

# The Effect of Virtual Reality on Postural Stability and Fall Risk Assessment of Older Women

Hassan Sadeghi<sup>1</sup>, PhD;  Seyed Sadredin Shojaedin<sup>1\*</sup>, PhD 

<sup>1</sup>Department of Biomechanics and Sports Injuries, Faculty of Physical Education and Sports Sciences, Kharazmi University, Tehran, Iran

\*Corresponding author: Seyed Sadredin Shojaedin, PhD; Department of Biomechanics and Sports Injuries, Faculty of Physical Education and Sports Sciences, Kharazmi University, Shahid Keshvari sport complex, Shahid Hesari st., Mirdamad Blv. Postal Code: 15447-33111, Tehran, Iran. Tel: +98 21 22223397; Email: sa\_shojaedin@yahoo.com

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## Abstract

**Background:** Exergames (exercise and gaming) or virtual exercises have been reported to improve balance and functional mobility in older adults. The present study was conducted to evaluate the effects of virtual reality exercise, on the static balance, postural stability, and functional mobility among older women.

**Methods:** In this quasi-experimental pilot study, 15 older women aged 65 years old and above were divided into control and experimental groups. Our participants were recruited from Gorgan Neighborhood House in Tehran-Iran in June and July 2020. Following the pre-test, the experimental group completed three weeks of virtual training three times per week via Xbox Kinect Software, and the effects were measured after three weeks. The Biodex Balance System was employed to measure the fall risk index and postural stability index. Moreover, Timed Up and Go (TUG) test were used for functional mobility.

**Results:** One-way analysis of covariance (ANCOVA) revealed a statistically significant difference in post-test between the groups concerning fall risk index in open eye conditions, ( $P < 0.001$ ), fall risk index in close eye conditions ( $P < 0.001$ ), overall stability index ( $P < 0.001$ ), and TUG ( $P < 0.001$ ).

**Conclusion:** This study demonstrated that virtual reality exercise could improve the fall risk index and functional mobility of healthy older women. Consequently, these types of exercise could be recommended as practical exercises for elderlies to be done at home or health care institutions.

**Keywords:** Postural balance; Accidental falls; Virtual reality; Frail elderly

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## 1. Introduction

Aging is an essential process from the perspective of sociologists and geriatricians (1). According to the World Health Organization, most developed countries face this problem, and developing countries will also face this problem in the near future (2). According to these reports, only 5.4% of the Iranian population was over 60 years old in 1975, which will increase up to about 10.5% in 2025 and, surprisingly, in 2050, it would reach 21.7% (3). With the increase in age, physical and mental function among the elderly gradually decreases, which leads to greater dependence on daily activities and therefore isolation (4). Falling is the result of a disturbance of balance and the departure of the center of gravity from the level of reliance (5). Fall is a serious issue among the elderly, which has caused widespread controversy among experts. Apart from the external factors triggered by environmental factors, the internal factors could also increase the risk of this issue; these factors include weakness of lower limb muscles, decreased mental and sensory abilities, decreased balance and instability in the body, and slow sensory

and motor responses (6). Yamada and colleagues (7) showed that around a third of 65-year-old adults fall once a year at minimum while 6% of such falls cause fractures. Moreover, it has been observed that two-thirds of falls in the older people can be theoretically prevented (8). Numerous ramifications of falling include hip and wrist fracture, permanent disability, reduced quality of life, and even death (9).

Women sustained fall-associated injury rates higher than men of comparable ages. Women's hospitalization rates for fall injuries were about 81% higher than those of men's, suggesting that women sustained more severe injuries (10). With the increase in age, bone structure of women deteriorate, which decreases bone mineral density, and increases fragility, lack of balance, and a greater likelihood of fracture (11). Active video game or exergame is a new enjoyment intervention to improve cognition, attention, intelligence, balance, physical mobility, and strength, which also affects pain improvement. There are certain significant deterrents to traditional balance training programs for the elderly residing in the society, such as the lack of

public availability of high-tech facilities, transportation barricades for the elderlies, the problems with the costs, and cost-effectiveness of any high-tech programs (12). Recently, investigators have examined the effects of Xbox Kinect intervention on reduction of falls among the older adults (13-15).

