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Investigating the Effect of Virtual Reality Techniques on Balance of the Elderly

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Abstract: *Balance is one of the determining indicators of independence in the elderly. Technology has the potential to improve the quality of life, health and functional abilities of the disabled elderly. The use of virtual reality techniques is one of the novel methods of using technology for improving the quality of life and balance of the elderly by fully participating elderly in this direction. The purpose of present study was to investigate the effect of computer-based and user-based virtual reality techniques on balance of the elderly. Sample consisted of 18 people aged between 70 to 90 years old in Garmdareh, Iran who were voluntarily selected and then randomly divided into two groups of nine. Participants in the experimental group participated in designed exercises for 10 sessions (2 sessions per week), but the control group did not participate on any exercises. Static balance was measured using the sharpened Romberg test and dynamic Balance was measured by the spent time to rise and go, before and after each exercise session. The Shapiro Villex test was used in order determine the normal distribution of data, and covariance analysis was used to determine the related effect of exercises. Results of the covariance analysis showed significant effect of designed exercises on both the static and dynamic balance of the elderly ($p < 0.05$). In sum, the results of present study showed that virtual reality techniques can improve the balance of performance among the elderly.*

Keywords: *Virtual Reality, Balance, Elderly, Computer Games.*

Introduction

Elderly is an inevitable and generic stage in the natural course of human life that occurs to everyone. The onset of elderly coincides with the beginning of changes in musculoskeletal, atrial, visual and emotional systems, which can be referred to as the physiological systems involved in balance. As a result, the elderly are at serious risk of imbalance. These changes threaten the quality of life among this group of people to such degree that inhibits their daily activities (Greg, Piraeus, Kaspersen, 2000). Balance is the ability to maintain the center of gravity of the body on its own reliance level with minimal oscillation or maximum stability (Emery, 2003). Postural control or balance can be categorized into static (ability to stay in a basic state with minimal motion) and dynamic (ability to perform a task while maintaining a stable position) (Jagi, Jay and Bim, 2006). Falling is a common problem among the elderly and almost 30% of the elderly experience it at least once a year. Half of the people over 65 who experience such falls are admitted to emergency rooms, in 6 percent it leads to serious injury and even causing death in some cases (Shamuki Cook and Woolakat, MH, 2007). 19 percent of all hip fractures occur as a result of falling (Park et al., 2008), and falling is the sixth leading cause of death among the elderly (Satin 1992). Previous researches indicate that imbalance has a prominent role among the internal factors leading to falls (Silsupadol et al., 2009). The system of balance and posture control is a composite and complex mechanism that requires the coordination of three balance systems, including the visual, atrial and sensory-vision systems (Sadeghi et al., 2009). Technology has the potential to improve the quality of life, health and performance of elderly people with disabilities, as it can increase their ability to carry out a wide range of actions in their daily lives (which they have not previously been able to do). (Pew, Van Haml, 2004) and (Hilal et al., 2008). Virtual Reality Therapy (VRT) is a technique

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that employs interactive games as a source of physical therapy and has shown positive results in reorganizing the cortex, improving the quality of movements and functional mobility (Ballista, 2013). From the beginning, virtual reality applications were used for training motor functions in complex actions and tasks such as practicing surgical techniques (McCloy, 2001), simulation of flight training (Anges, 1989), and military exercises (Ritzo et al. 2005). With the decrease of the cost of computer hardware and software and the increase in the popularity of video games, they can be used for pervasive, rehabilitation and preventive purposes. The virtual reality of computer graphics integrates real-world body tracking devices, visual displays, and other sensory inputs to immerse people in computer-generated virtual environments. (Emile Camp, 2005). From this definition, two basic properties of a virtual reality system are derived, which include: immersion and interaction. Immersion refers to the stimulation of a user's various sensory channels, which is usually obtained using visual, auditory, or tactility devices. But virtual reality is an interactive part, virtual reality does not mean inactive virtualization of the virtual world, but user can interact with it, and most importantly, respond to it in real time and in the real world. Virtual reality, using its two basic features, creates an illusion in the user and creates two physical feelings within the virtual world. Certainly, this sense of presence can have a positive impact on performance in the work. (Figure 1)

