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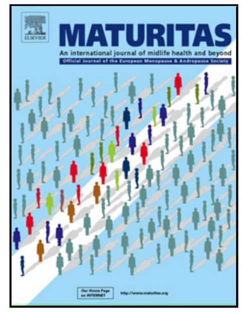

Can Exergames contribute to improving walking capacity in older adults? A Systematic Review and Meta-Analysis

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TITLE:

Can Exergames contribute to improving walking capacity in older adults? A Systematic Review and Meta-Analysis

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Highlights

- Exergames improves walking capacity, increasing functional mobility skills.
- Exergames decreased 3.3. seconds in the Test *Time and Go*
- Exergames motivates and improve adherence to rehabilitation program.

ABSTRACT

BACKGROUND: The accessibility, low cost and motivation generated by exergames has fostered its rapid expansion as a rehabilitation technique.

OBJECTIVE: To estimate the effectiveness of rehabilitation programs using IVGT in improving walking capacity of people aged 60 years and over.

MATERIAL AND METHODS: The electronic data research following the PRISMA Statement (Scopus, Cochrane, Web of Science, OT Seeker, National Guideline Clearinghouse, Trip Database, CSIC Spanish National Research Council) was completed in September 2018. The results of randomized clinical trials using exergames for rehabilitation of walking capacity were combined. The calculations have followed the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions. The Grading of Recommendations Assessment, Development and Evaluation system was used to evaluate the quality of the evidence.

RESULTS: We obtained data from 14 trials, including 11 meta-analysis studies. The size of exergames effects on walking capacity is moderate, but significant (SMD -0.56; 95% CI: -0.90, -0.21; p=0.002). Effectiveness was greater to recover the ability to transfer from one position or place to another (SMD -1.02; CI 95%: -1.70, -0.35; P=0.003). The intervention protocols, their duration and intensity varied considerably. The lack of masking, the allocation concealment, the absence of assessor blinding were the main causes of bias so the final grade of evidence has been low for walking and very low for transfers.

CONCLUSIONS: Positive clinical effects of exergames have been found to improve walking capacity, but the quality of evidence to refute its effectiveness is weak with risk of bias. Further research is needed in order to know the actual magnitude of its effect.

Key Words: walking capacity, functional mobility, virtual reality, game technology, exergames, older adults.

1. INTRODUCTION

Impaired functional mobility of older adults is frequently associated with loss of independence. Maintaining functional independence must be a priority in elderly care plans. Achieving autonomous participation in their own real everyday environment would contribute to improving their community involvement and as well as their overall health.

The rehabilitation programs that include the practice of real activities show more effectiveness [1,2]. The use of exergames has the potential to offer treatment settings very similar to actual environments and tasks, offering the possibility of playing by practicing physical exercise in immersive and attractive environments because of its similarity to reality[3] . The involvement of the player, far from being sedentary (as in traditional video games) requires active exercises that mobilize the different parts of the body. Interactive simulations containing exergames such as Wii Fit® (Nintendo), Kinect Sports® (Xbox) or Play Sport Eye Toy® (Play Station) recreate everyday virtual environments that allow repeated physical exercise directly related to the movements needed in activities of daily living.

The performance of motor exercises has been identified as a necessary action for motor learning and functional recovery [4–6]. It is well known that rehabilitation programmes have to mainly include balance exercises in order to prevent falls [7–9]. Older adults who participated in rehabilitation programs with exergames experienced a significant increase in balance and confidence in carrying out activities of daily living and a reduction of the fear of falling [10–14]. Other studies have shown that virtual reality sessions with institutionalized elderly people achieved improved levels of physical and psychological activity and quality of life [15–17]. Recent systematic reviews confirm these data in favor of the use of exergames in elderly persons with neurologic disorders [18–20].

The potential of exergames to offer ecological, safe and motivating treatments has awakened the interest of clinicians and researchers, developing a new discipline called *Clinical Virtual Reality* [21]. However, despite the proliferation of clinical trials, there is weak evidence of the effectiveness of this technology to improve walking capacity in healthy older adults. Previous reviews have quantified the impact of exergames in elders with Parkinson's disease [22–24], dementia [25,26] or stroke [27,28]so its effectiveness in healthy adults is unclear. On the other hand, most previous studies have attempted to quantify isolated motor skills or abilities such as balance or postural control [29,30], reaction time and muscle strength [31,32], so it is necessary to know the effects of the use of exergames as a rehabilitative technique to improve walking ability and its impact on the functional mobility of daily life. The objectives of this meta-analysis are to know: (1) the types of IVT and intervention protocols and (2) the level of effectiveness that the use of EXERGAMES has on the walking capacity and transfers.

2. METHODS

The systematic review and meta-analysis were conducted following the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions (https://handbook-5-1.cochrane.org/) and it was written following the PRISMA recommendations [33]. The GRADE system [34] was used in order to assess the quality of the evidence.

2.1.Study inclusion criteria

Population: Persons over age 60 without neurological, osteoarticular, or other type of disease that severely affects functional independence.

Intervention: Rehabilitation programs using exergames like Wii®(Nintendo), Kinect® (Xbox) or Eye Toy® (Play Station).

