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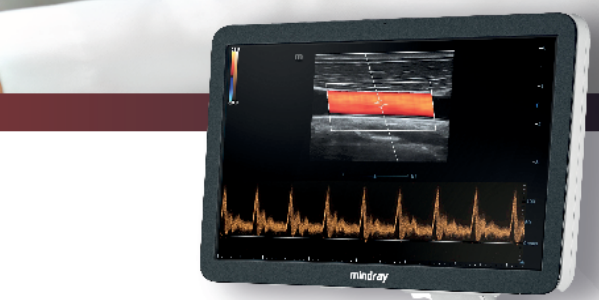

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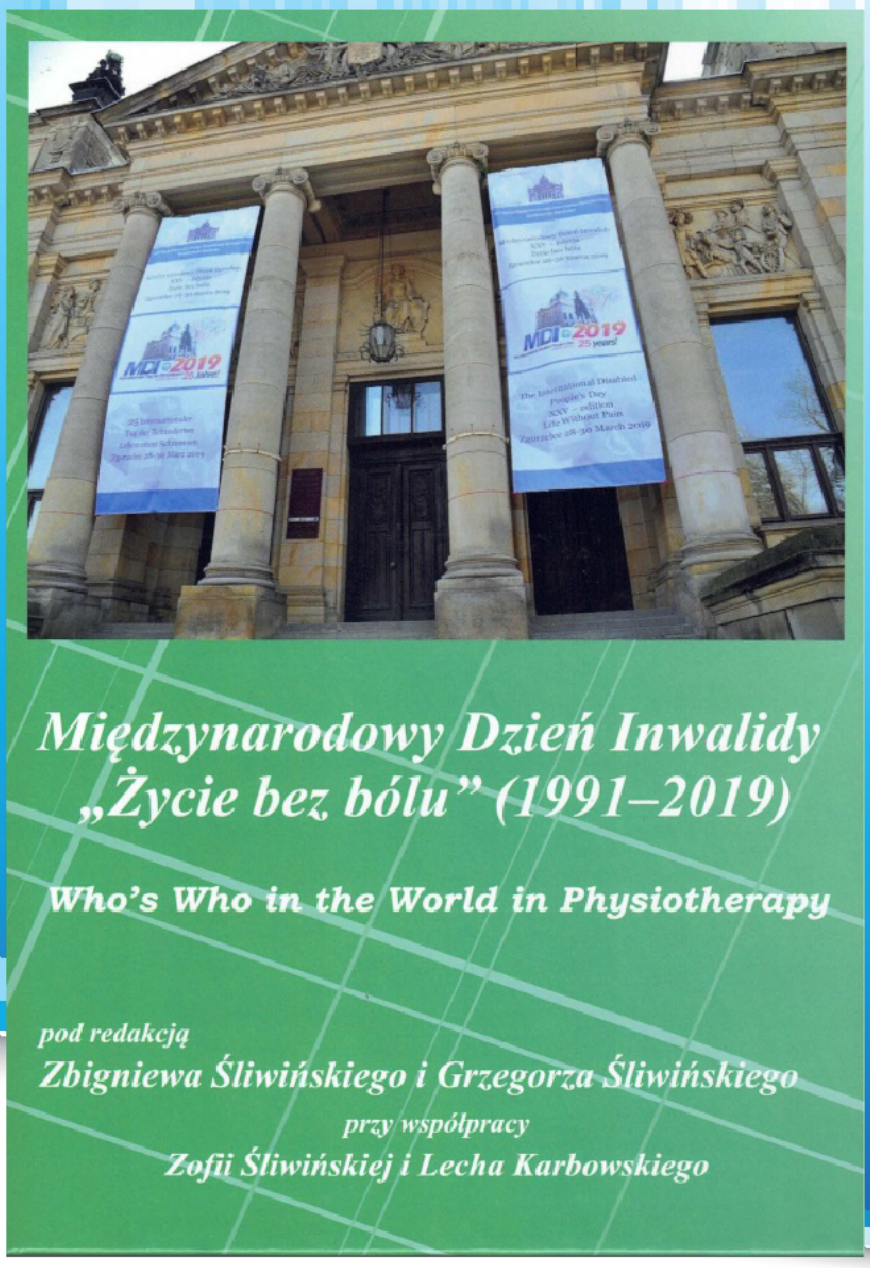