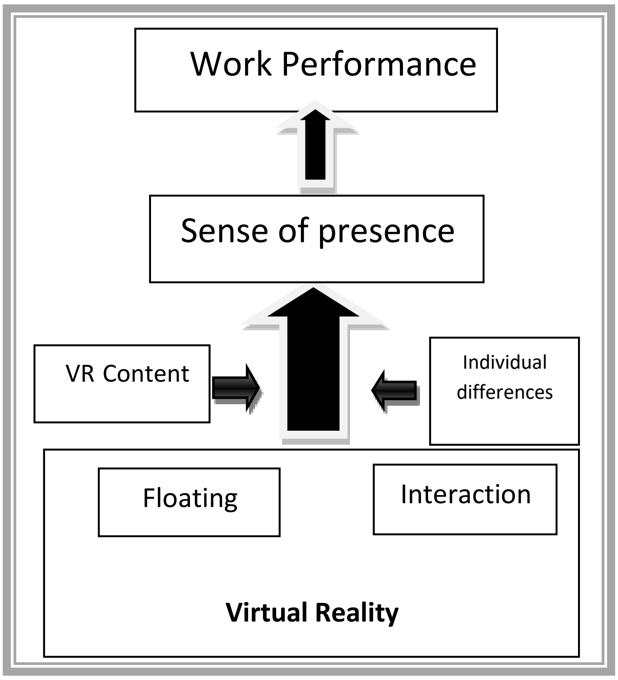

Figure (1): properties of a virtual reality system

On the other hand, artificial intelligence facilitates the design of intelligent agents able to engage in a natural conversation with humans (Nat, A, and Wollogger, p. 2008). Although virtual reality programs had applications in research and entertainment since the 1980s, virtual reality systems began to expand in the late 1990s and since have facilitated studies and contributed to rehabilitation. Various studies have suggested that virtual reality can be used as a valuable tool in treatment. For young people, for example, it has already been shown that exercising in cycling situations combined with virtual reality environments has brought more pleasure and reduced fatigue for cyclists (Planet et al. 2003) moreover it has enhanced progress in cognitive function of people with brain damage (Greeley et al. 1999). For the elderly, interacting with the virtual environment can control the condition that results in falling incidents, by triggering sensory signs responsible for maintaining balance and position (Virgo and McConnell, 2006). In one study on adults, exergaming intervention (for four weeks of practice) improved the static balance parameters more than a traditional balance program (Broomes et al., 2008). Exercises, performed with a virtual reality technique, improved hand movements in post-stroke patients, resulting in improvement in fingers, thumb, and a wide range of movements. The researchers also found that progress in the virtual world is transmitted to the real-world progress, and showed that virtual reality-based therapy has the ability to encourage more intensity in workout and participation that is comparable to conventional interventions (Myrins et al., 2006). It is believed that the distinct value of virtual reality training is due to the adaptation of visual information and a sense of depth during the learning, and as a result the elderly are faced with the real environment only after improving their sense of body (Bayson et al., 2007). In addition, the findings suggest that virtual reality education can cause changes in the sensory motor cortex in patients with stroke (Yu, Sh, et al., 2005). However, virtual reality exercises for elderly adults have not been widely studied, which this study aims to address this issue.

Research Method

Sample of this study consisted of 18 (male and female) members of the Association of Retirees in the city of Gomordeh, aged between 70 to 90 years old, whom fulfilled the entry criteria (including natural vision, ability to stand for at least one minute And walking distance of 10 meters independently or with a conventional cane, the ability to follow simple commands and lack of illness or use of drugs that affect the balance). They were voluntarily selected and then randomly divided into two groups of 9: The experimental group and control group. Sampling for this study was according to convenience method. After selection, a detailed description of the objectives and methodology of the research was handed to them and they were asked to consent to the written consent of participation in the study.

Data Collection Tools

Static Balance was measured by sharpened Romberg test with statistical reliability of 0.91-0.99 for open eyes and 0.77-0.76 for closed eyes (through closed blind test (through re-test by Franchgnoni et al., 1997) and Dynamic balance measurements were made by examining the time of ascent and going with a reliability of 0.99 (through a re-test by Chanler et al., 1990) and predicting the risk of falling was also measured before and after each training period (Paula and Kay Et al., 2000).

In the performance of the sharpened Romberg test (static balance measure), subjects were bare footed, while one of the legs (superior leg) was ahead of the other leg, and arms were placed crossed over the chest. So that the heel of the front foot would touch the toes of the back foot. The duration which this posture was kept with eyes open and closed was considered as subject's score (Paula et al., 2000). In the event of any errors (excessive swinging, loss of balance, eye opening and shaking hands) while maintaining the balance, a negative score was recorded for the subject (Figure 2).

Figure (1): sharpened Romberg test

To evaluate dynamic balance, ascent and going time tests were used as follows:

The test consists of five steps that the subject must perform in succession. In order to run this test, a chair without handle is placed at a distance of three meters from an obstacle (end of the path) (Fig. 3).

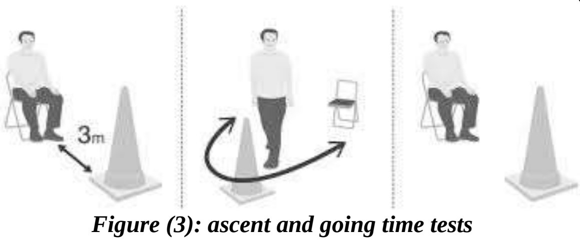

Figure (3): ascent and going time tests

The subjects were then asked to get up from the chair without the help of their hands and go back to the chair after walking the three meters distance to obstacle (Paula et al., 2000, and Terrasa et al. 2004).