Comparison: Any other intervention, including conventional physic therapy, routine activities or no intervention.

Outcome: (1)Walking capacity , defined as moving along a surface on foot, step by step, so that one foot is always on the ground, such as when strolling, sauntering, walking forwards, backwards, or sideways(d450 ICF)[35]. (2) Functional mobility, defined as the ability to move from one position or place to another, bed mobility, wheelchair mobility, as well as transfers from one surface to another [36].

Type of study: Controlled experimental studies with scores above 6 on the PEDro scale [7] were included.

Exclusion criteria:

The excluded studies were those with participants suffering neurological and osteoarticular conditions that severely affected functional independence, studies where exergames was not applied directly, and studies which did not report on changes in walking capacity.

2.2. Sources of information

Electronic searches were conducted in the databases Scopus, Cochrane, Spanish National Research Council CSIC databases, Web of Science, OT Seeker and Guideline National Clearing House. Date, study design, language or age limits were not included in order to increase the sensitivity of the search and carry out a manual screening. The electronic search was complemented with a hand search of bibliographic references of the studies included.

2.3Search strategy

The strategy was the following:

1.- Population: (aged OR ageing OR elderly OR geriatr* OR older OR "old age" OR seniors)

2.- Intervention: (“Wii*" OR "gaming technology" OR nintendo OR "video game*" OR exergam* OR kinect OR Xbox OR "Play Station”) OR ("virtual reality" OR virtual-reality OR "Virtual navigation" OR "Virtual environment" OR "Simulated reality" OR "virtual rehabilitation" OR vr-based OR "virtually simulated").

3.-Outcome: (“daily living" OR "daily self-care activities" OR adl OR "daily life activity*" OR "functional Independence” OR “Walking capacity” OR “Functional mobility”)

Final string: 1 AND 2 AND 3 in Title-Abstract-Key words.

2.4 Study selection and data extraction

It was conducted by two independent reviewers (AC and BP). Discrepancies were resolved by consensus. The protocol of data extraction was based on the PRISMA items [33] and the Cochrane Handbook for Systematic Reviews of Interventions [37]. The form included information regarding the characteristics of the methodology, the sample, the intervention and the results. Authors were contacted to retrieve non-reported data.

2.5 Risk of bias assessment in the individual studies

An independent reviewer (AS) assessed the methodological quality of the studies using the items included in RevMan [38].They were categorized as 'high', 'low' or 'unclear' for each of the items.

2.6 Summary measures and statistical analysis

Objective measures were included for walking (such as Timed Up & Go Test (TUG), Four Step Square Test (FSST), Gait speed, Gait cadence, Gait velocity, 6-minute Walk

Test, and 8-foot Up and Go Test) and for transfers (5-Times-Sit-to-Stand Test (5STS) and Chair Stand Test (CST)). Pre and post intervention means were used, with their standard deviations (SD). Post-Pre differences were calculated. The SD of these differences were calculated by imputing a correlation coefficient which was calculated in the studies with sufficient information, from pre and post SD and the SD of the difference. The mean of these coefficients was calculated (r=0.85), which was applied to the rest of the studies.

To measure the magnitude of the effect, the Edges' (adjusted) g Standardized Mean Difference (SMD) G of Hedges (95% CI),with its confidence interval at 95% (95% CI), was used as the summary statistic, since all studies evaluated walking capacity using different measurement scales [39].

The total effect size weighted by the sample size of the studies was calculated using the inverse variance method and a random effects model [40,41]. Its 95% CI and its statistical significance were calculated using the Z-test.

The effect size was interpreted using Cohen's criteria for pooled estimates [42]. A value of 0.8 was considered a large effect.

In order to facilitate clinical interpretation, the pooled SMD of each meta-analysis was converted to the original scale. This difference was compared with the minimum clinically important difference in order to assess the clinical utility of the intervention effect.

2.7 Heterogeneity of the studies

In order to know the existing variability relative to the clinical and methodological diversity of the different studies, heterogeneity was calculated through statistical heterogeneity I^2 . Heterogeneity was interpreted as absent (0), low (25), moderate (50) or high (75 or higher)[43]. Chi-square test was used to assess whether the differences observed in the results were compatible with random.

2.8 Publication bias

It was assessed using the funnel plot created with RevMan [38] and complemented with the DOI plot created with METAXL. Egger's method [44], Begg's test with Epidat 3.1 [45], and Luis Furuyama-Kanamori index (LFK) [46] were used. A LFK index ≤1 was considered as non-asymmetry, >1 ≤2 as minor asymmetry, and >2 as major asymmetry.

2.9 Assessment of level of evidence of the set of studies

The GRADE system [34] was used, considering eight factors to reduce or increase the level of evidence. The factors for downgrading the level were 1) risk of bias of the set of studies; 2) Inconsistency (heterogeneity) by a visual examination of the forest plot and the chi-square and I^2 statistics; 3) Indirect evidence; 4) Imprecision by the calculation of the optimal information size (OIS); 5) Publication bias by visual examination of the Funnel Plots and DOI plots, as well as Begg's and Egger's statistics and LFK index. The factors considered for upgrading the level of evidence were 1) Large effect size (SMD>0.8); 2) Dose-response effect; 3) Control for confounding factors in the individual studies.

