Croat Nurs J. 2023; 7(2): 153-160

Review

The Benefits of Virtual Reality in Preventing Falls in Older Adults: Literature Review

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Article received: 10.07.203.

Article accepted: 05.10.2023.

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https://doi.org/10.24141/2/7/2/5

Keywords: virtual reality, exergames, falls, fall prevention, older adults, elderly

Abstract

Introduction. The aging of the human organism brings with it a decrease in bodily functions, both motor and cognitive, and the probability of developing numerous diseases and conditions increases. The most common difficulties faced by the elderly are reduced ability to control balance and control gait due to muscle weakness and reduced coordination. The consequences of falls in elderly population are increase in mortality and morbidity and effects on quality of life, and work is needed to prevent falls in this population. Over the past few decades, the integration of information and communication technology (ICT) into healthcare has given rise to a novel research field. One prominent aspect within this field is the widespread adoption of virtual reality (VR) and/or exergaming in various medical areas. This study aims to explore the potential usability of virtual reality and exergames as a preventive measure against falls in older adults.

Methods. A search of literature was conducted through PubMed and Scopus databases, using search strings and inclusion and exclusion criteria.

Results. A total of 330 papers were identified through databases search, and after study selection process, 8 studies were included in this review.

Conclusion. The use of these interventions has a promising effect on improving the balance, gait, motor, and cognitive functions of the older adults, which are all factors that are correlated with a reduction in the risk of falls in the studied population.

Introduction

In recent decades, there has been a notable shift in the demographic makeup of the global population, primarily driven by advancements in healthcare and medical services, as well as broader societal factors. This transformation is characterized by an increasing proportion of older individuals worldwide, accompanied by a simultaneous decline in the younger population. The World Health Organization (WHO) reported in 2020 that the number of individuals aged 60 years and above outnumbered children under the age of 5. Furthermore, projections indicate that between 2020 and 2050, the global population aged 60 years or older is expected to double from 1 billion to 2.1 billion (1).

The stated development of today's society brings more than just advantages. The aging of the human organism inevitably leads to a decrease in bodily functions, both motor and cognitive, and the probability of developing numerous diseases and conditions increases (2). According to Owino, the most common difficulties faced by the elderly are reduced ability to control balance and control gait due to muscle weakness and reduced coordination (3). Due to this decline, elderly individuals often experience various complex health conditions, with falls being one of the most prevalent (4). The combination of reduced cognitive functions and the factors mentioned earlier contributes to the heightened susceptibility of the elderly population to falls. Additionally, falls in this population often result in more significant consequences and impacts on overall well-being. According to previous research, every third person aged 65 or more experiences at least one fall every year (5, 6). According to the World Health Organization (WHO), individuals aged 60 years and above experience the highest number of fatal falls (1). Additionally, Marschollek's research emphasizes that falls are the primary cause of non-fatal injuries among older adults (7).

The consequences of falls in elderly population are various, including increase in mortality and morbidity, but also psychological, such as reduction of quality of life due to loss of independence and fear of falling which can lead to depression and social isolation (8). In addition, falls represent a great socio-economic burden on health care systems all around the globe.

Due to all the above, work is needed to prevent falls in this population. Among the many ways to conduct measures of prevention, one of the most effective would be promoting individuals physical activity in order to slow down the decline of motor functions.

As time progresses, the activity levels of most individuals tend to decline. However, extensive research has consistently demonstrated that participating in physical activity positively impacts coordination, balance, and the likelihood of falls in this population (9-12). In fact, increased physical activity can potentially decrease the risk of falls by up to 50% (13). Taylor cites that the WHO recommends daily physical activity and combining balance and muscle-strengthening exercise to reduce the impairment of physical functions in people aged over 65 (14). However, here we encounter the problem of cooperation. Namely, older adults may have difficulty in mobility and are unable to regularly attend, for example, organized classical exercise programs. Furthermore, a major aggravating circumstance is the lack of motivation in this population, and according to de Groot and Fagerström, older people must see a certain potential in carrying out physical activity, such as a potential increase in independence or a potential better balance, which is difficult to achieve through classic exercise programs (15).