Indeks uczestników MDI z Polski i zagranicy

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Effect of virtual reality training on risk of falls and quality of life among elderly

Wpływ treningu w wirtualnej rzeczywistości na ryzyko upadków i jakość życia osób starszych

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Abstract

Purpose. One of the fall risk factors associated with aging is the deterioration of postural stability. This study aimed to evaluate the effects of Virtual Reality Training (VRT) on the risk of falls, and quality of life among elderly.
Methods. Thirty-five community-dwelling elderly aged 65 to70 years from both genders were included in the study. Participant were randomly assigned into two groups; VRT group: included 30 participants and were provided with VRT sessions using Xbox 360 Kinect. Each session was determined to be for 30 minutes; 5 days weekly throughout the program period which was 6 weeks (30 sessions in total). The Control group: included 10 participants, they were advised to follow conventional balance exercises. The dynamic postural stability was assessed using the overall stability index (OSI) of Biodex and the Functional reach test (FRT) before and immediately after the program for all the participants. And 36-items short form (SF-36) Questionnaire was employed to evaluate the general health quality of life.
Results. The overall balance showed statistically significant improvements after VRT. Results revealed significant improvement of OSI and FRT ($p < 0.05$) after VRT. Also, the results demonstrated significant improvements in levels of general health quality of life after the VRT compared with those of the Control group ($p < 0.05$).
Conclusion. VRT improves overall postural stability and general health quality of life and can help reduce the risk of falls in healthy older adults.

Key words:
elderly, postural stability, quality of life, overall stability index

Streszczenie

Cel. Jednym z czynników ryzyka upadku związanych ze starzeniem się jest pogorszenie stabilności postawy. Niniejsze badanie miało na celu ocenę wpływu treningu w wirtualnej rzeczywistości (VRT) na ryzyko upadków i jakość życia osób starszych.
Metody. Badaniem objęto 35 osób starszych mieszkających w domu opieki w wieku od 65 do 70 lat obu płci. Uczestników losowo podzielono na dwie grupy; Grupa VRT obejmowała 30 uczestników i miała zapewnione sesje VRT za pomocą Xbox 360 Kinect. Każda sesja trwała 30 minut; 5 dni w tygodniu przez cały okres trwania programu, tj. 6 tygodni (łącznie 30 sesji). Grupa kontrolna: 10 uczestników, którym zalecono wykonywanie konwencjonalnych ćwiczeń na poprawę równowagi. Dynamiczną stabilność postawy oceniano za pomocą wskaźnika ogólnej stabilności (OSI) Biodex oraz testu zasięgu funkcjonalnego (FRT) przed i bezpośrednio po programie dla wszystkich uczestników. Do oceny ogólnej jakości życia w zdrowiu zastosowano 36-punktowy kwestionariusz skrócony (SF-36).
Wyniki. Wykazano statystycznie istotną poprawę w zakresie ogólnej równowagi po zastosowaniu VRT. Wyniki wykazały istotną poprawę OSI i FRT ($p < 0,05$) po zastosowaniu VRT. Wyniki wykazały również znaczną poprawę poziomu ogólnej jakości życia po zastosowaniu VRT w porównaniu z grupą kontrolną ($p < 0,05$).
Wniosek. VRT poprawia ogólną stabilność postawy i jakość życia oraz może pomóc zmniejszyć ryzyko upadków u zdrowych osób starszych.