3. RESULTS

3.1 Study selection and characteristics

771 studies were identified. After de-duplicating, 669 articles were reviewed by title and abstract, selecting 89 manuscripts for complete reading. The review of the full text reported 14 studies of which 11 were included in the meta-analysis. Figure 1 shows the flow chart of this selection.

3.2 Participant characteristic

The total number of participants was 491, ranging from 20 [10,47] to 64[48] participants. The mean age was 77,2 years. The majority were female (˜73%), in one study gender [49] was not reported. All studies included independent older adults able to walk, with visual ability and without cognitive impairment.

3.3.Types and protocols of exergames interventions

All the studies used exergames as the primary intervention technique, comparing it with intervention based on traditional physical exercise or daily activities. Wii Nintendo® and Sony Play Station® low-cost equipment were mainly used in community and hospital care centres. The exergames used were related to sport (Wii Sports), balance maintenance (Wii Fit) or dancing (Stepmania). Wii Sports was used in five studies [15,16,47,50,51], Wii Fit in six studies [10,49,52–55], Eye Toy Kinetic in one study [48] and Stepmania in two studies [49,56]

Five studies were conducted in nursing homes [15,51,55–57], one in independent-living units [49], one in hospital units [16], and five with community-dwelling older adults [10,48,50,52,54]. The duration of the intervention was from 2 [16] to 24 weeks [47], with sessions between 20 and 50 minutes. The lowest number of sessions were 8 [15] and the highest 54 [10], distributed between 2 [12] and 18 [40] weeks. Table 1 shows the studies included, their descriptive characteristics and the results obtained.

High heterogeneity was found in the assessment protocols. The evaluation of the effectiveness of exergames was measured with different measuring tools. The ability to transfer from one surface to another was evaluated with Five Sit To Stand (5STS) and the Chair Stand Test (CST). Quality of life [15,51,55,57], cognitive level [47,50,51], depression [50,55] and risk of falls [10,48,49,53,54,56,57] were quantified secondary variables.

3.4 Effect of Exergames to improve functional walking and transfers

3.4.1 Magnitude of the effect

The effect size of programs with exergames on walking capacity is moderate, but significant. Eleven studies were considered with 17 comparisons and a total sample size of 337 patients. 6 comparisons in three studies had a large effect size with SMD >│0.8│[48,50,57] ; 7 comparisons in six studies had a medium effect size with SMD >│0.2│ and =<│0.8│[15,15,16,47,53,57], and 3 comparisons in two studies had a small effect size with SMD<=│0.2│[49,55]. The total combined SMD was -0.56 (95% CI: -0.90, -0.21), indicating that the intervention with exergames had moderate but significant effects (p=0.002). This combined SMD corresponds to an improvement of 3.3 seconds in the TUG test (95% CI 1.2; 5.4). Figure 3 shows the average effect size for each study, as well as the general effect size.

As for transfers ability, the effect scope was larger than for walking. 4 of the six projects obtained a SMD > │0.8│[53,55,55,57]. The total combined SMD was -1.02 (95% CI: -1.70, -0.35), indicating that the intervention had larger and significant effects (p=0.003). This combined SMD corresponds to an improvement of 3 units in the 5STS test (95 CI 1.0; 5.0). Figure 4 shows all the average effect sizes for each study, as well as the general effect size.

3.4.2 Risk of bias of the individual studies

The risk of bias was high for walking and transfers. Regarding walking, 4 studies had a high risk of bias due to randomization [15,53–55], none of the studies could blind participants, only 3 blinded outcome assessors [16,49,52], and only 1 [49] had a low risk of bias due to allocation concealment. On the contrary, only 1 study [15] had important losses to follow-up. As for transfers, 2 out of 6 studies had a high risk of bias for randomization[53,54], 5 had a high risk of bias for allocation concealment [48,50,53,54,57], none of the 6 studies could blind participants, and only 1 blinded outcome assessors [49]. Losses to follow-up were minor in all studies.

3.4.3 Heterogeneity

Heterogeneity was moderate for walking with I^2=55% (p chi-square=0.004) and high for transfers with I^2=77% (p chi-square=0.0007). The forest plot (Figures 3-4) shows an appreciable variability between the studies that favor experimental intervention.

3.4.4 Indirect evidence

None of the studies presented substantial differences among the population, the intervention or the results measured in the studies and those established in the systematic review.

3.4.5 Publication bias

The funnel plot and the DOI plot (Figure 2) show compatible signs with publication bias. Both plots display asymmetry, mainly in those studies with a smaller sample size, but with a larger effect on functional mobility. The LFK index showed minor asymmetry both for walking (LFK= -1.25) and for transfers (LFK= -1.74). The statistical significance of Begg's test for walking was p=0.0235 and of Egger's test was p=0.0057. As for transfers, Begg's test was 0=0.13 and Egger's test was p=0.11.

3.4.5 GRADE quality of evidence

In walking capacity, evidence was downgraded a level for risk of bias, because most of the studies presented an important risk of bias. It was also downgraded a level for inconsistency, because I^2=55%. Downgrading for imprecision was not considered even though the sample size n=337 was less than the limit of 400 patients. Downgrading for publication bias was not considered due to difficulty of interpretation given the small number of studies.