In recent decades, a novel research field has emerged that integrates information and ICT into healthcare, specifically through the widespread utilization of VR and/or exergaming across various medical areas.

VR technology can simulate a real exercise environment, and its popularity has been growing because it is entertaining, enables the use of all senses and can provide feedback and results (16). Virtual reality is defined in the Encyclopaedia of multimedia as technology that uses different multimedia technologies such as image, sound, video, text, as well as newer ones like touch, smell, taste, all to provide almost real experiences in a virtual way (17). Exergaming is actively playing videogames that includes physical movement (18).

The aim of this literature review was to investigate the benefits of virtual reality in preventing falls in older adults.

Methods

This study reviewed the scientific literature on the effect of virtual reality on fall prevention in the elderly population published from 2018 to 2022. The search was conducted in two scientific databases, PubMed, and Scopus, on February 17, 2023. The following keywords were used in various combinations when searching for titles, abstracts, and keywords of articles: virtual reality, exergame*, serious game*, fall*, fall prevention, preventing fall* older adult*, elder*. Boolean operators were used to create search strings, as shown in Table 1. Regarding the inclusion and exclusion criteria, shown in Table 2, the search was limited to English-language articles, and the target population were participants older than 65 years. Regarding the type of article, clinical trials and randomized clinical trials were included.

Results

By searching both databases, we obtained a total of 330 articles, of which 119 by searching the PubMed database and 211 by searching the Scopus database. After removing duplicates using Zotero, there were 221 articles left. After reading the title and abstract and following the inclusion and exclusion criteria listed in Table 2, another 209 articles were excluded (not randomized controlled trials - 195, articles not written in English - 5, population under 65 - 9). Additionally, 4 more articles were excluded due to content irrelevance. There were 8 articles left that were included into the final review. The procedure for extracting the final literature used for this literature review is shown in Figure 1 using the PRISMA flow diagram (19).

Table 1. **Databases with search string and number of hits**

Core collection	PubMed	Scopus
Search string	("virtual reality"[Title/Abstract] OR "exergame*"[Title/Abstract] OR "serious game*"[Title/Abstract]) AND ("fall*"[Title/Abstract] OR "fall prevention"[Title/Abstract] OR "preventing fall*"[Title/Abstract]) AND ("older adult*"[Title/Abstract] OR "elder*"[Title/Abstract])	(TITLE-ABS-KEY ("virtual reality") OR TITLE-ABS-KEY (exergame*) OR TITLE-ABS-KEY ("serious game*") AND TITLE-ABS-KEY (fall*) OR TITLE-ABS-KEY ("fall prevention") OR TITLE-ABS-KEY ("preventing fall*") AND TITLE-ABS-KEY ("older adult*") OR TITLE-ABS-KEY (elder*))
Number of hits	119	211

Table 2. **Criteria for including and excluding results**

Criteria	Inclusion	Exclusion
Population	> 65 years	Other
Language	English	Other languages
Article type	Clinical trial, Clinical randomized trial	Other