Słowa kluczowe
osoby starsze, stabilność postawy, jakość życia, ogólny wskaźnik stabilności

Introduction

Worldwide, fall is the second most common cause of unintended injury mortality, with those of age over 65 years having the greatest number of fatal falls [1,2]. Fall related injuries may require a healthcare intervention, and some cause ongoing disability and, as such, they are a cause of significant cost to the national health system [3].

The deterioration in mental and physical status, together with decline in the postural stability and functional capabilities are all barriers to the elderly's activities [4]. Additionally, reduced mobility and self-care abilities were found to be associated with their life dissatisfaction [5, 6]. Moreover, all these factors contribute to the risk of fall and its related injuries [7].

In healthcare facilities, ensuring mobility for elderly people has become a primary priority. Intensive physical exercise and activities may preserve independence in daily activities, hence reducing fall risk and consequently decreasing their mortality rate and the need for them to be admitted to institutional care services. Ultimately, increasing these activities play a role in improving their functional, psychological, and social abilities [8].

Long-lasting and high-intensive multi-component exercises are the best applied approach in order to reach to the expected rehabilitation goals. Conventional exercises given to the older adults as a home program are demonstrated and taught by physiotherapists during rehabilitation sessions, using written and/or figure handouts. These self-administered exercises may be executed incompletely or even stopped prematurely, as they consider these exercises boring and tedious [9, 10]. Modern interactive varieties of fitness dependent on VRT are playing an increasingly important role in the rehabilitation settings of older individuals [11, 12]. Additionally, some researchers reported that older adults showed higher satisfaction and commitment to VRT, thus led to controlling anxiety, obesity and improving cognitive abilities [13, 14].

Microsoft Kinect as an example of a non-immersive virtual reality technology has been recently introduced into the rehabilitation field [15]. It provides a 3-D environment allowing the individual to perform multi-functional tasks virtually without needing to hold a controller or a device in hand [16]. In a previous study, the authors assessed the efficacy of VRT in people older than 60 years using the “Xbox Kinect”. They concluded that VRT increases the opportunities for motor training by enhancing the dynamic and static balance and can help minimize the risk of falling [11].

Although the usage of VRT programs in geriatric rehabilitation attracts attention, only a few researches about the utilization of the game consoles on balance among the elderly were reported [17]. So, the present study was conducted to evaluate the effect of the virtual reality training using the Xbox 360 KinectTM game console on the balance and quality of life of geriatrics aiming to improve the evidence quality towards the adoption of this technology as a fall preventive tool.

Subjects and methods

Study design

This randomized controlled trial was conducted in the in the period from June 2019 to November 2020. Human use analysis has been complied with all applicable national regulations and institutional policies, and in accordance the tenets of the Helsinki Declaration and the acceptance of the Ethical committee approval from the Faculty of physical therapy, Cairo University, Egypt (No.P.T.REC/012/002295).

A signed written consent form with participant acceptance for participation in the study and publication of results were obtained before starting the procedures.

Participants

Thirty-five community-dwelling elderly aged from 65 to70 years from both genders in Cairo were included in the study. All the participants have met the following criteria: could move independently, with minimal pain level (level 3 or less in Visual Analogue Scale pain evaluation) and didn't follow specific regular exercise regimen before the study. The exclusion criteria were the presence of cardiopulmonary dysfunction that might hinder exercising; neurological disorder; existed musculo-skeletal problems in the lower limbs, which may affect free standing and movement; psychiatric disorders; and severe hearing or visual impairment. The elderly who met the inclusion criteria were divided randomly into 2 groups via simple randomization using a coin. VRT group, the Study Group, included 30 participants. The other was the Control group and included 10 participants. All participants were informed about the material, objectives, execution of the study, and each signed a consent form before the conduction of the study (Figure 1).

