 6WMT↔ 	The Cochrane Collaboration's tool for assessing the risk of bias	Yes	25
Ge et al. (19).	RCT/ NRCT	Older people; frail and pre-frail.	23 (2.071; EG: 1.044; GC: 1.027).	EG: age 75 ± 5.5 years; CG: age 74.8 ± 5.1 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	4/12 wk.; 1/3 wk. of 60 min.	FES, Icon-FES and Short FES-1	FES↑; Icon-FES↑; Short FES-1↑ 	PEDro	No	17
Liu et al. (27)	RCT/ NRCT	Older people, apparently healthy	10 (Both groups: 379).	Both groups: age 73.8 ± 6.2 years.	EG: Nintendo Wii. CG: No intervention	3/10 wk.; 2/3 wk. of 30/60 min.	BBS; TUG and 30-s chair stand.	BBS↑; TUG↓; 30-s chair stand↑ 	PEDro	Yes	23
Viana et al. (43)	RCT/ NRCT	Older people; apparently healthy.	47 (Both groups: 1.760).	Both groups: age 84.1 ± 7.6 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise.	6/14 wk.; 1/5 wk. of 30/60 min.	HGS and knee extensión.	HGS↑; Knee extensión↑ 	PEDro	Yes	25
Molina et al. (40)	RCT	Older people; frail and pre-frail.	8 (Both groups: 294).	Both groups: age 77.3 ± 4.4 years.	EG: Nintendo Wii. CG: traditional physical exercise or daily activities.	3/20 wk.; 1/5 wk. of 25/60 min.	BBS; TUG; ABC and LOB.	BBS↑; TUG↓; ABC↑ 	PEDro	No	19

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analysis; SR, systematic review; MA, Meta-analysis; RCT, randomized controlled trial; NRCT, non-randomized controlled trial; EG, experimental groups; CG, control group; wk, week; Min, minutes; BBS, balance Berg scale; TUG, timed up and go test; HGS, handgrip strength; 6MWT, 6-min walk test; FGA, functional Gait assessment; GS, gait speed test; FES, falls efficacy scale; FES-1, falls efficacy scale-international; Icon-FES, Iconographical Falls Efficacy Scale; Short FES-1, short falls efficacy scale-international; ABC Scale, The Activities-specific Balance; , high methodological quality; , moderate methodological quality; , low methodological quality; , very low methodological quality; ↑, significant improvement; ↓, significant decrease; ↔, no significant difference.

$I^2 = 84\%$; $p = 0.06$), with high-level heterogeneity using a fixed-effects model (Figure 5).

3.13 30-s chair stand

The 30-s chair stand test measured lower limb muscle strength. Four systematic reviews with meta-analysis were detected for meta-analysis (27, 37, 41, 42), with 352 participants in the active exergames groups and 339 participants in the control groups. Results indicate that the active exergames significantly improved in the 30-s chair stand test concerning control groups (SMD = 0.79; 95% CI = 0.33–1.25; $I^2 = 88\%$; $p = 0.0008$), with high-level heterogeneity using a fixed-effects model (Figure 6).

3.14 Knee extension

Two systematic reviews with meta-analysis were detected for the meta-analysis (41, 43), with 103 participants in the active exergames groups and 179 participants in the control groups. The results indicate that the active exergames, when compared to the control groups, did not significantly differ in knee extension (SMD = 0.20; 95% CI = -0.05 to 0.44; $I^2 = 95\%$; $p = 0.12$), with high-level heterogeneity using a fixed effects model (Figure 7).

Egger’s regression asymmetry test observed no significant publication bias in the 30-s chair stand ($p = 0.90$) and in the TUG ($p = 0.36$). However, significant publication bias was observed in the

following tests: 6-min walk ($p = 0.001$), HGS ($p = 0.04$), knee extension ($p = 0.01$), and BBS ($p = 0.00$). These results are presented in the funnel plot in Figure 8.

