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Review article

Exercise and rehabilitation delivered through exergames in older adults: An integrative review of technologies, safety and efficacy

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ABSTRACT

Background: There has been a rapid increase in research on the use of virtual reality (VR) and gaming technology as a complementary tool in exercise and rehabilitation in the elderly population. Although a few recent studies have evaluated their efficacy, there is currently no in-depth description and discussion of different game technologies, physical functions targeted, and safety issues related to older adults playing exergames.

Objectives: This integrative review provides an overview of the technologies and games used, progression, safety measurements and associated adverse events, adherence to exergaming, outcome measures used, and their effect on physical function. **Methods:** We undertook systematic searches of SCOPUS and PubMed databases. Key search terms included “game”, “exercise”, and “aged”, and were adapted to each database. To be included, studies had to involve older adults aged 65 years or above, have a pre-post training or intervention design, include ICT-implemented games with weight-bearing exercises, and have outcome measures that included physical activity variables and/or clinical tests of physical function.

Results: Sixty studies fulfilled the inclusion criteria. The studies had a broad range of aims and intervention designs and mostly focused on community-dwelling healthy older adults. The majority of the studies used commercially available gaming technologies that targeted a number of different physical functions. Most studies reported that they had used some form of safety measure during intervention. None of the studies reported serious adverse events. However, only 21 studies (35%) reported on whether adverse events occurred. Twenty-four studies reported on adherence, but only seven studies (12%) compared adherence to exergaming with other forms of exercise. Clinical measures of balance were the most frequently used outcome measures. PEDro scores indicated that most studies had several methodological problems, with only 4 studies fulfilling 6 or more criteria out of 10. Several studies found positive effects of exergaming on balance and gait, while none reported negative effects.

Conclusion: Exergames show promise as an intervention to improve physical function in older adults, with few reported adverse events. As there is large variability between studies in terms of intervention protocols and outcome measures, as well as several methodological limitations, recommendations for both practice and further research are provided in order to successfully establish exergames as an exercise and rehabilitation tool for older adults.

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1. Introduction

During the last decade, there has been a rapid increase in research on the use of virtual reality (VR) and gaming technology in the elderly population [1,2]. Exercise through video games, so-called exergames, is used progressively more to increase physical activity and improve health and physical function in older adults [1,3–5], and there is growing interest in using exergames as a potential rehabilitation tool to facilitate specific exercises in different clinical groups [6–8]. Studies suggest that exergaming promotes improvements in mobility [9,10], muscular strength of the lower limbs [11], balance control [2,12,13], and cognition [14] in older adults.

In line with this increased research interest, several reviews on exergaming have recently appeared. A Cochrane review from Laver et al. [8] evaluated the effects of VR and interactive video gaming in stroke rehabilitation. The authors concluded that exergaming is a promising rehabilitation approach for stroke recovery. Furthermore, few adverse events were reported across studies, and those that were reported (transient dizziness, headache, pain) were mild, indicating that the interventions were relatively safe for this patient population. However, interventions varied greatly with regards to which technology and games were used, leading to uncertainty about which characteristics of the interventions, such as technology, game consoles and game activity, may have been most important.

Similarly, Barry et al. [15] evaluated the evidence for the safety, feasibility, and effectiveness of exergaming as a rehabilitation tool in people with Parkinson's disease. They commented that commercial exergames that required fast decision making and rapid movements to avoid virtual obstacles, might be too difficult to use for many patient populations. Furthermore, only two of the included studies addressed patient safety, and neither objective (such as falls or near falls) nor subjective (participant perceptions) measures of safety were reported in any of the studies [15].

Likewise, Verheijden Klompstra et al. [16] conducted a scoping review that focused on the feasibility and influence of exergames on physical activity in different groups of older adults, to assess whether exergames increased physical activity in patients with

heart failure. Even though they concluded that exergames could be feasible to increase physical activity in patients with heart failure, they also highlighted that it would be challenging to find the most suitable exergame for any specific patient group as both the demands of games and the ability of the patients vary considerably [16].

In sum, these reviews indicate that exergames seem to be a feasible exercise tool for older adults with an acquired disease. Exergaming is also increasingly offered to elderly in general as a means of maintaining physical function, health, and, as a result, independence. Several reviews indicate that engaging older adults living in the community in an exergaming program is safe and feasible, and may enhance the participants' balance capabilities [5,17–20]. Laufer and colleagues [17] concluded that exergame programs may be an alternative to more conventional forms of exercise aimed at improving balance control. However, research on exergaming varies greatly in methodological quality as well as in intervention protocols and outcome measures used [17,19]. These factors make the evidence to support the effectiveness of using exergames for improving physical functioning in older adults inconclusive [19].

Exergames may have fundamental advantages compared to traditional exercise, as they easily allow for task-specific exercises to be delivered across a range of difficulty levels. This allows each user to begin at an appropriately challenging level that is attainable and comfortable, and then proceed with a gradual progression of difficulty that can be based on the individual's performance in real time [21]. However, commercial games that are readily available on the market are primarily designed for entertainment and recreation for younger populations, and tend to have colorful and visually busy game interactions, unsuitable music, and demanding navigation through the user interface. No easy one-touch interface is yet available, making the exergaming technology less feasible for many older people [21–23]. Furthermore, commercially available games are mostly designed for enjoyment and not based on basic exercise principles. In order for the games to be effective, they need to elicit specific movement characteristics in the players that are considered relevant for the function being trained. As falls and fall-related injuries are the leading cause for institutionalization and

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