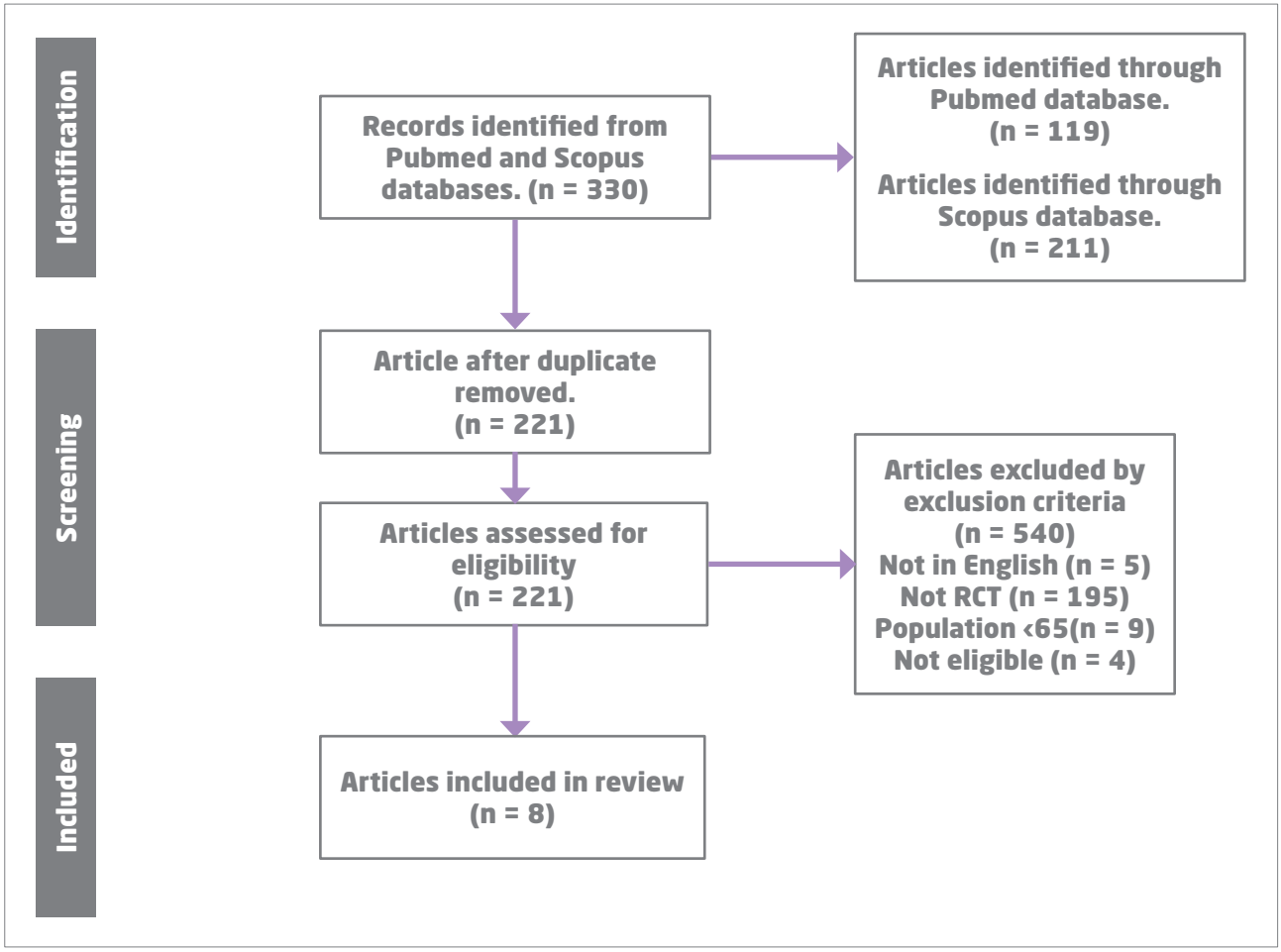

Figure 1. **PRISMA flow diagram for the literature research**

Discussion

This literature review has identified a collection of randomized controlled studies that provide substantial evidence supporting the advantageous impact of incorporating virtual reality and exergames-conducted exercise programs on the balance, gait, motor skills, and cognitive functions of older adults.

Authors Zak et al. wanted to investigate if there were advantages in using a VR application enhanced physiotherapy compared to classic programme. They conducted a double-blind study on a total of 60 participants randomly allocated into 4 groups (three VR enhanced groups and one classic programme group), where the sessions took place in the participants homes for 3 weeks. They concluded that the use of VR environments in the physiotherapy programme particularly improved static balance. Also, they claim that VR enhanced physiotherapy is good alternative to classic physiotherapeutic regimens (20). The above-mentioned results have been supported by similar studies, which further demonstrated superior improvements in gait among the VR group (21,22). Hauer et al. conducted research that also revealed notable enhancements in the performance of complex motor-cognitive stepping using exergames, which has potential relevance in fall prevention. The study involved fifty-eight older adults who participated in a 10-week intervention, engaging in strength and balance exercises once a week, along with supplementary stepping exergame training. The control group, on the other hand, solely performed the strength and balance exercises without the additional exergame component (23). Hassett et al. conducted research wherein they also demonstrated improvements in mobility among individuals with various health conditions through the utilization of digitally enabled rehabilitation (24).

