

# Augmented and Virtual Reality Exergames for Elderly People

Subjects: Others

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Keywords: augmented reality ; virtual reality ; exergame ; elderly

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## 1. Introduction

Exergames are a type of game that requires physical activity in order to play. These games may use motion-sensing technology, such as a Kinect or Wii remote, to track the player's movements and respond to them in the game <sup>[1]</sup>. Exergames are designed to provide an engaging and interactive way to exercise, and are aimed at promoting physical activity in a fun and entertaining way. Over the past several years, exergames have been extensively used in training motor and cognitive skills in older adults <sup>[2]</sup>. In particular, exergames can help improve balance and coordination, which are important factors in fall prevention <sup>[3][4]</sup>. Falls are a leading cause of injury among older adults and can have serious consequences, including physical injuries, loss of independence, reduced quality of life, and increased healthcare costs <sup>[5]</sup>.

Augmented and virtual reality (AR/VR) can be used in the context of the exergames to train motor and cognitive skills in the elderly population for health improvement <sup>[6]</sup>. For motor skills training, VR can be used to provide immersive simulations of tasks that may be difficult for older adults to perform in the real world, such as climbing stairs or reaching for objects <sup>[7]</sup>. This can help improve their physical function and mobility <sup>[8]</sup>. For cognitive skills training, AR and VR can be used to provide interactive and engaging exercises that target specific cognitive abilities such as memory, attention, and problem solving <sup>[9][10]</sup>. These exercises can be designed to be both fun and challenging, making them more likely to be used by older adults. Additionally, AR and VR can be used to provide social engagement, which is important for older adults, as well as provide a way to simulate real-life environments, which can be beneficial for older adults with mobility issues <sup>[11][12]</sup>.

Commercial VR exergames that target a range of physical capabilities, including balance and strength, have been used in studies to improve physical function in older adults, including balance, gait, and upper and lower body strength <sup>[13]</sup>. However, there are several challenges that have been reported with the use of commercial VR in formal rehabilitation <sup>[14][15]</sup>. Some of these include the complexity of technical setup, VR sickness (such as nausea or dizziness) caused by the immersive nature of the technology, and the suitability of the technology for older populations who may have difficulty using or adapting to the technology <sup>[16]</sup>.

Commercial exergames, like many other video games, are often designed for a general audience and may not take into account the specific needs and abilities of the elderly population <sup>[17][18]</sup>. This can include factors such as the level of difficulty, the type of physical movements required, and the interface design <sup>[19]</sup>. For example, some exergames may require quick reflexes and fast movements, which can be difficult for older adults with decreased mobility or coordination. Other exergames may have complex interfaces or controls, which can be difficult for older adults with visual or cognitive impairments. Therefore, it is important that exergames for seniors are age-appropriate and take into account the physical and cognitive abilities of older adults. This can include designing games that are not too fast-paced, have simple controls, and provide clear visual and audio cues.

## 2. Elderly Falls and Physical Exercises

As individuals age, alterations in the sensory, motor, and cognitive systems can impede their ability to regulate balance, making it arduous to generate an appropriate reaction to balance perturbations <sup>[20]</sup>. This, in turn, can increase the

likelihood of experiencing a fall <sup>[21]</sup>. Falls are a significant health risk for elderly individuals, and research indicates that a noteworthy proportion of falls (ranging from 5% to 20%) result in severe outcomes, including head trauma, fractures, and, in severe cases, immobility or fatality <sup>[22]</sup>. Apart from the individual implications, falls have a substantial economic impact on both healthcare systems and society at large. The costs associated with falls are estimated to account for between 0.85% and 1.5% of the total healthcare expenditure in several countries, including the United States, Australia, the United Kingdom, and the European Union <sup>[23]</sup>.