3.15 Adverse events

Only two systematic reviews and meta-analyses reported adverse events (25, 42). Specifically, the systematic review of Taylor et al. (42) reported minor musculoskeletal injuries (musculoskeletal strain) and vertigo sensation in both active exergames and control groups. For his part, Afridi et al. (25) reported that dropouts were due to back pain in some interventions with active exergames without requiring medical attention.

4 Discussion

This overview aimed to assess published peer-reviewed systematic reviews and meta-analyses concerning the effects of active exergames compared to active/passive controls on physical performance outcomes in older people. Fifteen systematic reviews and meta-analyses were identified, of which 10 provided sufficient information for meta-analysis and demonstrated moderate-to-high methodological quality. The main findings of the meta-analysis revealed statistically significant improvements in the BBS, TUG, and 30-s chair stand tests among the active exergames intervention groups compared to the control groups. However, no significant differences were found in the

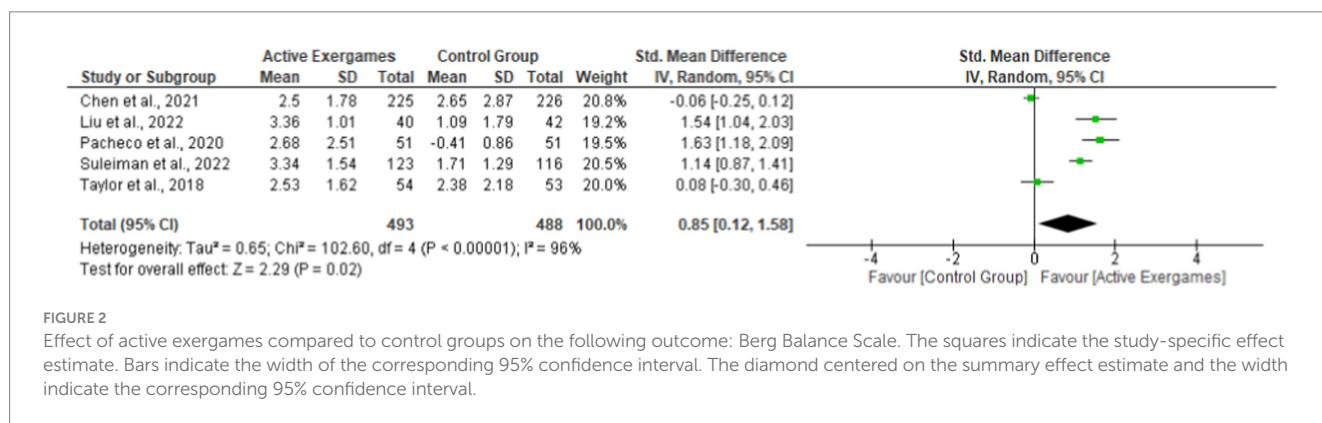


FIGURE 2 Effect of active exergames compared to control groups on the following outcome: Berg Balance Scale. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