Subjects were asked to do this in the fastest possible way without running. To get familiar with how the test was performed, the subjects practiced three times before any score was recorded. The subjects then performed tests thrice, and the average of these three times were documented as their records. The five steps of the test are as follows: 1. getting up from the chair 2. Walking the three-meter route 3. Turning around the obstacle 4. Returning the path of three meters in the second step 5. Seating on the chair. The person moves with the go command and the examiner calculates the time from start to finish. Duration time of this test is documented as the subjects scores (Paula et al., 2000). Akbari and Kamrani et al. (2010) showed that the test had a reasonable construct validity (with a mean of 0.68) for the elderly (t=11/84 & P = 0/0001). Also, the mentioned test has a good time reliability (r = 0.91 and P = 0.0005). Additionally, the normal time to run the test for the elderly is less than 10 seconds (1, 2, and 3)

Virtual Reality Device

Applying the VR technique, the VR Shinecon SC-G06E (Figure 4) virtual reality device was used with the MATE 7 mobile hardware and the Balance-Cardboard VR software (Figures 5 and 6).

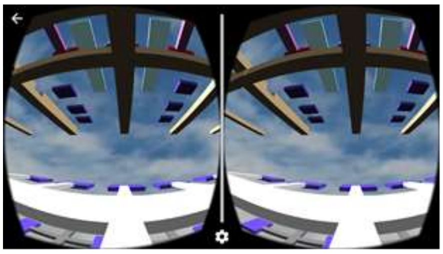

Figure (4): Balance - Cardboard VR Software

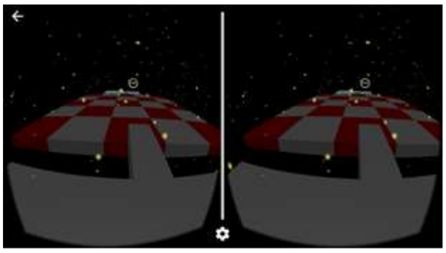

Figure (5): Balance - Cardboard VR Software

Figure (6): VR Shinecon SC-G06E Virtual Reality Headset

- **First step: Performing a pre-test**
- **Second step:** Applying the independent variable to the first group was a virtual reality training session consisting of 2 sessions per week for 10 sessions 5 weeks and each session was 30 minutes.
- **Third step:** Performing post-test, re-measurement of static balance using sharpened Romberg test and dynamic balance with ascend and going test.

Virtual Reality Technique Intervention

For the virtual reality program, the Balance-Cardboard VR software was used, which was chosen because its engagement with physical activity, balance skills, physical coordination and visual coordination and coordination of large movements. Initially, we started the sessions after adjusting the headset and the program, as well as informing the participant about the steps. In this software, there are virtual pathways built on a height. The participant starts to move with the push of a button on his headset, while by rotating physically the participant can see 360 degrees of the environment. After assessing the situation, the participant should move in the right direction. If the participant goes out of the way, the feeling of a fall will be induced through the software.

Additionally, the used headset is equipped with headphones able to transmit Dolby sound to participants. After getting to the end of the chosen pathway, the participant should reach a globe to finish this stage and begin the next step. Each step that goes through is more complex and stressful with more sounds.

During this session, the entire traveled route and every movement of participants were monitored by computer. We also used motivational words such as: "Well done, you can do it, very well, go ahead, go get it and ...".

Limitations of the study

1- Lack of regular physical exercise was a requirement to this study and participants were also reminded not to engage in such activities during their participation. However it was not possible to monitor all their activities during this period and the possibility of unwanted existing physical exercise cannot be ruled out entirely.
2- Obtaining a large sample was unfeasible.

Statistical Methods

Covariance analysis (ANCOVA) was used to compare the effect of training interventions. The pre-test scores were entered as an interventional variable. SPSS statistical software (version 21) with Significance level of α = 0/05 was used.
However, before any statistical inference regarding the effects, the reliability of the statistical model of the normal distribution of error was investigated using the Shapiro Villex test and the similarity of error variances between the groups with Levin's test. Covariance analysis was also used to determine the exercise related effects.

Results

Demographic information related to the age of subjects is presented in Table 1. The results of ANOVA test showed that there is no significant difference between the groups in the age factor. Table 2 shows the mean and standard deviation of the two groups in this study in different situations.