Table 3. **An overview of articles identified in the literature review**

Authors	Purpose	General outcomes	Limitations
Zak et al. 2022 (20).	To investigate the effect of physiotherapeutic intervention aided by an innovative application of VR software package (VR OCULUS device) on a total of 60 participants randomly allocated into 4 groups	Use of VR in the physiotherapeutic management of older adults improved functional performance, especially static balance. Authors conclude that physiotherapy aided by VR technology offers a great alternative to conventional physiotherapy.	Small number of participants, tests conducted in a non-random order
Taylor et al. 2018 (26).	To examine whether an exergame program conducted in groups could improve mobility compared to a control group, in a total of 65 long-term care residents.	Exergames did not significantly improve the mobility of the participants in the intervention group, but a higher attendance rate was measured, indicating the motivational potential of exergaming.	Small number of participants, not being able to monitor the out-of-the study activities of participants
Moreira et al. 2021 (27).	To compare the effects of exergaming vs. traditional multicomponent training program on cognitive and motor functions of a total of 66 participants randomly allocated into two groups.	Both intervention programs demonstrated effectiveness in reducing the fear of falling, increasing fall risk awareness, and improving cognitive status, muscle function, and physical function. The exergame training showed potential for enhancing cognition, while the traditional program appeared to be more effective in improving physical function.	Large drop-out rate, lack of control group
Liao et al. 2019 (21).	The aim of this study was to compare the effects of VR-based training to traditional physical and cognitive training and to assess the impact of VR-based training on executive function and dual-task gait performance in older adults with mild cognitive impairment.	Significant improvements in dual-task gait performance were observed in the VR group, suggesting that the enhancements may be linked to improvements in executive function.	No actual control (placebo) group, simple motor skills tasks chosen.
Lee K. 2021 (22).	The aim of this study was to examine the impact of virtual reality gait training on balance and gait among older adults.	Virtual reality gait training is useful for preventing falls and improving balance and gait in the elderly.	No follow-up.
Kim and Cho 2022 (25).	The objective of this study was to assess the effects of VR and motor imagery training as a preventive measure against falls in older adults who are socially isolated.	VR and motor imagery training have been shown to be effective in preventing falls among older adults.	Small number of participants.
Hauer et al. 2020 (23).	The aim of this study was to examine the impact of a stepping exergame training on the stepping performance of older adults.	The authors have demonstrated the positive effects of a complex motor-cognitive stepping exergame on performance, indicating its potential relevance in fall prevention.	The completion rates decreased with progression to more complex levels, the participants were mostly female.
Hasset et al. 2020 (24).	To test the effectiveness of affordable devices to improve mobility and physical activity in people with mobility limitations.	The study revealed improvements in mobility among individuals with various health conditions using digitally enabled rehabilitation.	15%–19% loss to follow-up at 6 months.

Kim and Cho's research findings indicated that VR and motor imagery training (MIT) can effectively contribute to fall prevention among older adults. Furthermore, they recommended VR and MIT as viable alternatives to physical activity for older individuals who may be socially isolated (25).

However, it is important to note that not all studies included in this review demonstrated advantages of VR-enhanced exercise in comparison to traditional training. For instance, one study investigated the effects of exergames played on Xbox Kinect platforms in the intervention group, while the control group engaged in their usual activities. The study, however, yielded no statistically significant improvements in the intervention group. But the authors emphasize that the attendance rate was high, which can be indicative of the motivational potential of exergames on older adults (26). Another study conducted by Moreira et al. did not demonstrate a significant advantage of VR-aided training. In their study, they compared the impacts of exergaming and a traditional training program on cognitive and motor functions. The study enrolled a total of 66 participants who were randomly assigned to two groups. Surprisingly, both programs demonstrated equal effectiveness in reducing the fear of falling, enhancing fall risk awareness, and improving cognitive status, muscle function, and physical function (27).

