

VIRTUAL/AUGMENTED REALITY TRAINING AS AN INTERVENTION FOR BALANCE IN OLDER ADULTS: A SYSTEMATIC REVIEW

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ABSTRACT

Virtual/augmented reality training are new interventions used by the physical therapist in the treatment of balance disorders in older adults. Virtual/augmented reality is a computer-based technology that allows the use of a simulated environment that challenges the visual, auditory, and proprioceptive senses in order to improve balance reactions and reduce falls in the elderly. The purpose of this review was to evaluate the effectiveness of virtual reality (VR) or augmented reality (AR) on postural balance in older adults with no major medical issues as compared to traditional therapy.

PubMed and Embase were systematically searched for articles pertaining to the topic. Studies were eligible for inclusion if they met the following criteria: 1) Randomized-control or randomized-clinical trials, 2) written in English, 3) participants were 60 years of age or older, 4) participants had no major medical issue, and 5) used virtual reality or augmented reality as treatment.

Seven studies met all inclusion criteria. Six of the seven studies included demonstrated no significant differences between VR and conventional exercise groups. One of the seven studies showed a significant between group improvements in favor of the VR intervention. Five of the seven studies demonstrated significant within group improvements utilizing both VR and conventional physical therapy balance exercises.

Virtual reality and augmented reality training are effective interventions used to improve postural balance in elderly patients, but there is no compelling evidence to suggest that VR/AR is more effective than traditional therapy options when treating the older adult without major medical issues.

INTRODUCTION

One in four Americans over the age of 65 fall each year [1]. According to the Center of Disease Control (CDC), falls are the number one cause of fatal injuries in older adults [1]. Falls and fear of falling can significantly limit activity levels and, consequently, quality of life for these older adults. Balance impairments are significant contributors to the cause of these falls [2]. While conventional exercise with adequate challenge has been found to be effective in reducing and preventing falls [2], [3], the occurrence of falls continue to be a significant health concern for older adults. Virtual reality (VR) and augmented reality (AR) are emerging technologies that are currently being used in physical therapy departments to treat functional impairments such as balance and/or gait deficits in order to reduce falls. VR/AR are computer-based technologies that allow the use of a simulated or immersive environment that challenges the visual, auditory, and proprioceptive senses. The computer program simulates real-life environments such as sports activities, grocery shopping, and games, providing a challenge to balance within this environment [2], [3]. This challenge can lead to improved balance reactions and reduction of falls.

Several studies have been published that have focused on the use of VR/AR in elderly patients with pathologies such as Parkinson's Disease or patients with history of cerebrovascular accident. However, we are not aware of any systematic reviews that have focused on using VR/AR as an intervention to treat balance deficits in older adults with no other major medical issue. "Exergaming", such as Wii gaming console, is sometimes considered a VR intervention. However, for the purpose of this study, we do not consider exergaming an aspect of VR because it does not create an immersive environment. In addition, VR/AR systems can be costly to install and implement in the treatment of patients that present with balance deficits within the clinical setting. Therefore, the effectiveness of VR as an

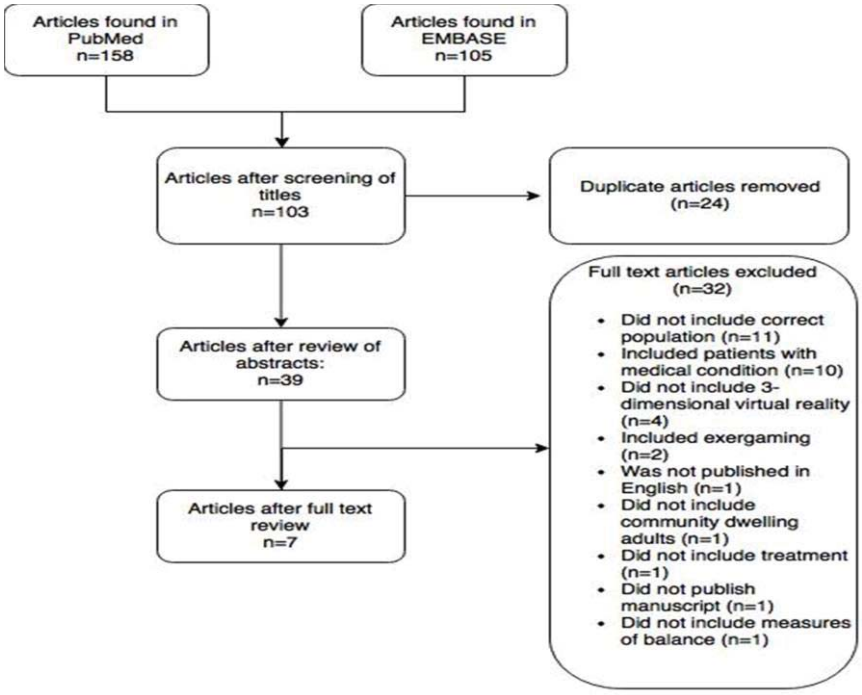
intervention to improve balance should be analyzed to determine its usefulness in populations that frequently experience issues with balance.

METHODS

A search of the literature was conducted on November 10, 2017, using PubMed and Embase. No limits were place on date of publication. The search string used in PubMed was as follows: (((virtual reality or augmented reality)) AND (gait or postural balance)) AND aged. A similar search strategy was used to search the Embase database. No limits were placed on the search. All studies published prior to the day of search were available. Eligibility criteria included randomized control or randomized clinical trials, written in English, participants were 60 years of age or older. In addition, participants had no major medical issues such as stroke, TBI, SCI, Parkinson's Disease, dementia, etc, and treatment utilized virtual reality or augmented reality technology as a treatment intervention.