Table (1): Demographic Information

Group	Quantity	Min	Max	Mean± Standard Deviation
Male	11	70	90	81.54 ± 7.07
Female	7	70	84	76.42 ± 5.02
VR	9	70	86	77.55 ± 5.85
Control	9	70	90	81.22 ± 7.79

Table (2): Mean and Standard deviation of the two groups

Mean and standard deviation of Static and Dynamic Balance (seconds)						
p	After		Before		indicator	group
	SD	Mean	SD	Mean		
P < 0.0001	10.1495	131.71	3.151	105.044	Static balance with open-eyed	Virtual reality
P = 0.2015	3.1583	26.84	2.48	25.06	Static balance with eyes closed	
P = 0.0092	1.6	7.4	1.4	9.5	Dynamic balance	
P = 0.1581	9.75	114.25	4.253	109	Static balance with open-eyed	Control
P = 0.3182	2.23	24.76	2.84	26	Static balance with eyes closed	
P = 0.6083	2.15	9.2	1.9	8.7	Dynamic balance	

In pre-test and post-test, both open and closed eyes were taken for static equilibrium. Covariance analysis was used for the effect of training interventions. In both pre-test and post-test, both open and closed eyes were measured for static balance. Covariance analysis was used to evaluate the effect of training interventions. Earlier, homogeneity of variances was confirmed with the help of the Levine test. The results of the test showed a significant difference between the studied groups in the static balance of the elderly with open eyes (P <0.0001). Accordingly, the virtual reality group had better performance with open eyes in static balance (P = 0.1581) compared to the control group. Also, there was no significant difference in the static balance with closed eyes of the virtual reality group in comparison to post-test and control group (P = 0.2015), and (P = 0.3182). In dynamic balance, covariance analysis was used. Levine test results showed a significant difference in covariance analysis between the groups in the dynamic balance test scores (P = 0.0092). To determine the exact location of the differences, Bonferron's post hoc test was used. Accordingly, there was a significant difference between the virtual reality group and the control in open-eye balance and dynamic balance (P = 0.002). In pictures 7 to 9 you will see post-test and pre-test charts and comparison between groups in each of the balances.

Discussion

The purpose of this study was to investigate the effect of virtual reality techniques on the static and dynamic balance of the elderly. For this purpose, 18 elderly people were selected from volunteers and were divided into two groups of virtual reality and control. The overall study results showed the positive effect of virtual reality in both static and dynamic balance states. We will continue to explain the results of the research. According to Pew and Van Hamel in 2004, technology has the potential to improve the quality of life and improve the health and performance of elderly people with disabilities, as it can lead to an increase in their ability to carry out a wide range of actions in their daily lives (which they have not previously been able to do), and the results of the verifying research have unveiled the validity of this potential. Also confirming this potential is Balista's research in 2013, suggesting that virtual reality treatment (VRT) is a technique that uses interactive games as a source of physiotherapy and has shown positive results in re-organizing the cortex, improving the quality of exercise and applied mobility. The important thing to note in this study is that interacting with the virtual environment can enhance the posture control and stimulation of the sensory symptoms, and is thus consistent with the research conducted by Virgo and McConnell in 2006. Moreover, in 2006, Merrians et al. found that advances in the virtual world are transmittable to real-world advancement, as shown by current study, the virtual world progress in static and dynamic balance has also been transmitted to the real world and significantly changed test results. Additionally, the results show improvement of response time (Goldstein et al., 1997), (Dostmann et al., 1992), (Clark et al., 1987), cognitive function (Freys et al., 1994), Logical decision making, motor visual coordination (Drew and Waters J, 1986), attention and concentration (Wiseman S, 1983), self-esteem and overall quality of life (Goldstein et al., 1997) and (Lange, Flynn, Ritzo, 2009) in middle aged people who play video games.

Conclusion

According to the results of this study, we can state that modern tools such as virtual reality techniques have been used to improve the quality of life, especially for the elderly. Based on the results of this study, it is recommended that decision makers of this area consider these practices, first and foremost as a preventing factor in the declining elderly balance by strengthening their motor systems and then as a helping mechanism to restore balance in the elderly with balance problems. Interaction with virtual reality systems require concentration and attention from the user, but it should be noted that these systems can also encourage the users with a disability to move and to continues to use the system, creating a sense of success and progress in the user and encouraging him to perform these functions in the real world. The use of these systems has led to the creation of a real, affordable and accessible environment for practicing rehabilitation activities in home which facilitates positive conditions of being safe, tailored to the needs, abilities and disabilities of the patient, which ultimately has led to improved performance, increased confidence and quality of life for elderly people with disabilities. The virtual reality device must possess the ability to interact with users and the ability to collect information about the patient's physical condition and movements and to provide feedback through a user-friendly interface. The patient should be able to communicate with the system as easily and as much as he can, and the system should also monitor and track the progress of the patient and further the progress of components involved with recovery, based on the data collected from the patient, the progress made so far and the intention of the therapist.

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