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## The efficacy of exergames on balance and reducing falls in older adults: A narrative review

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### Abstract

Falls in older adults are a very important health concern worldwide with enormous social and economic ramifications. The advancement of medical technology and the creation and dissemination of exergames has gained more and more ground in recent decades as it combines exercise with a pleasant environment. However, their efficacy over conventional exercise methods is under investigation. The aim of this review is to present recent research data regarding the efficacy of exergames in older adults with balance deficits who experience falls. Method: The PubMed and Google Scholar databases were searched with the following keywords: exergames, elderly falls, balance and Exercise. Articles that were clinical studies and had been published in the last four years were selected. Six clinical studies were found to meet the criteria and were included in the review. The total sample was 287 older adults. Results: Most clinical studies concluded that exergame rehabilitation is effective, enjoyable, and well received by older adults. In two studies, a combination with conventional physical therapy was reported to show better results. Discussion - Conclusions: The results of our review provide evidence that interventions based on virtual reality and exergames are effective in improving balance and reducing the number of falls in older adults. Our review also derives positive results of exergames effects compared to conventional physical therapy. Exergames-based intervention is cost-effective, safe, without adverse effects, and appears able to cause adaptations in balance and functional ability in older adults, thus reducing the risk of falls. Their application is proposed for the training of older adults in future interventions.

**Keywords:** Falls, balance, older adults, exergames, physical therapy

### Introduction

Traumatic falls in older adults are the leading cause of fatal accidents in old age in Europe and the second leading cause of accidental death in older adults worldwide. Regarding prevalence, one in three people over 65 experience a fall annually with 10% of them being traumatic [1-2]. Negative consequences of falls in older adults include psychological impact, quality of life deterioration, injuries, motor impairments, functional ability reduction, or even death [2, 3]. Falls also contribute to high healthcare costs for older adults. Falls are caused by several factors, both environmental as well as related to aging, making prevention strategies targeted at older adults a research focus [4, 3].

Main causative factors of falls are the deficits in strength and balance of older adults because aging affects muscles, bones, joints, and the nervous system [4]. Exercise has been shown to help reduce these deficits by protecting older adults from experiencing another fall [2, 5, 6]. Studies have shown that older adults participating in therapeutic exercise programs that include exercises such as balance and resistance training can have reduced fall risk by improving standing and walking performance [7].

Various methods of training older adults have been applied in the past for this purpose. The Otago exercise program [6, 8], Pilates [9], and conventional resistance and balance programs have been shown to have a positive effect on reducing falls in older adults [10, 11]. However, in recent years, special software games (exergames) have been developed that combine active physical participation with a friendly fun environment.

The idea of combining games with exercise was introduced as a coping strategy for patients with motor and cognitive impairments and provided great benefits for balance [12].

Exergaming includes a series of cognitive and motor exercises that allow the performer to provide live feedback. The main advantage is the combination of play with exercise, which allows older adults to improve their adherence to the program, as well as negate any preconceptions they might have related to traditional exercise and its outcomes<sup>[13]</sup>. The efficacy of exergames in reducing falls in older adults, however, requires further research.

Our review aimed to evaluate the effects of exergames in reducing falls and improving balance in older adults.