Outcome Measurements

The overall stability index (OSI) of the Biodex Balance System was utilized to assess dynamic postural stability. OSI represents the participant's ability to control balance in the antero-posterior (AP) as well as the medio-lateral (ML) directions. A high score of OSI indicates poor balance. The OSI score is considered to be a reliable indication for dynamic balance and represented by the person's ability to balance the platform [18]. The software protocol used was the stability Test. Each participant had two test trials for the purpose of familiarity with the instrument prior to data collection. Participants got a 1-min rest between test conditions. For the elderly's' safety, handrails were attached to the instrument. Functional reach test (FRT) was to evaluate the potential risk of fall in the sample. FRT is one item test designed as a simple screening for balance impairment in senior adults [19]. FRT was administered while the person is standing. A yardstick was fixed to the wall at about shoulder height. The person was instructed to stand beside the wall and place the arm closer to the wall, but not touching it, with a closed fist and shoulder flexion at 90 degrees. The starting point was marked on the yardstick at the level of 3rd metacarpal head (point 1). The person was instructed to reach as far as he could without stepping forward and the furthest point, he could reach was marked on the yard stick at the level of the 3rd metacarpal (point 2). The scores which represent the reach distance were determined by calculating the difference between the two points, measured in inches. Three trials were done and the average of the last two was taken.

36-items Short Form (SF-36) Questionnaire was employed to evaluate the quality of life (QOL) of general health. All the