Regarding transfers, evidence was downgraded a level for risk of bias, another for inconsistency and another for imprecision. Downgrading was not considered for publication bias. None of the criteria established for upgrading the level of evidence (sample size, control for confounding factors or dose-response effect) could be applied in walking. One level could be upgraded in transfers due to the large magnitude of the effect (SMD>0.8). The final quality level of evidence grade of this meta-analysis is low for walking and very low for transfers. Table 2 summarizes the GRADE evidence profile for the effectiveness of exergames on functional mobility of elderly persons.

4. Discussion

The objective of this meta-analysis was to estimate the effectiveness and quality of evidence of exergames to improve functional mobility of healthy older adults. Our results suggest that has a moderate effect (SMD=0.56) on increasing the level of performance in walking, and a large effect on improving the performance of transfers (SMD= -1.02). Most of the studies proved that intervention with exergaming technology had positive and significant effects on functional mobility as opposed to nontreatment or other more conventional interventions. According to Lange [5] and Weiss [58], rehabilitation programs with exergames provide advantages over traditional rehabilitation programs, since they may offer immersive, exciting and challenging environments to the patient. Moreover, its ecological character allows for the possibility of adjusting and directing movement towards completion of lifelike activities. These features could explain our results, in line with previous reviews [37,38].

The Timed Up & Go Test (TUG) is one of the most widely used tools to assess balance and walking, and is recommended by clinical practice guidelines to assess the risk of falling [43,44,45]. Our findings reveal a 3.3 second improvement in this test in the experimental group, exceeding the minimum clinically important difference (MCID) which has been set at 0.9-1.14 seconds for people aged over 60 years [46,47]. Regarding the 5STS test, we obtained an average improvement of 3 seconds, with a MCID for this test of 2.4 seconds [48]. All in all, it should be noted that exergames may have a clinical impact on functional mobility and fall prevention. In this line, other works have found a reduction of the fear of falling in elderly people who have used exergames as a therapeutic exercise [59–62]. Although these findings must be interpreted with caution, bearing in mind the high risk of bias of most studies. Future research should be based on analyzing clinically significant difference and its correlation with fall prevention by increasing the sample size.

Two studies [31,32] reported that walking did not improve with exergames. Neither did Donath [49] or Booth find significant differences between exergaming interventions and other types of intervention in previous works. This may be due to the sort of exercises chosen, since they focused specifically on balance abilities, without developing functional mobility training. Moreover, only 3 studies included control groups that participated in rehabilitation programs without exergames [32,36,51], one of them being the one that did not find significant differences in any of the groups [32].

Beyond functional mobility, seven studies quantified participants' fear of falling. In line with the work of Gomes [10] or Gallo [59], we found no differentiating results between groups. We speculate that the assessment tools used may not be sensitive enough or specific for the assessment of the actual risk of fall, they only assessed the fear of falling.

The heterogeneity when comparing experimental and control groups was moderate for walking and high for transfers.

The variety of exergames devices used, the intervention protocols, the different assessment tests applied, and the differences in intervention duration hinder result comparison and combination. However, a more qualitative analysis reveals the predominance of exergames over no intervention or intervention with more conventional techniques in improving balance, gait quality, transfers, motivation, and adherence to treatment.

Concerning the limitations we encountered in carrying out this review, risk of bias was found. Most of the included studies presented a high risk of bias, which may generate overestimation of exergame's true effect. The lack of masking, the allocation concealment, the absence of assessor blinding were the main causes of bias together with the lack of follow-up. These methodological limitations have also been found in previous reviews [15,41,50,52], so we suggest that future trials make advance planning of control for possible confounding factors, and make use of adequate statistical techniques, and follow-up protocols once the exergames intervention is completed. Clear signs of publication bias have also been found in those studies with smaller sample sizes having a larger effect on functional mobility, fact that indicates the possibility that there may be unpublished studies that had not shown important effects in favor of virtual reality.

Regarding quality of evidence, the use of the GRADE system indicated that the grade of recommendation of exergames to improve functional mobility of older adults is low or very low, due to risk of bias, inconsistency and imprecision of the studies analyzed. It is evident from this result the necessity of more solid randomized controlled trials, with a methodological planning that includes participant blinding, assessor blinding and allocation concealment.

5. Conclusions

Our findings suggest that exergames is a novel promising technique for improving walking capacity and functional mobility of healthy older adults, although clinical trials of higher methodological quality are needed in order to know the real magnitude of its effect.