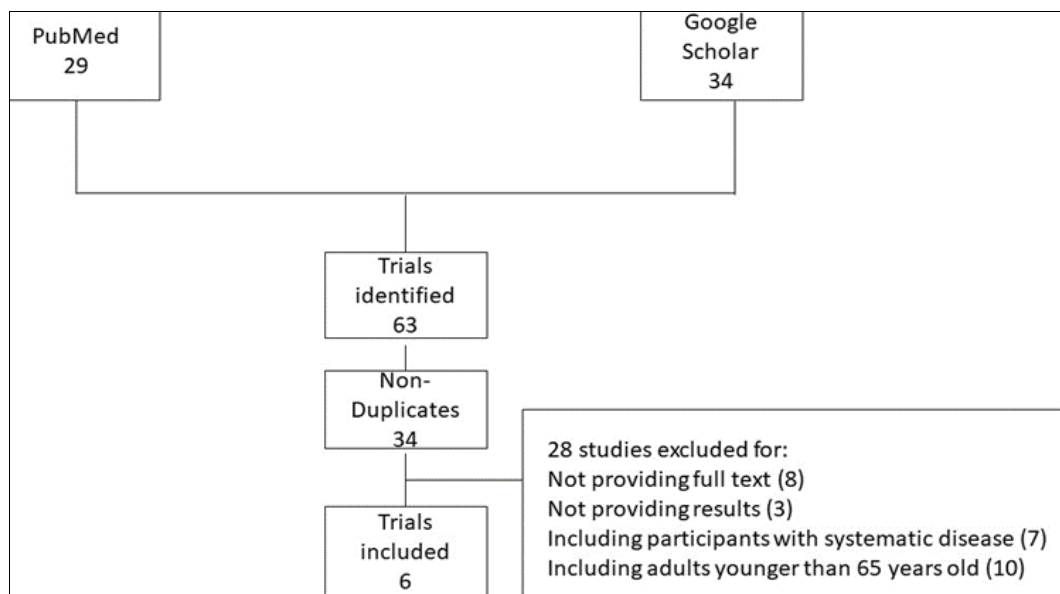
## Method

The PubMed and Google Scholar databases were searched during Nov-Dec 2002. The search strategy included different Boolean operators with the following keywords: “exergames AND elderly falls AND balance”. The search was also filtered for articles that were clinical studies published in the last four years. The criteria for the inclusion of the articles in the

review were to include the implementation of an exergame as a means of intervention, to have been applied to a sample of older adults, and to evaluate the effect of the intervention on the balance of older adults or on the reduction of the number of falls.

## Results

The search initially resulted in 63 articles from both databases. The titles and abstracts of all the resulting articles were first evaluated, followed by retrieval and reading of the full texts. Six clinical studies were ultimately found to meet the criteria set and were included in the review. The selection process of the articles is presented in the flowchart of Figure 1. The total sample consisted of 287 older adults aged 65 and over. Below is a detailed description of the main characteristics of the included studies, while an outline of these studies is also presented in Table 1.



**Fig 1:** Flowchart of studies selection

**Table 1:** Characteristics of the included studies

Author, Year	Number of participants	Intervention duration	Intervention	Outcome measures	Conclusions
Morat <i>et al.</i> , 2019 <sup>[15]</sup>	51	8 weeks	Group 1: Dividat Senso device with fixed platform Group 2: Dividat Senso device with moving platform Group 3: Control	postural sway upon perturbation Y-balance TUG Heel rise test Isometric leg extension	Training with the Dividat Senso device platform effectively improves the balance of older adults by causing adaptations to their strength and balance, while training on a moving surface brings greater adaptations to these parameters than on a fixed surface.
Zahedian-Nasab <i>et al.</i> , 2021 <sup>[16]</sup>	60	6 weeks	Group 1: Intervention – Xbox Kinect Group 2: Control – conventional training	BBS FES TUG	Six weeks of Xbox Kinect use was more effective in improving balance and reducing fear of falling than the conventional program.
Yousefi Babadi & Daneshmandi, 2021 <sup>[17]</sup>	35	9 weeks	Group 1: Intervention – Xbox Kinect Group 2: Intervention – conventional balance training Group 3: Control	FABS TUG FRT SLS	Nine weeks of Xbox Kinect use is as effective as conventional balance training in improving balance and functional ability in older adults.
Sadeghi <i>et al.</i> 2021 <sup>[18]</sup>	64	8 weeks	Group 1: traditional balance training (BT) Group 2: exergame (VR) Group 3: Combination exercises (MIX)	Isokinetic quadriceps and hamstrings strength TUG 1-legged stance on firm surfaces 1-legged stance on foam surfaces	The VR group showed significant differences compared to the BT and CON groups in balance and functional mobility, while the BT group demonstrated better balance and functional mobility relative to CON.

			Group 4: Control	Tandem stance Gait speed	
Phirom <i>et al.</i> 2020 <sup>[19]</sup>	40	12 weeks	Group 1: Physical-cognitive game-based training program through exergames Group 2: Control	PPA TUG MoCA	A physical-cognitive game-based training program seems able to reduce the risk of falling and simultaneously improve the cognitive functions of older adults.
Lima Rebêlo <i>et al.</i> 2021 <sup>[20]</sup>	37	8 weeks	Group 1: VR training (Oculus Rift) Group 2: Conventional physical therapy	DGI CTSIB TUG FRT DHI	Virtual reality, although effective in preventing falls, is not superior to conventional physical therapy protocols.