Identified gaps

Most of the studies mentioned above have been conducted on a relatively small number of participants, so it is questionable if their results can be applied to the total population. However, this field of interest has been present for some time now. Many studies were conducted investigating the use of VR and exergaming in rehabilitating patients suffering from different diseases and conditions. A great majority of those studies concluded that using VR and exergaming can be a significant benefit, not only because they give better results but also because of the long-term cost-benefit. So, the question is not whether they are helpful but how can we make them more useful in a specific design and tailoring for certain groups of patients.

Furthermore, some of the research lack long-term follow-up, and we do not know if the immediate good results of VR-based training had a long-term impact and how long. This is therefore considered vital because this data would greatly help to tailor and design the VR mentioned above and exergames targeting a specific population or group of patients.

Conclusion

Through a comprehensive review of the literature on this subject, the research findings consistently indicate that the implementation of VR and/or exergaming can have a positive impact on enhancing the balance, gait, motor skills, and cognitive functions of older adults. These improvements directly contribute to reducing the risk of falls within this population. The results obtained from this study align with the majority of previously conducted research in this specific area of interest, reinforcing the coherence and validity of the findings. The common conclusion derived from all the studies conducted is that, considering the fact that the ageing population, which is at the greatest risk of falls, and will be a great burden on health and socioeconomic systems globally, there is a need to develop instruments and methods for fall prevention, and exergaming or VR has shown great potential to do so. Further studies should be conducted on larger number of participants to better examine the mechanisms by which such technologies can help in preventing falls. Also, further work is needed to identify the best ways to implement these technologies to be used by the said population, considering aggravating factors such as lack of motivation, inactivity, digital literacy, and aversion to the use of technology.

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PREDNOSTI VIRTUALNE STVARNOSTI U PREVENCIJI PADOVA KOD STARIJIH ODRASLIH: PREGLED LITERATURE

Sažetak

Uvod. Starenje ljudskog organizma sa sobom nosi smanjenje tjelesnih funkcija, kako motoričkih tako i kognitivnih, te se povećava vjerojatnost razvoja brojnih bolesti i stanja. Najčešće su poteškoće s kojima se susreću starije osobe smanjena sposobnost kontrole ravnoteže i kontrole hoda zbog slabosti mišića i smanjene koordinacije. Posljedice su pada u starijoj populaciji povećanje mortaliteta i morbiditeta te utjecaj na kvalitetu života te je potrebno raditi na prevenciji padova u ovoj populaciji. Tijekom posljednjih nekoliko desetljeća integracija informacijske i komunikacijske tehnologije (IKT) sa zdravstvenom skrbi dovela je do novoga istraživačkog polja. Jedan od aspekata u ovom području je široko prihvaćanje virtualne stvarnosti (VR) i/ili *exergaminga* u različitim područjima medicine. Ova studija ima za cilj istražiti potencijalnu upotrebljivost virtualne stvarnosti i *exergaminga* kao preventivne mjere protiv padova kod starijih osoba.

Metode. Pretraživanje literature provedeno je kroz baze podataka PubMed i Scopus, primjenom nizova za pretraživanje te kriterija uključivanja i isključivanja.

Rezultati. Pretraživanjem baza podataka identificirano je ukupno 330 radova, a nakon postupka odabira studija, u ovaj pregled literature uključeno je osam studija.

Zaključak. Primjena ovih intervencija ima obećavajući učinak na poboljšanje ravnoteže, hoda, motoričkih i kognitivnih funkcija starijih odraslih osoba, što su sve čimbenici koji su u korelaciji sa smanjenjem rizika od padova u proučavanoj populaciji.

Ključne riječi: virtualna stvarnost, *exergaming*, padovi, prevencija pada, starije osobe