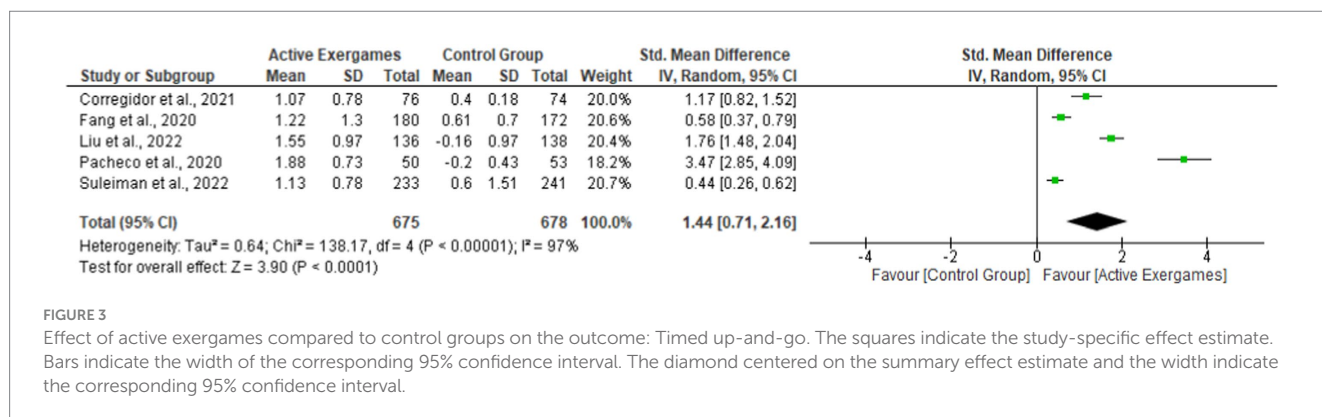


FIGURE 3 Effect of active exergames compared to control groups on the outcome: Timed up-and-go. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

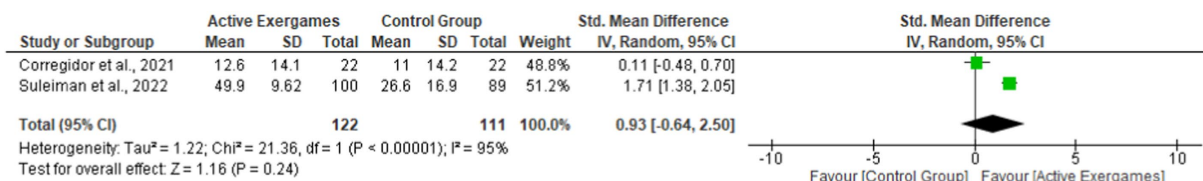


FIGURE 4 Effect of active exergames compared to control groups on 6-min walk test. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

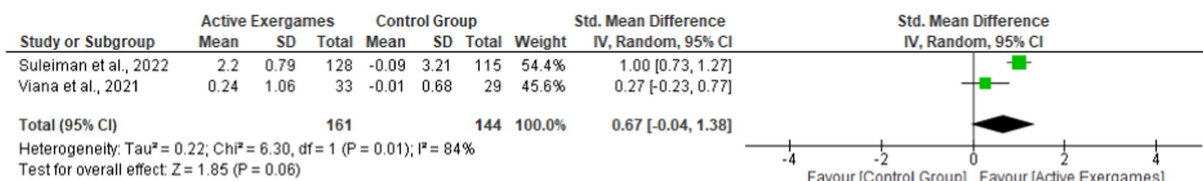


FIGURE 5 Effect of active exergames in comparison to the control group on handgrip strength. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

6-min walk, HGS, and knee extension tests when comparing the two groups.

4.1 Balance

In the present overview, significant differences were detected in favor of the active exergames groups in static balance measured through the BBS (SMD = 0.85; 95% CI = 0.12–1.58; I² = 96%; *p* = 0.02) concerning the control groups. This is similar to that reported in a meta-analysis by Lesinski et al. (45), which shows statistically significant improvements (*p* = 0.03) in BBS in favor of interventions in older people through balance training concerning active/inactive control groups. Similarly, Lemos et al. (46), in a meta-analysis of older people, showed statistically significant improvements (*p* = 0.010) in BBS in favor of multicomponent training interventions concerning active/inactive control groups. Aging leads to alterations in the vestibular, sensory, and proprioceptive systems that lead to decreased balance, which increases the fall risk in older people (47). In active exergames interventions, actions involving visual, auditory, and proprioceptive feedback movements are performed, which would favor the balance of older people; in the same way, to advance in the game phases, the difficulty increases; this implies a greater complexity in the movements to be executed and the intensity of the game (48). Therefore, early detection of balance changes or alterations is significant. In this sense, the BBS is a simple indirect test, easy to apply, with widespread use, low cost, and high reliability (0.96–0.98) and validity (0.97–0.99) to assess older people (49).