### Literature review

The study of Morat *et al.*<sup>[14]</sup> investigated the effect of the Dividat Senso training platform (Senso, Dividat, Schindellegi, Switzerland), which consists of a moving support base with sensors and a screen. The study involved 51 older adults with balance deficits, who were divided into three groups (two intervention and one control). In the intervention groups 1 and 2, a protocol was applied based on the use of the Dividat Senso device with a fixed and moving base respectively for eight weeks with a frequency of three times per week, while in the control group no treatment was applied. Active balance through the postural sway upon perturbation test, functional balance through the Y-balance test, functional ability through the Timed Up-and-Go (TUG) test, and lower limb strength through the heel rise test and the isometric leg extension were assessed before and after the intervention. The results of the research showed a significant difference in the reactive balance group that followed the protocol with the moving surface compared to the other two groups, while significant differences were also noted between the two intervention groups and the control group in calf strength and endurance. The researchers concluded that training using the Dividat Senso platform is an effective training method for improving the balance of older adults and causes adaptations in their strength and balance. Furthermore, they found that training on a moving surface causes greater adaptations in these parameters than on a fixed surface.

In another study, Zahedian-Nasab *et al.*<sup>[15]</sup> sought to investigate the effects of a virtual reality program on balance and fall prevention in older adults living in nursing homes. The 60 participants were equally divided into two groups. The intervention group (n = 30) performed balance exercises with the use of the Xbox Kinect, while the control group (n = 30) followed a conventional exercise program. Both groups followed their respective program for six weeks, with the intervention group attending one weekly session of 30-60 minutes. The assessment tools used to measure participants at the beginning and end of the programs were the Berg Balance Scale (BBS) for balance, the Fall Efficacy Scale (FES) for fear of falling, and the TUG test for mobility. The results of the research showed that there were statistically significant differences in the BBS and TUG test values ( $p < 0.001$ ), which were significantly improved in the intervention group compared to the control group. Fear of falling was also significantly reduced in the intervention group compared to the control group ( $p < 0.001$ ). According to the results of this study, six weeks of using the Xbox Kinect was more effective in improving balance and reducing fear of falling compared to the conventional program followed by the participants of the control group. Therefore, its use could provide satisfactory therapeutic results.

A study<sup>[16]</sup> compared the effect of virtual reality in the balance of older adults to conventional physical therapy

exercises. The sample was 36 older adults, who were equally divided into three groups: the virtual reality group, the conventional balance exercises group, and the control group. The virtual reality group used the Xbox Kinect platform, the balance exercise group performed conventional balance exercises that gradually increased in difficulty, while the control group was asked to perform simple activities of daily living without any specific exercise. The intervention duration of the virtual reality programs and balance exercises was nine weeks with a frequency of three sessions per week and a session time of one hour. Balance with the Fullerton Advanced Balance Scale (FABS), mobility with the TUG test, static balance while completing a task with the Functional Reach Test (FRT), and static balance on one leg with the Single-Leg Stance (SLS) were evaluated by the physical therapists before the start of the programs and at their end. The research results showed that in both intervention groups (virtual reality, balance exercises) TUG, FABS, FRT, and SRS variables (with eyes open and eyes closed) improved significantly ( $p < 0.05$ ), in contrast to the control group, which did show any statistically significant change. Between-group differences for the intervention groups were also statistically insignificant. The researchers concluded that both their intervention improved balance in older adults and could contribute to reducing fall risk, individually or in combination.

In the study of Sadeghi *et al.*<sup>[17]</sup> various balance training modalities to reduce falls were investigated in 64 older adult men. Participants were divided into 4 groups: the intervention group with traditional balance exercises (BT), the intervention group with exergame (VR), the combined exercise group (MIX), and the control group (CON). All intervention groups exercised for 40 minutes three times a week for eight weeks. Isokinetic quadriceps and hamstrings strength with the Biodex isokinetic dynamometer, 1-legged stance on firm and foam surfaces, tandem stance, TUG test, and gait speed test were evaluated at baseline and post-intervention. Results showed significant improvements in strength, balance and functional mobility in the MIX group compared to the other groups. The VR group demonstrated significant differences compared to the BT and CON groups in balance and functional mobility, with the BT group also improving more than the CON group in those areas.