Contributors

- Ana Isabel Corregidor-Sánchez ran the searches, screened the results of the search, assessed titles and abstracts for eligibility, performed full-text screening, data extraction, drafted the paper, and contributed to editing and reviewing the manuscript.
- Antonio Segura-Fragoso screened the results of the search, data extraction, análisis data, quality assessment, drafted the paper, and contributed to editing and reviewing the manuscript
- Marta Rodriguez-Hernández contributed to editing and reviewing the manuscript.
- Jaime González Gonzalez contributed to editing and reviewing the manuscript.
- Juan Jose Criado-Alvarez acted as an independent reviewer, drafted the paper and contributed to editing and reviewing the manuscript
- Begoña Polonio-López ran the searches, screened the results of the search, assessed titles and abstracts for eligibility and contributed to editing and reviewing the manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

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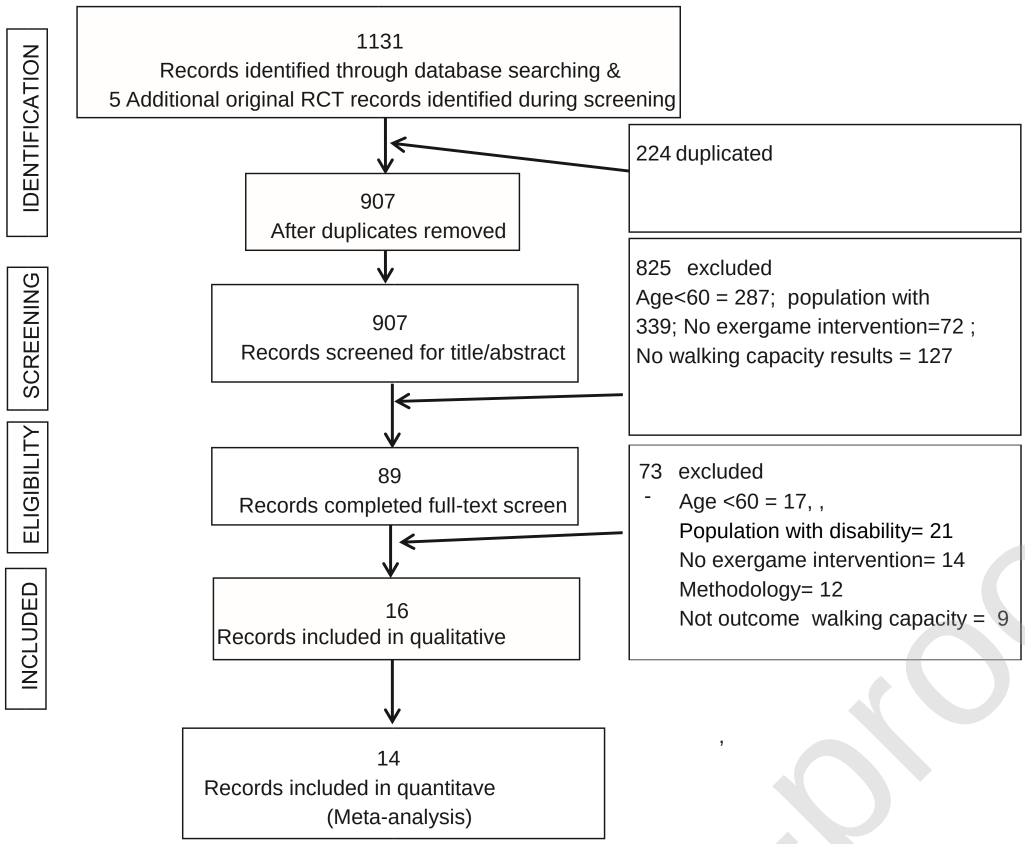


Figure 1. PRISMA Flow chart of search results and included studies

Funnel Plot	DOI Plot

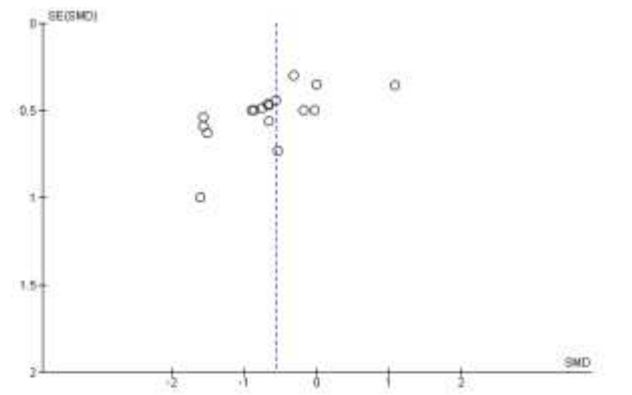
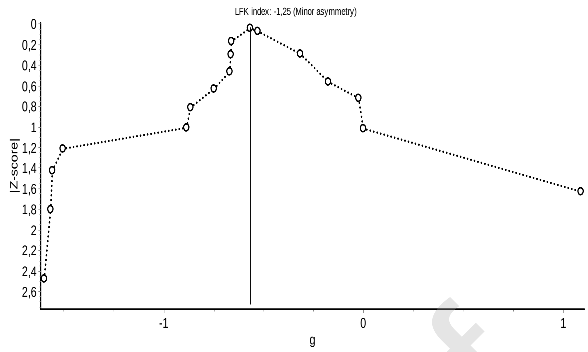

	