There was a step by step process used to complete the study selection. Two authors screened the titles, and a third author was the tiebreaker to determine which titles remained. The abstracts and full texts were screened/selected using the same process. Two authors reviewed the abstracts/articles initially with a third author settling any discrepancies. (Figure 1)

Figure 1



RESULTS

The search revealed 7 articles that are included in this systematic review. Each research article utilized a VR or AR system as an intervention and compared the VR/AR data to a more traditional balance intervention utilizing a variety of outcome measures. Six of the seven studies included demonstrated no significant differences between VR and conventional exercise groups. One of the seven studies showed a significant between group improvements in favor of the VR intervention. Five of the seven studies demonstrated significant within group improvements utilizing both VR and conventional physical therapy balance exercises.

Bisson, et al (2007) enlisted 24 participants who underwent a 10 week trial using a virtual reality activity where the participants juggled virtual balls without lifting arms over head or heels off the ground. The comparator group underwent biofeedback training using a force plate and used their center of foot pressure to move a red cursor on a

computer screen to corners of a rectangle and back to center. The Community Balance and Mobility scale and static balance measures from the force plates were used as outcome measures. Results revealed no significant difference ($p > .05$) between virtual reality and biofeedback group [4].

Duque, et al (2013) included 60 participants who completed visual-vestibular rehabilitation and postural exercises for 6 weeks utilizing a Balance Rehabilitation Unit. The group was compared to a traditional exercise program that included medication review and educational session on fall prevention. The outcome measure used was limit of stability measurements obtained on the force plate with both eyes open and eyes closed. Results revealed a significant difference in the VR group ($p<.05$) nine months post treatment as compared to the traditional exercise group [3].

Kim, et al (2013) engaged 32 participants in virtual reality training using the XBOX 360 which included the Kinect sensor. Although XBOX can be considered exergaming which was included in the exclusion criteria, this study was accepted due to ability to measure whole body sway utilizing the motion capture sensor (KINECT). The participants attended 8 weeks of Tai Chi and yoga within the VR environment. The control group performed a non-specified daily routine with no specific intervention. Outcome measure used for comparison was data from a force plate measuring ground reaction forces. Results revealed no significant difference ($p < .05$) between virtual reality and control group [5].

Lee, et al (2017) enlisted 30 female participants who participated in an augmented reality based program incorporating Otago program for 6 weeks. The comparator group participated in 8 weeks of Yoga and self-directed Otago program for falls and balance. Outcome measure used to collect data was a Force plate and the Morse Fall Scale (MFS). Results showed a significant difference ($p < .05$) in the AR Otago group for center of pressure with eyes open and closed. There was also a significant decrease in the MFS in the AR Otago group [6].

Parijat, et al (2016) included 24 participants who underwent virtual reality slip training for 6 visits. The control group participated in a self-paced walking program. Outcome measures were data collected following an induced slip. The VR group demonstrated a significant decrease ($p < .03$) in frequency of falls in VR group posttest. Control group had no significant difference ($p > .05$) in frequency of falls [7].

Park and Yim (2016) included 72 participants in a Kayak training that was simulated by 3-D images of moving kayaks for six weeks. A control group was utilized that completed a conventional exercise program with warm up and cool down exercises. Outcome measures included standing and sitting balance measurements using postural sway. Results indicated a significant improvement ($p < .05$) of static standing balance in experimental group compared to the control group. Static balance in sitting also showed a significant improvement ($p < .05$) when compared to the control [8].

Yesilyaprak et al (2016) had 18 participants who participated in balance training with experimental group completing 6 weeks of balance training utilizing the BTS NIRVANA VR Interactive system. A control group completed conventional balance exercises that were performed in standing. Multiple outcome measures were utilized which included the Berg Balance Scale, the Timed up and Go, the Fall Efficacy Scale, Once Legged Stance, and Tandem Stance. Both the VR and conventional exercise groups showed significant improvement on the Berg, Timed Up and Go, and the Tandem Stance. There was no significant between group differences in any of the outcome measures [2].

DISCUSSION

Six of the seven studies included demonstrated no significant differences between VR and conventional exercise groups. One of the seven studies showed a significant between group improvements in favor of the VR intervention. Five of the seven studies demonstrated significant within group improvements utilizing both VR and conventional physical therapy balance exercises. According to this research, VR/AR are effective physical therapy interventions that can improve balance in older adults, but there is no evidence that VR/AR interventions are more effective interventions than those used in conventional physical therapy. VR/AR technology can be costly to implement in the clinical setting. Therefore, clinics should keep this in consideration when deciding whether or not to install this technology. However, patient preference for VR/AR or conventional physical therapy may be influential to potential outcomes. VR/AR can facilitate participation and motivate individual due to the interactive environment and game-like approach. [1], [6], [7]. There were some limitations to this study that should also be considered. Many of the outcome measures used in these studies are not consistent with currently accepted outcome measures used in physical

therapy practice. The PEDro scores, used to assess risk of bias, for the seven selected studies ranged from 4 to 7 out of 10. Three studies were of poor quality, three were of moderate quality, and only one was of high quality. Based on the risk assessment of these studies, there is a need for higher quality studies regarding VR/AR.

CONCLUSIONS

VR/AR are effective in improving postural balance in elderly patients, but there is no compelling evidence to suggest that VR/AR are more effective than traditional therapy options. VR/AR does provide a fun, stimulating, and motivating alternative to traditional balance activities that may provide improved compliance to a physical therapy plan of care within the elderly population.

DISCLOSURES

W. Benjamin Hammond- Author has nothing to disclose and no conflict of interest in conducting this research.

Elise D. Ethridge- Author has nothing to disclose and no conflict of interest in conducting this research.

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Sherry Colson. Author has nothing to disclose and no conflict of interest in conducting this research.

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