The effect of combining training through exergames with cognitive tests on fall risk and cognitive performance in older adults was also studied<sup>[18]</sup>. The total sample size was 40 individuals aged 65 and over, who were randomly assigned to two groups (intervention and control). Participants in the intervention group performed a one-hour session three times a week for 12 weeks with a physical-cognitive game-based training program, while the control group received educational materials on fall prevention strategies. Fall risk with the Physiological Profile Assessment (PPA), functional

ability with the TUG test, and cognitive function with the Montreal Cognitive Assessment (MoCA) were assessed at the beginning and end of the intervention. The results showed a significant improvement in the PPA fall risk score, as well as in the MoCA and the TUG test scores compared to the control group ( $p < 0.05$ ). The results showed that a physical-cognitive game-based training program seems able to reduce the risk of falling and simultaneously improve the cognitive functions of older adults.

Finally, a study <sup>[19]</sup> focused on the efficacy of virtual reality compared to conventional physical therapy on balance and reducing falls in older adults with balance disorders. The sample consisted of 37 older adults, who were divided into two groups, intervention ( $n = 20$ ) and control ( $n = 17$ ). The intervention group followed a virtual reality program using the Oculus Rift device aimed at training balance, while the control group performed a conventional physical therapy protocol with balance exercises. Both groups attended two 50-minute sessions per week for eight weeks following their respective program. Outcome measures that were evaluated at baseline, at the end of the intervention, and at the two-month follow-up included: functional ability with the TUG test, general static balance with the Clinical Test of Sensory Interaction and Balance (CTSIB) and static balance when completing a task with the FRT, functional balance with the Dynamic Gait Index (DGI), dizziness with the Dizziness Handicap Inventory (DHI), and fear of falling with the FES. The results showed a significant improvement of the intervention group in the DHI and TUG scores. Furthermore, both groups improved their FRT and DGI scores with no statistically significant difference found between the groups. The researchers concluded that conventional treatment protocols are equally effective with virtual reality interventions in preventing falls.

## Discussion

The aim of our review was to examine current research data on the efficacy of exergames as an intervention for training older adults with balance deficits who are at high risk of falls. Since technology is quickly advancing and exergames are being renewed at a rapid pace, we wanted to do an update on the modern literature including only clinical studies from the last four years (2019-2022). The results of the review showed that the application of exergames is more effective than a control group <sup>[14, 16, 17]</sup>. It seems that 8-9 weeks of intervention with exergames improves balance, functional ability, and reduces the risk of falling. The results of this review also exhibit that exercise programs with exergames are more effective than conventional physical therapy <sup>[15, 16, 19]</sup>. Additionally, the combination of the two therapy protocols seems more beneficial than their individual application <sup>[17]</sup>. Recent studies also support the notion that older adults accept and enjoy participating in programs based on exergames and virtual reality <sup>[20-22]</sup>. Specifically, Pacheco *et al.* <sup>[23]</sup>, in their systematic review, agree with the findings of our work that exergames can keep older adults active and positively affect their balance and quality of life. Moreover, Chen *et al.* <sup>[24]</sup> also found that conventional training is less effective than training based on virtual reality. Conventional exercise focuses more on body function, whereas exergames also target other areas and skills, such as balance, mobility, cognitive function, and mood. On top of that, virtual-reality-based training seems to improve reaction times and external stimuli perception of older adults, which is crucial in preventing falls. However, their efficacy should be further

studied under different conditions (i.e., in rehabilitation from home remotely supervised by clinicians) or in the long term. Exergaming alone at home could prove dangerous for frailer older adults, thus the matter requires further research.

## Conclusions

Fall prevention strategies that incorporate exergames seem effective in preventing falls in older adults. They contribute to injury-averse, cost-effective, and adaptation-inducing training programs that improve the balance and functional ability of older adults. The application of exergames is recommended in future studies and their efficacy requires further investigation.

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## Author's Contribution

Not available

## Conflict of Interest

Not available

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