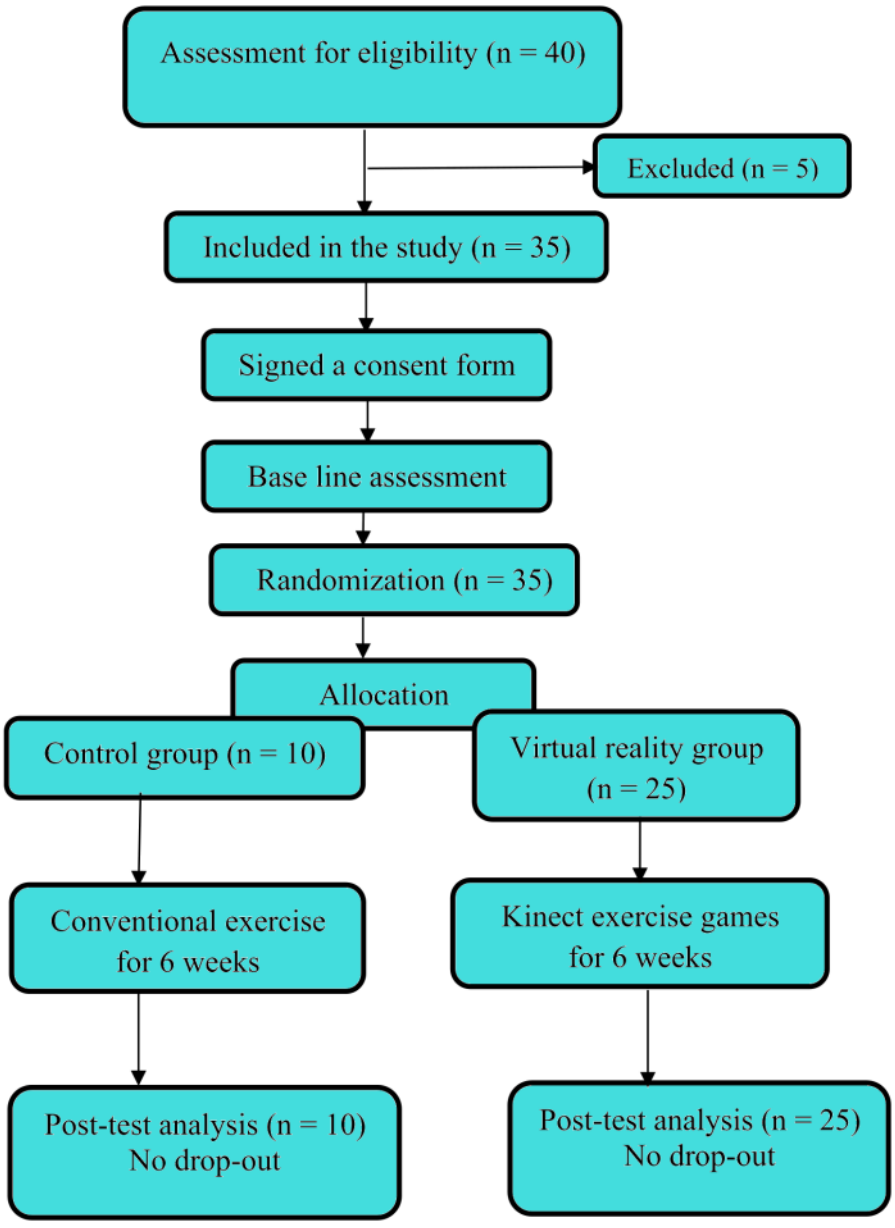

Figure 1. Flow chart of the study

participants were requested to fill in the questionnaire (tick boxes) by themselves twice; before and after the program then it was scored. Scores range from 0 to 100, with the highest scores indicating the best level, and the lowest scores indicating the worst level of health. All the variables were tested for each group twice; before and after the program (6 weeks) for all the participants in the study.

Intervention

For the VRT group (study)

The Xbox 360 Kinect, game console and 40-inches LCD screen were utilized. This group was enrolled in playing Kinect Sports video games with the chosen option of competitive single player mode. These games included "bowling; boxing; track and field; table tennis, and beach volleyball sports". The participants started the session by standing in front of the Kinect sensor that detects body's gesture and movements. Then he/she competed in a way like the real-life sports actions. Each game was demonstrated to the elderly, and each one was instructed to play the games for 30 minutes every day for six weeks with two days off weekly (30 sessions in total).

For the control group

The elderlies were advised to follow conventional balancing exercises, including muscle stretching exercises for knee flexors and extensors; hip adductors; and pectoral group, and also strengthening exercises for the anti-gravity muscles of the lower limbs involving calf; knee extensors; hip extensors. Also, exercises included standing on two feet, a semi tandem stance, single leg standing, trying to stand on the heels, and trying to stand on the toes. The exercise regimen was determined as 30 minutes daily for six weeks with two days off every week. A list of warning symptoms was demonstrated for the participants to stop exercising and consult a physician if felt.

Statistical analysis

Results are expressed as mean ± standard deviation or number (%). Comparison between categorical data was performed using Chi square test. Test of normality, Shapiro Wilk test, was performed to measure the distribution of data measured at pre-intervention. Comparison between pre- and post-intervention data within the same group was performed using the paired t test. Comparative analysis of data between-groups were performed using the unpaired t-test. The SPSS vr.24.0 (IBM, Inc., USA) software was used for data analysis. P value ≤ 0.05 was considered significant.

Results

As observed from (Table 1), there were no significant differences between both groups in the mean age values and gender distribution. (Age: p = 0.64; Gender: p = 0.63).

Table 1. Demographic data of the two studied groups

Variables	VRT group (n = 25)	Control group (n = 10)	p-value
Age [years], Mean ± SD	66.96 ± 1.62	67.3 ± 2	0.64
Gender, (F: M) [n (%)]	14: 11 (56%: 44%)	4: 6 (40%: 60%)	0.63

VRT: Virtual reality training, n: number, F: Female, M: Male, SD: standard deviation, P > 0.05 = not significant

Comparative analysis of OSI between pre and post-program

In VRT group, there was a statistical significant decrease in the mean value of OSI measured at post-intervention when compared to its corresponding value measured at pre-intervention (p = 0.001). While in control group, there was no statistical significant different between pre- and post-intervention (p = 0.786). The unpaired t-test revealed no statistical significant difference between the two groups measured at pre-intervention (p = 0.326) while at post-intervention it was significantly increased in VRT group when compared with its corresponding value in control group (p = 0.001) (Table 2).