Regarding dynamic balance, the meta-analysis reported significant differences in favor of the active exergames groups for control groups measured through the TUG (SMD = 1.44; 95% CI = 0.71–2.16; I² = 97%; *p* < 0.0001). Similarly, interventions using elastic bands in older people have shown statistically significant improvements

(*p* < 0.01) in TUG compared to active/inactive control groups in previous meta-analyses performed (50, 51). In the same way, Labata-Lezaun et al. (7), in a meta-analysis of older people, showed statistically significant improvements in TUG (*p* = 0.0001) in favor of multicomponent training interventions regarding active/inactive control groups. However, interventions using active exergames in a shorter period range from 3 to 20 weeks with 2–3 sessions per week for 30–60 min, compared to interventions using elastic bands, which range from 8 to 28 weeks with 1–3 sessions per week for 30–90 min (51), and multicomponent training, which range from 9 to 48 weeks with 2–5 sessions for 30–90 min (7); this can lead to an increase in lower limb muscle strength along with balance related to improvements in BBS and TUG; these adaptations can reduce the risk of fear and falls in older people (22). Limitations in lower limb mobility, such as alterations in dynamic balance, actions such as walking, getting up from a chair, or both, are indicators of impaired functional independence (22). The TUG has demonstrated high reliability (0.98) and validity (0.98) for measuring dynamic balance indirectly in older people (52).

The previously mentioned measurements to assess balance (BBS and TUG) present high reliability, validity, and wide use in the scientific literature related to older people (49, 52). On the other hand, direct methods such as oscillography have higher reliability and validity values (0.99) and provide values of the center of pressure (53). However, having oscillography equipment is more expensive, and it is difficult for some care centers for older people (residences, neighborhood councils, and groups of older people) to have access to this instrumentation, while health and sports science professionals cannot always move this material to the spaces where older people practice physical activity (53). Therefore, having evidence of the benefits of active exergames on balance, even if measured indirectly, provides relevant information for its use in the clinical and health context (22, 54, 55).

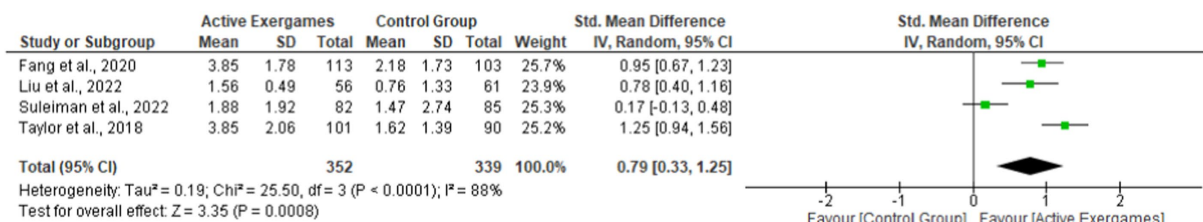


FIGURE 6 Effect of active exergames compared to the control group on the following outcome: 30-s chair stand. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

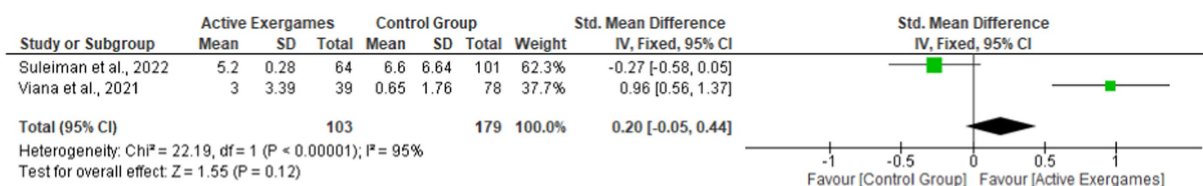


FIGURE 7 Effect of active exergames compared to the control group on the following outcome: knee extension. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