Previous studies have evaluated the effects of the intervention on balance improvements using manual balance-testing methods. The Biodex Balance System (BBS) has been proven to be a reliable and objective tool for balance assessment among older adults (16). The BBS measures the fall risk index and stability index among this group.

Ibrahim and colleagues (17) measured the effects of virtual reality exercise on balance among older male and female adults. To the best of our knowledge, no studies have so far considered Xbox Kinect exercise to improve the static balance and fall risk index among older women. The current pilot study aimed to evaluate the effectiveness of virtual reality exercise on fall prevention of older women.

## 2. Methods

### 2.1 Study Design

Fifteen older women participated in this quasi-experimental pilot study. They were recruited from Gorgan Neighborhood House in Tehran-Iran in June and July 2020. They were randomly divided into two groups of experimental and control using an online randomization system (randomizer.org). A member of the research team, who was not involved in the selection of the samples, determined the randomization sequence with a computer program. The participants were notified of their group allocation with a sealed envelope. The virtual training was as independent variables and the fall risk index, timed up and go test, and postural stability index were as dependent variables.

### 2.2 Selection and Description of the Participants

The inclusion criteria comprised women aged 65 years and older, able to walk without an assistive device, and with no history of syncope falls. The exclusion criteria included those with an acute or chronic disease with influence on balance control (for example, Parkinson's disease, diabetes, or peripheral neuropathy) and those who participated in regular exercise programs in the final 6 months prior to this study. The proposal

and design of the study were approved in the Ethical Committee of Kharazmi University in Tehran. All our participants filled up and signed the consent form.

The sample size estimation was determined a priori utilizing G\*Power (version 3.1.6). Assuming an effect size of 0.54 (18), with an alpha level of 0.05, 16 subjects participated in this study with 90% power.

### 2.3 Exercise Protocol

In this group, the virtual training sessions were performed with Xbox Kinect software with a Console and Kinect Sensors. The sensor is an infrared camera that diagnoses the position and movements of the players automatically and records various activities of the them. After selecting the games, the person is placed in front of the infrared camera and performs the movements based on the movements performed by the console (19). The experiment was carried out three times per week and continued for three weeks. Each session was 40 minutes, including warming up and cooling down before and after the exercise protocols. All the exercise sessions were performed by a certified physical trainer and under the supervision of the researcher.

### 2.4 Test Protocol

#### Balance Test

The Biodex Balance System (Biodex Medical Systems Inc) was employed for assessing fall risk index and postural stability index. In the fall risk test, the platform was unstable, and the subjects' sway was used for the calculation of the fall risk index. The test was done in close and open eyes conditions. According to the standard software configuration, two trials, 20 seconds each at a stability level of 8, were calculated with a 10-second rest between the trials (17). (Figure 1)

For the postural stability test, three 20-second trials were conducted with one-minute intervals between them. The platform was fixed, and the subjects' sway was considered in order to calculate the overall stability index (OSI).

#### Timed Up and Go Test

The TUG is widely used for balance and gait and is typically employed to measure the risk of fall in the elderlies (20). The TUG evaluates different parts of functional mobility, which includes balance or



**Figure 1:** The Biodes Balance System™ device.

**Table 1:** Anthropometric Variables of Participants between Groups (mean±SD)

Variables	Virtual	Control
Age	71.28±5.70	73.12±5.38
BMI	23.45±3.25	24.65±2.54

BMI: Body Mass Index (kg/m<sup>2</sup>)

stability, walking, standing up and sitting down, and also turning whilst walking (20). The test has shown inter-rater reliability (ICC=0.99) and intra-rater reliability (ICC=0.99) in a sample of a community-dwelling older people aged 62 years old (21). Moreover, concurrent validity has been reported with the Berg Balance Scale ( $r=-0.61$ ) and the Barthel index ( $r=-0.51$ ) (21). In the TUG test, the partakers have to arise from a standard chair having a seat height of 40 cm. At that juncture, they were queried to walk for 3 meters at a normal speed, turn, walk back to the chair, and sit down. The time, recorded in seconds, is computed once “go” was expressed and stops once their backs touch the chair backrest. If this stage takes a shorter time, it could be said that a better balancing ability exists. To achieve the TUG score The average of the two trials was

documented and kept for the data analysis (7).