Figura 2.1 Funnel Plot Walking Capacity	Figura 2.2. DOI PlotWalking Capacity

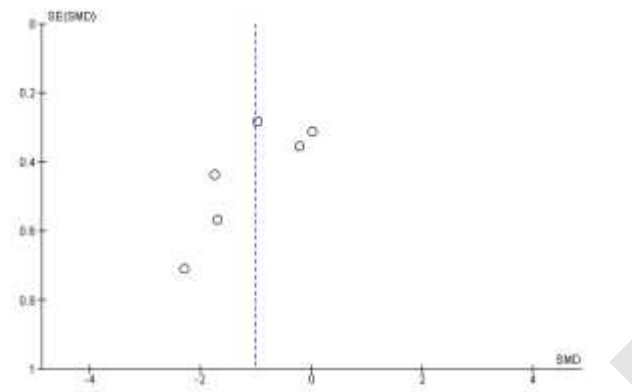
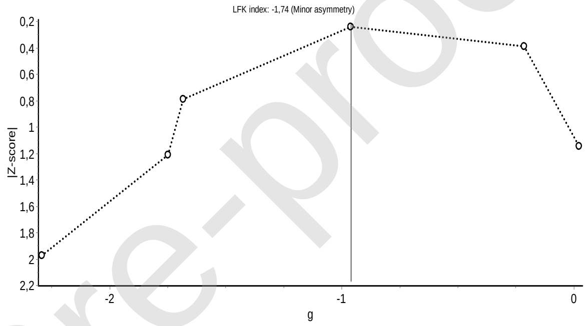

	

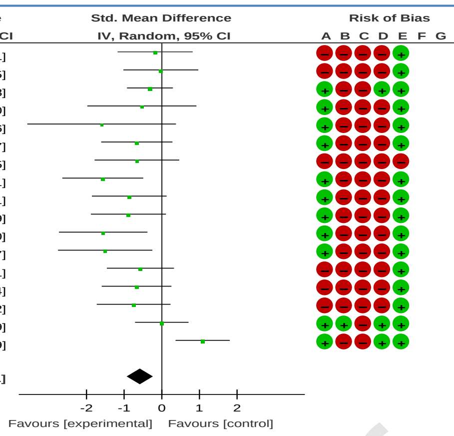
Figura 2.2. Funnel Plot Trasnfer	Figura 2.3 DOI Plot Transfer

Figure 2. Gráficos Embudo y Gráficos DOI. Sesgo publicación

Figure 3.1. Forest plot for the effect of exergames on walking capacity

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chao 2014	-3.25	2.95	8	-1.3	14.48	8	6.0%	-0.18 [-1.16, 0.81]
Chao 2014	-22.62	56.63	8	-21.1	56.82	8	6.0%	-0.03 [-1.01, 0.95]
Crotty 2011	-10.1	11.37	22	-6.5	11.04	22	8.5%	-0.32 [-0.91, 0.28]
Daniel 2012	-0.6	0.6	4	0	1.26	4	3.9%	-0.53 [-1.96, 0.90]
Daniel 2012	-134	149.97	4	154	154.42	3	2.5%	-1.60 [-3.56, 0.36]
Hughes 2014	-0.48	1.76	10	0.6	1.29	9	6.3%	-0.66 [-1.59, 0.27]
Keogh 2014	-0.04	3.54	10	3.6	7.69	5	5.3%	-0.66 [-1.77, 0.45]
Lee 2013	-1.7	1.27	9	0.61	1.52	10	5.5%	-1.57 [-2.63, -0.51]
Lee 2013	-9.71	10	9	-1.06	9.03	9	6.0%	-0.86 [-1.84, 0.11]
Lee 2013	-7.97	6.29	9	-1.13	8.27	9	6.0%	-0.89 [-1.87, 0.09]
Maillot 2012	-0.94	0.62	8	0.48	1.05	8	5.0%	-1.56 [-2.72, -0.40]
Maillot 2012	-58.05	40.45	7	-3.07	26.54	7	4.7%	-1.50 [-2.74, -0.27]
Nicholson 2015	-0.61	0.69	10	-0.14	0.88	11	6.6%	-0.57 [-1.44, 0.31]
Nicholson 2015	-0.04	0.12	9	0.04	0.11	11	6.4%	-0.67 [-1.58, 0.24]
Orsega-Smith 2012	-0.4	0.57	9	0.08	0.65	9	6.1%	-0.75 [-1.71, 0.22]
Schoene 2013	-0.5	0.75	15	-0.5	0.96	17	7.8%	0.00 [-0.69, 0.69]
Singh 2012	-1.28	0.87	18	-2.34	1.03	18	7.7%	1.09 [0.38, 1.79]
Total (95% CI)			**169**			**168**	**100.0%**	**-0.56 [-0.90, -0.21]**

Heterogeneity: Tau² = 0.28; Chi² = 35.39, df = 16 (P = 0.004); I² = 55%
Test for overall effect: Z = 3.13 (P = 0.002)

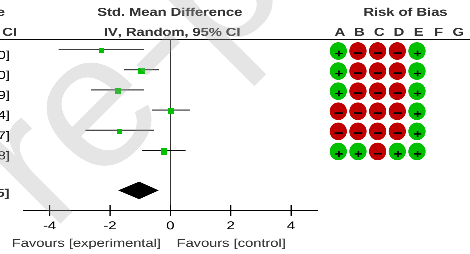


Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Figura 3.2 Forest plot for the effect of exeragmes on transfer