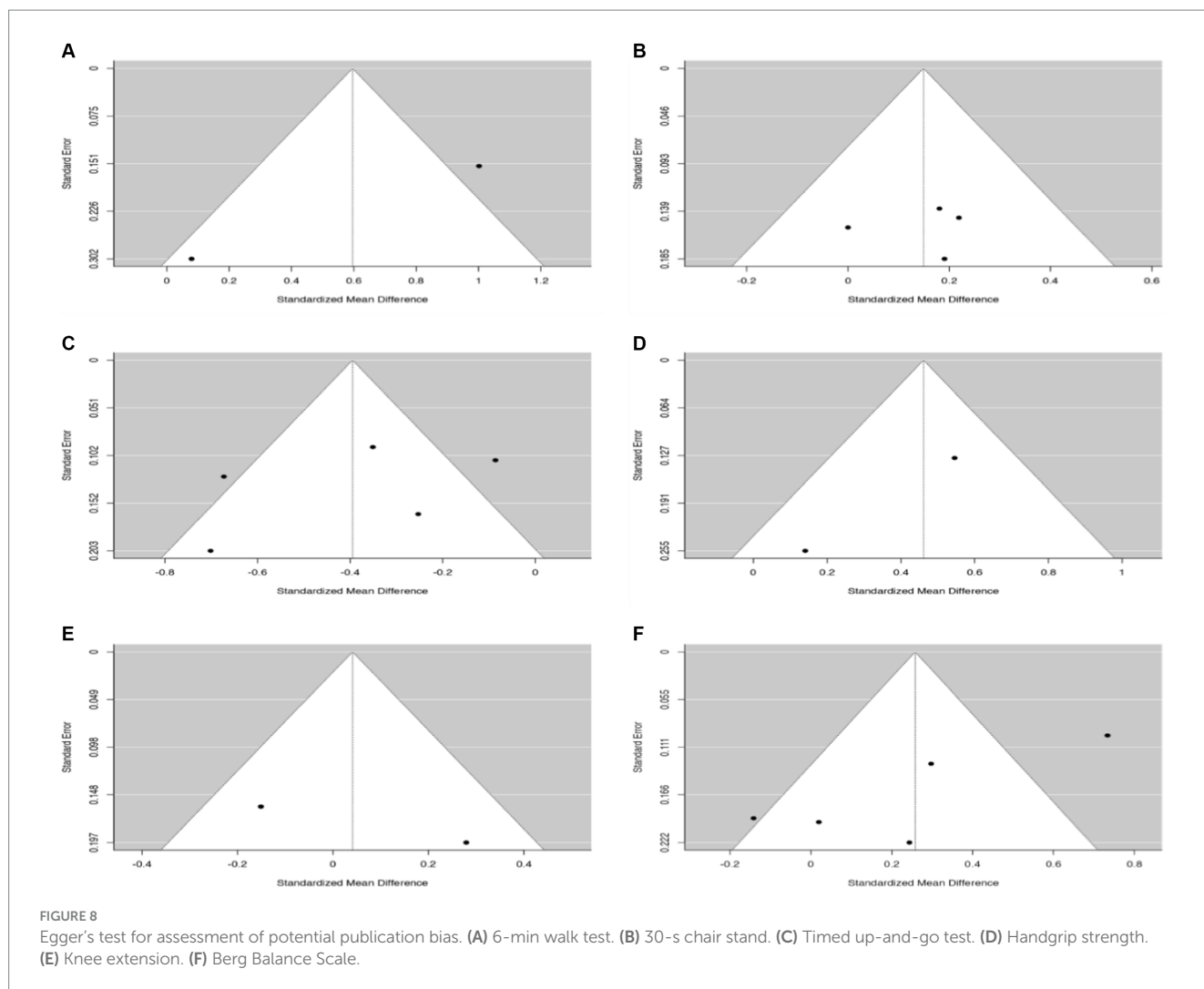
4.2 Cardiorespiratory fitness

In the present overview, no significant differences in cardiorespiratory fitness measured by the 6-min walk test were reported in the active exergames group compared to control groups (SMD = 0.93; 95% CI = -0.64 to 2.50; I² = 95%; p = 0.24). In contrast to active exergames, a meta-analysis in older people by Stern et al. (56) reported statistically significant improvements (p = 0.01) in the 6-min walk test in favor of high-intensity interval training (HIIT) interventions concerning active/inactive control groups. Similar to that reported by Labata-Lezaun et al. (7) in a meta-analysis, statistically significant improvements (p = 0.01) were detected in favor of multicomponent training interventions concerning active/inactive control groups in 6-min walk test in older people; this may be because active exergames interventions are performed at a low-to-moderate intensity during most games, in the first weeks of neuromuscular adaptation to the intervention, and along with short minutes performed during the game stage that cannot be individualized for each person (57). During aging, neuromuscular deterioration occurs, accompanied by a decrease in cardiorespiratory fitness associated with decreased mobility, which can affect independence in older people (58). The 6-min walk test is an indirect method to measure cardiorespiratory fitness in older people, unlike ergospirometry, which assesses cardiorespiratory fitness directly in older people by maximum oxygen consumption, showing a high reliability and validity of 0.95 (59). However, this is a method of high economic cost and not easily accessible compared to the 6-min walk test, which has proven to be a simple, easy, and quick application test with a high reliability and validity of 0.96 that measures cardiorespiratory fitness in older people (60).

4.3 Upper limb muscle strength

In the present overview, no significant differences were detected in maximal upper limb muscle strength measured by HGS between active exergames and control groups. Similar to that reported by Daryanti Saragih et al. (61) in a meta-analysis, no statistically significant improvements (p = 0.40) in HGS were observed in interventions using elastic band training concerning active/inactive control groups in older people. However, a meta-analysis in older people by Khalafi et al. (62) reported statistically significant improvements (p = 