Table 2. Inter- and intra-group comparison between OSI values in the two studied groups measured at pre- and post-treatment

OSI (in degrees)	VRT group	Control group	p-value[a]
Pre-intervention	5.58 ± 2.64	4.69 ± 1.58	0.326
Post-intervention	3.26 ± 1.28	4.64 ± 1.86	0.001
Mean changes	2.32	0.05	
% of change	41.58 ↓↓	1.07 ↓↓	
p-value[b]	0. 001	0.786	

OSI: Overall stability index, VRT: virtual reality training, a: between-group comparison, b: within-group comparison, p > 0.05 = not significant, p ≤ 0.05 = significant

Comparative analysis of FRT between pre and post-program

In VRT group, there was a statistical significant decrease in the mean value of FRT measured at post-intervention when compared to its corresponding value measured at pre-intervention (p = 0.001). While in control group, there was no statistical significant different between pre- and post-intervention (p = 0.103). The unpaired t-test revealed no statistical significant difference between the two groups measured at pre-intervention (p = 0.833) while at post-intervention it was significantly increased in VRT group when compared with its corresponding value in control group (p = 0.001) (Table 3).

Table 3. Inter and intra-group comparison between FRT values in the two studied groups measured at pre- and post-treatment

FRT (in inches)	VRT group	Control group	p-value[a]
Pre-intervention	10.42 ± 1.66	10.55 ± 1.72	0.833
Post-intervention	12.88 ± 1.38	10.85 ± 1.53	0.001
Mean changes	2.46	0.30	
% of change	23.61 ↑↑	2.84 ↑↑	
p-value[b]	0. 001	0.103	

FRT: Functional reach test; VRT: virtual reality training; a: between-group comparison; b: within-group comparison; p > 0.05 = not significant; p ≤ 0.05 = significant

Comparative analysis of (SF-36) between pre and post-program
In VRT group, there was a statistical significant decrease in the mean value of (SF-36) scores measured at post-intervention when compared to its corresponding value measured at pre-intervention (p = 0.001). While in control group, there was no statistical significant different between pre- and post-intervention (p = 0.196). The unpaired t-test revealed no statistical significant difference between the two groups measured at pre-intervention (p = 0.882) while at post-intervention it was significantly increased in VRT group when compared with its corresponding value in control group (p = 0.010) (Table 4).

Table 4. Inter and intra-group comparison between (SF-36) values in the two studied groups measured at pre- and post-treatment

SF-36 (%)	VRT group	Control group	p-value[a]
Pre-intervention	41.30 ± 12.72	42.0 ± 11.11	0.882
Post-intervention	52.39 ± 8.38	46.0 ± 14.10	0.010
Mean changes	11.09	4.0	
% of change	26.85 ↑↑	9.52 ↑↑	
p-value[b]	0. 001	0.196	

SF-36: 36 items short form questionnaire ; VRT: virtual reality training; a: between-group comparison; b: within-group comparison; p > 0.05 = not significant; p ≤ 0.05 = significant

Discussion

The current study was conducted to evaluate the effects of virtual reality training using x box Kinect sensor on the risk of falls, and quality of life among the elderly. Regarding the postural stability, the results of the current study revealed that the overall balance indices showed statistically significant improvement in the VRT group, but with no significant difference in the control group at post-intervention. The percentage of reduction of OSI in VRT group was 41.58%, while that for the control group was 1.07%. Such outcomes showed that VRT was useful in revamping the elderly overall balance performance, as shown in the reduction in OSI scores of the participants. A high score in the OSI indicates poor balance. A likely reason for such improvement is that exercise games attracted the older adults and encouraged them to participate in shifting movements of posture which ultimately led to enhancement of physical behavior and retaining their postural control. This explanation is in support with that of previous studies in that higher motivation and interest led to the awareness of balance control [20, 21]. Also, the enhancement of postural control can be attributed to improvement in muscle strength reinforcement [17, 20, 22].