### 2.5 Statistical Analysis

For the data analysis, we employed the SPSS software (IBM SPSS Statistics for Windows v. 26, Armonk, NY, USA). Separate one-way analysis of covariance (ANCOVA) across the two groups (VR vs CON) was also used. To compare the within-group (pre-test and post-test) differences, A Wilcoxon signed rank test was conducted. The  $\alpha$  level was set to 0.05.

### 3. Results

Table 1 represents the demographic variables of the participants. The results of independent t-test showed no significant differences between the experimental ( $n=7$ ) and control ( $n=8$ ) groups regarding age ( $P=0.532$ ) and BMI ( $P=0.437$ ).

Following the intervention period, ANCOVA analyses revealed the significant effect between groups for fall-associated risk index in open eye conditions ( $P=0.001$ ,  $\eta^2=0.752$ ,  $\omega^2=0.717$ ). A Wilcoxon signed rank test showed a significant difference ( $Z=-2.371$ ,  $P<0.05$ ) between the scores given for the pre-test fall risk index in open eye conditions compared to the post-test fall risk index in open eye conditions. The median score for the post-test was 2.98 compared to 4.94 for the pre-test. Furthermore, ANCOVA analyses revealed the significant effect between groups for fall risk index in close eye conditions ( $P<0.001$ ,  $\eta^2=0.893$ ,  $\omega^2=0.877$ ). A Wilcoxon signed rank test illustrated a significant difference ( $Z=-2.366$ ,  $P<0.05$ ) between the scores given for the pre-test fall risk index in close eye conditions compared to those of the post-test fall risk index in close eye conditions. The median score for the post-test was 4.33 compared to 6.34 for the pre-test.

According to ANCOVA analyses, there was a significant effect between groups for the overall stability index ( $P<0.001$ ,  $\eta^2=0.723$ ,  $\omega^2=0.685$ ). A Wilcoxon signed rank test showed a significant difference ( $Z=-2.366$ ,  $P<0.05$ ) between the scores given for the pre-test fall risk index in close eye conditions compared to those of the post-test fall risk index in close eye conditions. The median score for the post-test was 1.75 compared to 2.24 for the pre-test. ANCOVA analyses exhibited a significant main effect of group for the TUG test ( $P<0.001$ ,  $\eta^2=0.645$ ,  $\omega^2=0.624$ ). Based on A Wilcoxon signed rank test, a significant difference ( $Z=-2.366$ ,  $P<0.05$ ) was observed between the scores given for the pre-test fall risk index in close eye conditions compared

**Table 2:** Pre-test and posttest of dependent variables (mean±SD) of groups

Variables	Groups	Pre-Test	Post-Test
Fall Risk Index Open eyes (°)	Virtual	4.84±0.34	3.10±0.53*
	Control	4.94±0.26	4.68±0.43
Fall Risk Index Close eyes (°)	Virtual	6.31±0.54	4.51±.43*
	Control	6.38±0.31	6.50±.28
Stability Index (°)	Virtual	2.27±0.19	1.68±0.18*
	Control	2.23±0.21	2.34±0.24
TUG (s)	Virtual	11.80±0.55	9.97±0.66*
	Control	11.60±1.22	11.80±0.84

(°)=Degree, (s)=Second, TUG=Timed Up and Go Test, \*Signifies difference between pre and post-test.

to those of the post-test fall risk index in close eye conditions. The median score for the post-test was 9.96 compared to 11.45 for the pre-test. Table 2 depicts the mean differences between the pre- and post-tests for each group.

#### 4. Discussion

The findings of the current study indicated that the virtual training significantly affects fall risk index, postural stability, and functional mobility among older women. Virtual reality exercise could increase the muscle group's coordination and improve the response to the sensory information. It might also lead to an increase in balance and functional mobility. The static balance ability, which is referred to as the capability of sustaining equilibrium while stationary. Balance is the essential element in the daily activities and a factor of great necessity for function among the elderlies. Balance and motor control are crucial for every skill and a pivotal part in preventing injuries.

The outcomes of the present research revealed that the Xbox Kinect exercise significantly improved the static balance among elder women in opened and closed eye conditions. In contrast to the earlier findings reported by Van Diest and colleagues, the balance concerning sway characteristics enhanced averagely by 17.4% (Eye Open) and 23.3% (Eye Close) following six weeks of training ( $P<0.05$ ) (22). Nonetheless, the above-mentioned study was conducted during six weeks as an unsupervised home exercise with a small number of participants; meanwhile, the current study was conducted during three weeks with three training sessions a week of supervised exercises. In addition, in the previous research, the single-leg stance test was utilized whereas the current study measured the balance with the Biodex Balance System.