0.001) in HGS in concurrent training interventions to active/inactive control groups. Interventions using active exergames, unlike strategies using traditional physical activity (i.e., concurrent training), do not produce an increase in the load used because only bodyweight movements are executed, which may lead to less neuromuscular activation, muscle hypertrophy, strength, and muscle quality in wrist flexor-extensor muscles (41, 43, 63, 64); this may be because interventions using Xbox Kinect do not manipulate any control in hand hence do not grasp or hold any control, because the sensor that tracks the movements executed in the game is in a camera that is in front of the player (65).

In contrast to the Nintendo Wii, the movements to perform the games are executed by a controller that must be grasped and held by hand because the sensor is on the controller (65). In neither of the two interventions using active exergames is there an improvement in HGS because there is no stimulus that leads to an increase in the load used in the upper limbs, mainly in the wrist flexor-extensor muscles that leads to an increase in HGS (65). The HGS is an effective direct method for assessing upper limb muscle strength of the wrist flexor-extensor muscles in older people, with a high reliability and validity



of 0.98 (66). A good performance on this test is considered a good predictor of a lower risk of all-cause mortality (67).

4.4 Lower limb muscle strength

Similarly, the overview did not detect significant differences in lower limb muscle strength measured by the knee extension test between the active exergames groups compared to the control groups. However, a meta-analysis by Khalafi et al. (62) reported statistically significant improvements ($p=0.001$) in favor of multicomponent training interventions concerning active/inactive control groups in older people. Neural adaptations and/or alterations at the muscle fiber level or changes in the main components of excitation-contraction coupling may explain strength gains in traditional physical activities such as resistance training (43). However, the lack of overload in active exergames interventions may have limited the significant isometric strength gains for the lower limbs in the knee extension test (43). The knee extension test is a direct method that measures maximal isometric strength in the knee extensor muscles in older people with a high reliability and validity of 0.98 (68).