In community-dwelling older adults, difficulties with maintaining balance have been identified as a key contributor to the elevated risk of falling <sup>[24]</sup>. Falls often transpire in circumstances that disrupt postural stability, such as when individuals are turning or reaching, or during walking activities <sup>[25]</sup>. As such, impairments in postural control can have far-reaching effects on an individual's ability to move around safely and effectively, limiting their mobility and independence <sup>[5]</sup>. The significant rise in the incidence of falls among older adults highlights the urgency of prioritizing research aimed at preventing such incidents as a crucial public health issue. Previous investigations have demonstrated that interventions aimed at enhancing the physical capabilities of older individuals can result in a substantial reduction of up to 50% in the risk of falling <sup>[26]</sup>.

Research conducted in the past several years has consistently demonstrated that balance exercises are a crucial component of effective exercise programs for older adults in reducing the risk of falls <sup>[3]</sup>. These exercises focus on improving neuromuscular control, postural stability, and the ability to respond to balance perturbations. As a result, fall prevention programs for older adults should incorporate exercises that challenge balance and target these abilities. Such exercises should focus on reducing the base of support, shifting the center of gravity, and reducing the reliance on upper limb support <sup>[27]</sup>. These types of exercises have been shown to improve balance and reduce the risk of falls in older adults, underscoring the importance of including them in fall prevention programs.

The World Health Organization (WHO) recommends 150 min of moderate aerobic activity weekly and also highlights the importance of incorporating physical activities that enhance balance and increase muscle power for seniors with limited mobility <sup>[28]</sup>. Engaging in such exercises three times per week has been shown to reduce the risk of falling by up to 30% <sup>[29]</sup>. Balance exercises include standing on one leg, walking heel-to-toe, and standing on a balance board. Strength training exercises include squats, lunges, and leg presses.

According to research, stepping exercises have been proposed as a potentially effective intervention for improving balance in older adults <sup>[30]</sup>. It has been demonstrated that older adults who engage in a regular exercise program, which incorporates stepping exercises, can experience notable enhancements in both balance and overall physical health. Similarly, stepping or walking exercises have been recommended by major health organizations such as the WHO as an effective means of promoting physical activity and reducing the risk of falls in older adults <sup>[28]</sup>.

Therefore, incorporating a combination of aerobic, strength, stepping, and balance-enhancing exercises into an older adult's routine is essential for promoting overall physical health and reducing the risk of falls.

Utilizing the Internet of Things and AR technologies, a scenario-based exergame prototype with gamification components was developed <sup>[31]</sup>. As a proof of concept, a couple of exergame scenarios were produced. In the first example, the player must ascend a staircase by stepping with high knees. In the second scenario, the mission is to fly like a parrot in a canyon environment which requires the player to make the proper shoulder and elbow movements. In order to measure variables such as heart rate and balance for potential fall detection, a smart wristband and foot pressure sensors controlled by an Arduino board were also integrated into the system. Three individuals participated in user testing of the prototype, and their feedback will be applied in the following development cycle.

The development of AR and VR exergames aimed at rehabilitating seniors with balance issues, along with their design and applicability topics, were discussed in a relevant study <sup>[32]</sup>. A balloon popping exergame was created in a variety of immersive AR and VR configurations in order to grasp the key design considerations and enable its evaluation by physicians for suitability in reducing fall risk. In the case of the VR version, moving around the scene is necessary to touch ascending balloons. In the case of the AR version, simple hand movements are sufficient. The exergame is played using the proper headsets in both settings. The results of the evaluation point to both a promising outlook and the need for technical advancements, such as the use of more practical headsets and the inclusion of new physical and cognitive activities.

In order to co-develop VR exergames to engage elderly people with dementia in physical practice that fosters upper limb elasticity, muscle strength, and endurance, a participatory design approach was used with the involvement of relevant stakeholders, including demented elderly, exercise experts, researchers in the development of VR-based exergames and

content developers [33]. Seas the Day is a VR exergame developed in this context that immerses users in a tropical virtual reality setting and requests them to complete three tasks in 15 min. To warm up, the participants perform Tai Chi exercises. Next, they perform activities involving rowing to train their muscles. Finally, they engage in fishing, which requires neck rotations and elbow movements. An evaluation study was performed to assess user experience with the participation of five elderly people who live in the community. In addition to playing the exergame, participants helped define a protocol for remote deployment and system evaluation.

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