The results of this study illuminated that the Xbox Kinect exercise as virtual reality improved the balance

among older adults. Our findings seem to be consistent with those of other researches which found that exercises with virtual reality could improve the balance among the older adults (23). However, our results are in contrast with the results reported by (24) who did not observe any balance improvement following virtual based balance exercise. Such a difference could be attributed to the differences concerning the methodology and exergame software.

The results of the current study demonstrated that Xbox Kinect exercise significantly improved the static balance compared to the conventional balance exercise. The obtained findings herein mirror those of the previous studies that compared the effect of exergaming activities with the traditional rehabilitation program influencing the balance in older adults (25-27). The research conducted by Sims and colleagues (28) established that Wii fit exercise was more effectual compared to that of the traditional exercise on balance. The efficacy of Wii Fit training on the balance control among the elderlies in comparison with the conventional balance training was established in the study of (29) as well, where they concluded that Wii Fit training could enhance balance more effectively. The results of our research are not in accordance with those of the research by Yesilyapark and colleagues (30) who found no significant differences between virtual and conventional balance exercises among the older adults aged between 65 and 82 with a history of fall and living in nursing homes. In our study, Xbox Kinect was utilized for game exercise, which was more feasible for older adults. Playing without any remote or cable connection and force plate is one of the advantages of the Xbox Kinect exercise. This also accords with our earlier observations which shed light to the fact that exergaming might elevate the balance confidence and diminish the risk of falls in the community-dwelling females (31). It is suggested that Xbox Kinect exercise could increase the muscle group's coordination and improve the response to the sensory information. A

possible explanation for this might be the fact that Xbox Kinect exercise program, in comparison to the conventional interventions, is beneficial and enjoyable and seems to be more achievable and feasible (32, 33). There are certain significant deterrents to the traditional balance exercise programs for the older adults living in a community, such as the lack of public availability of high-tech facilities, transportation barriers for the older adults, and the problem of cost-benefit and cost-effectiveness of any high-tech program (12). It was hypothesized that Xbox Kinect exercise could bring about an interactive setting demanding gestures and movements of the upper or lower extremities to prompt the on-screen gameplay. Virtual environments are based on real environments to be able to add new virtual environments efficiently and quickly.

The results herein would be useful for the physiotherapists and physical therapy centers; they could adopt them in treating and prevent the fall risk among the elderlies. Exergaming interventions are also safe for older adults and include home situation, monitoring performance, motor control and cognitive function, motivation, and social interaction. New types of exergaming systems, the Microsoft Xbox Kinect for instance, do not oblige the players to stay on a raised surface or hold the controller and could yield a securer exercise than the other systems of exergaming for older people. Therefore, this enjoyable and low-cost activity would prevent illness and health problems associated with physical activity and motivate people to have further practice, particularly the older adults in families and society. The findings from this study make several contributions to the current literature. Primarily, previous studies have measured the effects of virtual reality employing other types of balance tests. To the best of our knowledge, not a lot of studies used the Biodex balance system for measuring the effects of virtual reality on balance. Secondly, this is the first study reporting an advantage of virtual reality on balance among women in Iran. Overall, this study suggested that the exergames with the conventional exercise are practicable and suitable for the community-dwelling elderlies and might characterize an innovative way in diminishing the fall-risk factors among the elderly.

There are some limitations for the current study, firstly, this study only investigated the female elderly, and the researcher could not apply the fall preventions intervention to the male elderlies. Second, Routine daily activities and nutritional status of the participants could not be controlled by the researcher in this research.

## 5. Conclusion

The results of the current study revealed that virtual reality training, as an enjoyment and feasible tool, improves balance and functional mobility of older women and as a result, reduces the risk of fall. In sum, this study suggested that exergames are practicable and suitable for the community-dwelling elderlies and might characterize an innovative way of diminishing the risk factors associated with fall among older people.

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## Ethical Approval

The Ethics Review Board of Kharazmi University approved the present study under the following number: IR.KHU.REC.1398.038.

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**Conflicts of interest:** None to declare.

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