Another result reported in the present overview had significant differences in favor of the active exergames groups in the 30-s chair stand test (SMD=0.79; 95% CI=0.33–1.25; $I^2=88\%$; $p=0.0008$) compared to control groups. Similar to that reported by Labata-Lezaun et al. (7) in a meta-analysis, statistically significant improvements ($p=0.002$) in the 30-s chair stand test were observed in interventions through multicomponent training regarding active/inactive control groups in older people. Similarly, de Oliveira et al. (69), in a meta-analysis, reported statistically significant improvements in the 30-s chair stand test in favor of interventions using elastic band training concerning active/inactive control groups in older people. Some games that are performed through interventions with active exergames such as bowling, table tennis, athletics, volleyball, soccer, Kinect adventure, and Wii fit participants adopt a knee angle at 90° , similar to the angle considered for the realization of the 30-s chair stand test, which can generate adaptations at the neuromuscular level that can lead to improvements in this test (70). Getting up from a chair independently is essential for safe performance in activities of daily living (71). Community-dwelling older people with and without health problems stand and sit from a chair between 33 and 71 times daily (72). The 30-s chair stand test measures lower limb muscle strength indirectly by the number of repetitions a person can execute

by standing and sitting from a chair for 30 s (71), with high reliability and validity of 0.97 for measuring older people (73).

4.5 Methodological quality and certainty of evidence

The AMSTAR-2 program has been used to measure and evaluate the methodological quality, while certainty of evidence was obtained using GRADE (30, 74). Importantly, it allows us to deliver conclusive information on the variables analyzed (30, 74). A review by El-Kotob et al. (75) on the effect of resistance training in adults showed a low methodological quality with AMSTAR-2; this is similar to that reported by Leung et al. (76) in an abstract that analyzed the effect of Tai Chi training on indicators of functionality in older people showing low methodological quality with AMSTAR-2. However, in the present overview, a moderate (13–14 points)-to-high (15–16 points) methodological quality was reported in the 10 meta-analyses detected for the analysis (17, 18, 26–28, 37, 38, 41–43). In comparison, there was moderate-to-high certainty of evidence in the BBS, TUG, 30-s chair stand, and 6-min walk tests. Similar to the findings in the study by Shen et al. (77), which demonstrated moderate-to-high quality evidence on physical performance through resistance, balance, and aerobic training in older people through GRADE, this allows us to recommend interventions using active exergames to improve the BBS, TUG, and 30-s chair stand tests in apparently healthy older people.

4.6 Active exergames dosage

Regarding the dose used by the interventions with active exergames that report results for the BBS, TUG, and 30-s chair stand tests, a duration between 3 and 20 weeks was reported with 2–3 weekly sessions for 30–60 min, with moderate-to-vigorous intensities ranging from 3 to 6 in the 10-point RPE (78). Another type of training with elastic bands has shown statistically significant improvements on these variables with interventions ranging from 8 to 28 weeks with 1–3 sessions per week for 30–90 min with intensities of 25–80% of the one-repetition maximum (1RM) from 1 to 2 sets per session of 5–20 repetitions per set in upper and lower limbs exercises as reported in various meta-analyses in older people (50, 51, 61, 69). As the multicomponent training has shown statistically significant improvements in these previously mentioned variables (BBS and TUG), the following is a good example with interventions ranging from 9 to 48 weeks with 2 to 5 sessions per week for 30–90 min with upper and lower limbs exercises, as reported in different meta-analyses (7, 46). However, no significant differences were reported regarding active exergames in HGS and knee extension tests in the present overview. However, the 30-s chair stand test was significant. In other types of interventions, such as concurrent training with a duration of 4 weeks to 12 months with 3–5 sessions per week for 30–140 min with intensities of 60–90% of 1RM and 60–90% of maximum heart rate (HR_{max}) with upper and lower limbs exercises, statistically significant improvements have been reported in HGS and knee extension tests as demonstrated in a meta-analysis in older people (62). However, HIIT training has demonstrated statistically significant improvements in the 6-min walk test with interventions of 6–28 weeks of 2–7 sessions per week for 30–60 min with intervals of 6–30 at intensities $\geq 90\%$ of the HR_{max} as demonstrated in a meta-analysis in older people (56). However, these interventions (HIIT) have shown low adherence due to the high intensities at which the

intervals are performed as the repetitive actions executed (79). In contrast, active exergames have shown high adherence to the interventions with high enjoyment of the activity performed due to the diversity of games that are executed during the interventions (80); therefore, it could serve as a complement to other physical activity strategies.