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Daniel 2012	-5.53	2.08	8	0.8	3.1	7	11.6%	-2.29 [-3.68, -0.90]
Lee 2013	-3.73	3.38	27	-0.87	2.43	28	19.8%	-0.96 [-1.52, -0.40]
Maillot 2012	-2.73	2.28	15	1.07	1.94	15	16.7%	-1.75 [-2.61, -0.89]
Nicholson 2015	-1.9	2.16	19	-1.96	2.97	22	19.3%	0.02 [-0.59, 0.64]
Orsega-Smith 2012	-1	0.94	9	0.67	0.95	9	14.1%	-1.68 [-2.80, -0.57]
Schoene 2013	-0.8	1.48	15	-0.5	1.27	17	18.4%	-0.21 [-0.91, 0.48]
Total (95% CI)			**93**			**98**	**100.0%**	**-1.02 [-1.70, -0.35]**

Heterogeneity: Tau² = 0.52; Chi² = 21.42, df = 5 (P = 0.0007); I² = 77%
Test for overall effect: Z = 2.97 (P = 0.003)



Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Tabla 1. Characteristic of included studies

Author	***PEDro***	***Evidence Level Design***	***Participants***				***Intervention***			
			n	Age (yrs) Mean (SD), Range	Sexo	Inclusion Criteria	Experimental Group	Control Group	Ourcome Measures	Resullts
Crotty 2011 **[16]**	7	Level I ECA	n= 44 EC=22 CC= 22	84 (80-88)	79% Female	>65 years; <150 kilos; Independence walking; MEC :21-30; , good level of vision	Nintend Wii 2 week 5 times/week	Strength, balance, aerobic exercises	TUG; BBS; SPPB; FIM; AIDL	Wii is feasible for providing treatment to elderly patients. It can improve mobility and balance in comparison with traditional approaches.
Portela 2011 **[51]**	4	Level I ECA	n= 65 EC=23 CC=42	79 (78-80)	61% Female	>65 years; good level of vision and hearing; Stand for 2 minutes without upper limb support	Nintendo Wii 12 weeks 1 time/week	Traditional physical exercise	BI; BBS; MMSE SF36	The supervised use of Wii has an impact on physical improvement. The unsupervised use of Wii has positive impact on vitality and mental health
Daniel 2012 **[57]**	7	Level I ECA	N=23 EC=16 CC=7	76 (55-86)	57% Female	>65 years; 1–2 of the characteristics of frailty	*Nintendo Wii Fit* 15 weeks 3 times/week	Traditional senior fitness program	SENIOR FITNESS TEST, BODY WEIGHT, BES, CHAMPS, LLFDI SF-36.	Both groups improve scores in ABC and CHAMPS scales. The experimental group increases caloric expenditure.
Maillot 2012 **[50]**	7	Level I ECA	N=32 EC=16 CC=16	71 (65-78)	84 Female	Never playing video games and living a sedentary lifestyle. Recommendations (Canadian Health Network)	Nintendo Wii Sports 14 weeks	Without Intervention	MAQ; GDS MMSE	Improvement in the experimental group in cognitive and physical tests. There were no differences in visuospatial function
Orsega-Smith 2012 **[53]**	5	Level I ECA	N=30 EC=20 CC=9	71 (66-83)	92% Female	-	*Nitendo Wii Fit: balance and yoga)* 4 weeks 8 weeks	Without Intervention	ABC/FES; ADL BBS; TUG; CS	The experimental group improved transfers, balance and ADL. The control group did not show any changes.
Pichierri 2012 **[56]**	8	Level I ECA	n= 31 EC= 15 CC= 16	85 (81-91)	77% female	>Age 65 or older; Independent walking 8 meters > 22 points MMSE Without rapidly progressive or terminal illness, acute illness or unstable chronic illness	*DDR Stepmania* 12 weeks 2 times/week	*Physical Exercise Program*	PPA FPA GAIT RITE FES	Exergames improves gait speed and dual-task performance in comparison with a traditional program
Rendon 2012	8	Level I ECA	n= 20 EC= 10 CC= 10	84 (60-95)	65% Female	Able to participate in physical activities during 45-60 minutes; good level of vision	*Nintendo Wii Fit* 18 weeks	Without Intervention	ABC GDS 8 FUG Test	EXERGAMES improves confidence with activity and functional movement in the experimental group. It also