FRT was used for ascertaining dynamic balance through 1-simple task. It is dependent on the analysis of stability limits without exposure to external shocks, the measurement of maximum displacement which could reach a target without losing stability. Thus, it integrates body mechanics, postural control, and perceptions and correlates the results of falling chance [23].

The results of this study revealed that the dynamic balance showed a statistically significant increase in the VRT group after training compared to the control group. The percentage of improvement of FRT in the VRT group was 23.61% and that of the control group was only 2.84%. Therefore, VRT was more effective in enhancing the elderly's' dynamic balance, thus reducing the falls risk. Again, this result is consistent with that of previous studies [17, 20, 24, 25].

The numerous changes in posture and shifting weight needed by Kinect exercise games could provide one possible explanation. Additionally, Yang et al. reported that Kinect games, coupled with specific body movements, required the user to mimic the trainer's movements on the screen, such as leaning over, abrupt posture adjustments, and weight shifting. Therefore, the exercise games helped to achieve more successful and accurate movements through instant visual and auditory feedback, in addition to postural control throughout the whole session [20].

The Kinect allows for multiple functional reactive interactions simulating reality during games. Thus, Kinect exercise games can be put under the category of functional oriented task. From the rehabilitation point of view, it is important to employ the functional activities into the rehabilitation sessions.

Various previous studies demonstrated efficacy of functional oriented exercises in reducing the age-related deterioration of mobility through improving balance, gait parameters, muscle power and endurance [26-28]. These findings support the effectiveness of VRT interventions in improving balance and reducing fall rates in elderly. And exercises of Kinect were particularly helpful to overall balance enhancement. The findings of this study, on the other hand, are contradictory to those conducted by Yu et al. [29]. They didn't find improvement in the static balance ability although the intervention group showed significant improvements in cardiopulmonary endurance and leg muscle strength. However, the authors attributed this to the different measurement equipment used in their study as they evaluated balance using a force plate system. Also, few pertinent studies on exercise games have reported similar outcomes in which no significant differences were noticed between exercise games and conventional balance training on certain areas [15, 30].

Although exercise interventions that focus on improving strength and balance are the most effective intervention for reducing falls and fall-related injuries, the participants in the control group didn't show significant improvement in OSI and FRT compared to the VRT group as the percentages of change were only 1.06% and 2.84% respectively. A possible explanation for these results is the compliance of the elderly to execute prescribed physical activities by themselves varies considerably. This explanation is aligned with those reported by Cameron et al, 2010 and Meron et al., 2012 who said that older adults do not routinely practice these

types of exercises and The conventional exercise programs are often considered tedious and boring, hence prematurely stopped [10, 31].

Regarding the elderlys' QOL, the results of this study demonstrated significant improvements in levels of general health QOL after the VRT intervention compared to the control group. The percentage of improvement of (SF-36) scores in VRT group was 26.85%, while the percentage of improvement of that in the control group was only 9.52%. These findings showed promise for the utility of VRT interventions for improving their motor ability and health quality of life.

Findings of the current study have shown that VRT can be a more effective fall prevention program through enhancement of postural stability. Also, VRT is an engaging activity for older adults and this could lead to better adherence to a rehabilitation program, which in turn may lead to optimal health benefits.

This study was limited by the lack of a long-term follow up assessment to check the effectiveness of VRT intervention on the elderlys' balance condition over a longer time frame. Also, other secondary outcomes were not measured such as Antero-psterior and Medio-lateral stability indices.

Conclusions

Virtual reality training improves the overall postural stability and general health quality of life for people aged 65 - 70 years after 6 weeks. It can help reduce the risk of falls in healthy older adults.

It is recommended to use VRT as a fall preventive intervention in the elderly. Future studies should increase the number of participants to enhance generalizability and incorporate other community groups with different lifestyles.

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