4.7 Strengths and limitations of the overview

The limitations of the present overview are as follows: (i) the low number of similar assessments among the systematic reviews and meta-analysis available to meta-analyze the data, limiting the recommendations for some assessments analyzed, and (ii) the high heterogeneity found in the group analyses may limit the recommendations of the results obtained; however, finding low heterogeneity in systematic reviews and meta-analyses is unlikely as well as the optimal size of information due to the diversity in the number of population found in the available studies (81–83). Afonso et al. (81) recommended being careful in misinterpreting the concept of publication bias in meta-analyses (i.e., using definitive rather than provisional statements), misusing funnel plots and associated statistical tests to assess potential publication bias, and misinterpreting subsequent results. The main strengths are as follows: (i) the use of 7 (PubMed, Web of Science, Scopus, CINAHL, Cochrane Library, MEDLINE, and Psychology and Behavioral Sciences) generic databases, which broadens the scope of the search; (ii) performing meta-analysis which allows quantifying what is reported in the systematic reviews and meta-analysis; (iii) comparison with active/inactive control groups which increases the quality in the comparator on its effect on the variables analyzed; (iv) meta-analyzing only systematic reviews with moderate-to-high methodological quality this allows recommending intervention on the variables analyzed; and (v) analyzing different consoles and virtual reality games that allow a broader vision of their impact on health status in older people. Future overviews could analyze systematic reviews on the effect of active exergames on psychoemotional and physiological variables or see if there are differences between the type of consoles or games on physical performance in older people.

4.8 Practical applications

This overview of systematic reviews with meta-analysis highlights the potential impact of active exergames to improve physical performance in the BBS, TUG, and 30-s chair stand tests in apparently healthy older people with interventions ranging from 3 to 20 weeks, the improvement in the indicated tests being related to greater functional independence and lower fall risk (18, 26–28, 37, 41, 42). Therefore, active exergames could serve as a complementary physical activity strategy in clinical practice and could be used in primary healthcare, community centers, nursing homes, and physical activity programs oriented to older people.

5 Conclusion

Interventions utilizing active exergames have shown significant improvements in the static and dynamic balance and lower limb

muscle strength of apparently healthy older people, compared to control groups of active/inactive participants, as measured by the BBS, TUG, and 30-s chair stand tests. However, no significant differences were found in the 6-min walk, HGS, and knee extension tests. The certainty of the evidence was rated as moderate-to-high, thus suggesting that active exergames can be recommended as a physical activity strategy to enhance the performance of older people in terms of balance and lower limb muscle strength. Nevertheless, it is essential to supplement this intervention with activities focusing on improving cardiorespiratory fitness and upper limb muscle strength.

Data availability statement

The datasets generated during and/or analyzed during the current research are available from the Corresponding author upon reasonable request.

Author contributions

JH-M and PV-B: conceptualization, software, writing-original draft preparation. JH-M, CM-V, and PV-B: methodology. JH-M, CM-V, FR-E, and PV-B: formal analysis. JH-M, FR-E, CM-V, EG-M, TH-V, BB, MC-C, and PV-B: investigation and writing-review and editing. PV-B, EG-M, TH-V, and BB: supervision. All

authors have read and agreed to the published version of the manuscript.

Acknowledgments

PV-B thanks the Chile's National Research and Development Agency (in Spanish, ANID) for the award of the FONDECYT (code: 11220035) project.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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