[10]							3 times/week			improves balance and postural stability. No differences were found on the GDS scale.
Lee* *2013 **[48]**	6	Level I ECA	n= 64 EC= 32 CC= 32	74 (69-79)	71% Female	> 65 Years Diagnosis MD II Communication capacity	Sony PlayStation y EyeToy 10 weeks 2 times/week	Health education session	BBS TUG STS Gait Rite FES	Exergames can be used for the prevention of falls and improve the quality of wandering.
Schoene* *2013 **[49]**	7	Level I ECA	n= 37 EC= 15 CC= 17	77,5 (73-82)	-	Walking independently 20 meters Independent for ADL	Exergame DDR Stepmania 8 week 2times/week	Usual routine activities	CSRT RT/CRST MT; 5STS; TUG TRIAL MAKING FES; PPA; AST	Exergames is safe and can be applied at home. It improves physical and cognitive parameters for fall prevention
Singh* *2013 **[52]**	8	Level I ECA	n= 38 EC= 16 CC= 16	62,5 (58-69)	100% Female	>65 years; Independence walking	Wii Balance Board 6 weeks	Traditional senior fitness balance program	OPI; TST; TUG	Exergames improves agility, balance and functional mobility. There was no significant difference between groups
Huges* *2014 **[47]**	8	Level II ECA	n= 20 EC= 10 CC= 10	77,4 (72-83)	70% Female	MYHAT Cognitive Classification	Nintendo Wii Sports 24 weeks 1time/week	-	CAMCI; CRSQ AIVD GAIT: 6 meter	The experimental group improved in overall cognition, perceived cognitive ability and gait speed
Keogh* *2014 **[15]**	9	Level II Cuasi Exper	n= 34 EC= 19 CC= 15	83 (75-91)	55% Female	>65 years; Walk 10 min without aid, cognitive capacity to understand instructions	Nintendo Wii Sports 8 week	Usual routine activities	FSST RAPA WhOQOL-BREF	The intervention group showed a statistically significant improvement of strength in superior members, levels of physical, psychological activity and quality of life participating in virtual reality programs with Wii
Chao* *2015 **[55]**	7	Level II	n= 32 EC= 16 CC= 16	85 (79-91)	67 % Female	> 65 years; walking independence; able to read and speak English; able to follow instructions	SAHA + Nitendo Wii Fit 4 weeks 2times/week	Health educational session	BBS; TUG SMWT; GDS FES; SF8	The experimental group improved gait speed, reduced depressive symptoms and increased confidence in activities of daily living. The control group did not show improvement in any result.
Nicholson* *2015 **[54]**	6	Level II Two groups, nonrandomized studies	n= 43 EC= 21 CC= 22	74 (69-79)	76% Female	>65 years, no involved in balance exercises for the last 3 months; walking independence; adequate visual capacity; without progressive or terminal illness, acute illness or unstable chronic illness.	*Nitendo Wii Fit* 6 week 3 times/week	Without Intervention	TUG; FES STS; PACES; FR	The experimental group improves in all variables but only left lateral reach showed statistical significance

***Vieira 2019* [13]**	9	Level I ECA	n= 30 EC= 15 CC= 15	84 (78-90)	93% female	> 60 years able to walk independently normal or corrected visual acuity good hearing no previous experience with VR	Nintendo Wii Fit 7 week 2 times/week	advice regarding the importance of physical activity	FGA; MoCA; FES	VR Wii-Fit was feasible, acceptable, and safe for frail older adults and improved their postural control and gait. There were no effects on cognition, mood, or fear of falling.
***Stanmore 2019* [49]**	7	Level I ECA	n= 106 EC= 56 CC= 50	78 (58-96)	78 Female	>55 years Mental capacity Able to speak English Able to watch television from 2 m distance Able to use VR	Exergame FAME OTAGO 12 week	Physical Exercise	BBS; FES TUG; GDS	VR Exergame improve balance, pain and fear of falling and are a cost-effective fall prevention strategy in assisted living facilities
***Hung 2019* [64]**	8	Level I ECA	n= 24 EC= 12 CC= 12	68 (66-72)	57% female	>60 years Medical diagnoses of diabetes Independent community ambulatory MEC>24	Xavi Sport VR 6 week 3 time/week	Without Intervention	TUG; BBS UST; *MFES*	VR group with positive effects on functional balance

ABC: Activities-specific Balance Confidence**; ADL:** Activities of Daily Living**; AIDL:**Activity Instrumental Daily Livin**g; AST:**Alternate Step Test**; BBS**:Balance Berg Scale; **BE:** Brain Exercise; **CAMCI:**Computer Assessment of mild cognitive Impairment; **CHAMPS**: Community Healthy Activities Model Program for Seniors Questionnaire **CSRT:** Cognitive Self-Report Questionnaire; **CRST-RT:** Choice Stepping Reaction Time; **CS=** Chair Stand**; ECA:**Randomized Clinical Trial; **FES:** Falls Efficacy Scale; **FGA:** Functional Gait Assessent**; FIM:** Functional Independence Measure; **FPA:** Foot Placement Accura**cy; FR:**Functional Reach; **FSST=** Four Square Step Test; **GAS:** Geriatric Anxiety Scale**; GDS:** Geriatric Depression Scale; **IADL:** Instrumental Activities of Daily living Scale**; IB:** Index Barthe**l; IBM:** Index Barthel Modificated**; PRMQ**: Prospective Retrospective Memory Questionnaire**; MAQ:** Modifiable Activity Questionnaire; **MEC:** Mini-Examen Cognoscitivo**; MD:** Mellitus Diabetes; **MFES**: *Modified Falls Efficacy Scale***; MMSE**=Mini Mental State Examination; **MT:**Movement Time; **OPI=** Overall Performance Index; **PPA:** Physiological Profile Assessment score; **PACES=** Physical Activity Enjoyment Scale;**PE:** Physical exercise**; RAPA**: Rapid Assesstmen Physical Activity Scale; **SF8:** Short Form **SF36:** Short Form 36; **SMWT**: Six-Minute Walk Test; **SPPB**: Shot Physical Performance Battery; **TST:** Ten Step Test; **TUG**: Timed Up and Go; Test**; VR**: Virtual Reality: **WHOQL-BREF:** World Health Organization Quality of Life; **5STS =** Five Times Sit-to-Stand;

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