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THE EFFECT OF BALANCE EXERCISES BASED ON ACTIVE VIDEO GAMES ON STATIC AND DYNAMIC BALANCE OF SEDENTARY FEMALE STUDENTS

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Aim. The aim of this study was to investigate the effect of balance exercises using active video games on static and dynamic balance of sedentary female students. **Materials and Methods.** In this semi-experimental study with a pre-test--post-test design, 24 sedentary female students in Izeh city, aged 18–29, were purposefully selected. After performing the pre-test, they were randomly divided into two equal groups of balance exercises based on active video games (Xbox) and the group of traditional balance exercises (TE). The duration of the training was four weeks, two sessions per week of twenty minutes (totally eight sessions). The intervention of the Xbox group was performed by the Kinect 360 device, and the TE group performed traditional balance training. Data analysis was performed at the level of $p \leq 0.05$. **Results.** The within-group results showed both of Xbox group and TE improved static and dynamic balance. The between-group results showed that there was no significant difference in static balance between the two groups, but there was a significant difference in dynamic balance between the two groups and this significance was in favor of the Xbox group. **Conclusions:** According to the results of the present study, it seems that virtual reality exercises can be used as a new and attractive training method as an effective intervention in improving balance, especially dynamic balance.
Keywords: active video game, static balance, dynamic balance, virtual reality.

Introduction

Today, many children and adults use video games for entertainment purposes. A large fraction of these individuals needs to have physical activity [34]. They are games that require essential movements by the player, unlike conventional video games that are played by pressing buttons. These games are a common technique to encourage individuals to achieve a higher level of physical activity to improve health among those who are at a high level of inactivity [45]. Postural control lays the ground for many motor skills and represents a perfect condition for routine activities. It is typically defined as the ability to maintain, achieve, or revive balance during a state or activity [29]. A number of instruments have been introduced to contribute to postural control. Several research teams recently utilized such methods for balance exercises, reporting positive findings of their effects on balance [15]. Active video games have been increasingly considered as a technique of balance training in the game and media industries [6]. These games were played using Kinect sensors. Previous studies have shown that kinematic measurement using Kinect sensors to measure postural control is accurate and reliable [12].

The Covid-19 pandemic appeared in December 2019, in Wuhan, China [50]. Since the COVID-19 virus has been present all around the world, authorities implemented different protective measures, such as closing schools and universities and banning travels, cultural and sports events, and human gatherings [27]. These measures led to spending longer time watching screens and had consequent negative impacts on physical health, sleep cycle, quality of life, and motor behavior. Therefore, a compatible physical exercise at home during the pandemic, which may last longer, can mitigate the negative physiological and mental impacts of sedentary behavior [28]. As a result, physical activity motives can be an efficient approach to keep adolescents active at home. Active video games are very popular, and some of these games may sufficiently increase the level of physical activity to influence the health and fitness of adolescents. These games can facilitate joy, and research has shown that increased joy is associated with physical activity among girls [4]. Furthermore, falling becomes more likely and more intensive as individuals grow older [31]. Falling is a health condition that needs preventive intervention and research [35]. It can occur at any age rather than being specific to the elderly [40]. However, regular exercising to enhance the ability to maintain balance and reduce the risk of falling and hurt has been significantly accepted [16]. Since most adults are working and educating, they somewhat have to be sitting for a large portion of the day. It is important to realize the possible adverse impacts of immobility on health [21]. These games have become popular as an instrument to improve the ability to maintain balance in the past decade [26]. Balance is necessary for daily and sports activities and is often endangered after an injury [24]. Freiwald, Papadopoulos, Slomka, Bizzini and Baumgart [18] mentioned the importance of training balance in scientific curriculums in order to avoid injury and improve performance. The use of active video games is a balance improvement method. These games represent a combination of player motion, attractive entertainment, performance feedback, and social interaction through a competition. They enhance motivation and increase the following of exercises among children and adults [3].

Most studies in the literature focused on the use of different technologies to enhance balance in elderly populations [23, 33, 36], while only few studies investigated sedentary students. To the best of the author's knowledge, the most of the studies employ Nintendo Wii Fit rather than Microsoft Xbox Kinect technology. Therefore, it is expected that balance exercises using Xbox Kinect device leads to higher balance improvement among sedentary girls as compared to traditional exercises since Kinect is a greater motivator of physical activity.

Materials and methods

Participants

The present semi-empirical study is applied research in terms of objectives and adopted a pretest-posttest design. Twenty-four participants were selected from female students at the age of 18–29 with a sedentary lifestyle in Izeh, Iran, by using purposeful sampling (those with a score below 600 in the international physical activity questionnaire (IPCQ). Then, the participants were divided into two equal groups: 1) the group of balance exercises based on active video games and 2) the group of traditional balance exercises. The participants voluntarily participated in the study and signed a prior written consent. Also, they were allowed to withdraw from the study. The present study was approved by the Committee of Research Ethics at the Shahid Chamran University of Ahvaz, Iran.

Tools

Xbox 360 Console with a Kinect Device. This console uses motor sensing rather than a joystick. It stores information, color, and depth, creating a spot cloud of colorful points. The software can calculate the three-dimensional positions of points and establish a 3D image of the environment. This technology has a Kinect video recorder to record facial expressions and a microphone to detect and locate sounds. Each movement is an input to the console.

International Physical Activity Questionnaire (IPCQ). IPCQ was used to measure the physical activity of the participants. It involves questions on the physical activity status and classifies participants into low, medium, and high physical activity groups. This questionnaire measures physical activity in the past seven days, detecting the intensity of activities based on the final score. The energy of the total activity in the past seven days is calculated based on IPCQ, where individuals with total weekly energy below 600 MET/cal/week is classified as low, energy between 600 to 3000 MET/cal/week is classified as medium, and energy above 3000 MET/cal/week is classified as high. IPCQ gives a score of 3.3 METs to walking, 4 METs to medium activity, and 8 METs to intense activity. One metabolic equivalent (MET) is equall to the energy consumed for one minute of resting. To calculate the total physical activity per week, the low (days×minutes×MET), medium, and high activities in the past week are summed up.

Flamingo Balance Test (FBT). FBT was used to measure static balance. It involves a static status where the participant stands on a flat surface without shoes on, puts their hands on the hips, and raises the non-support leg (preferred foot) and holds its foot close to the knee of the support leg (non-preferred leg). The participant performs this procedure for a while. Then, they raise the heel off the ground to keep balance on the toes. The stopwatch starts once the heel is raised off the ground. The time during which the participant keeps balance on the toes is recorded as the score, and the stopwatch stops once an error occurs. Errors include taking the hands off the hip, support leg motion in any direction, the separation of the non-support foot from the knee, and touching the ground with the support foot.

Timed Up and Go (TUG) Test. The TUG test was used to measure dynamic balance. It involves six stages. A chair without an armrest is used 3 m from an obstacle (the end of the path). Then, the participant was asked to stand up without using their hands and go three meters and then return back on the chair. The participant was asked to go as fast as possible without running. The process was practiced three times by the participants before the test. Then, the participants performed three rounds of the TUG test, recording the average value as the final result. The six stages of the test include: 1) standing up, 2) going a path of three meters, 3) revolving the obstacle, 4) returning to the chair, 5) revolving the chair, and 6) sitting on the chair. The participant starts once they are told to go, and the time was recorded as the score.

Procedure

The objectives of the study and the FBT and TUG tests were explained to the participants. Then, the participants signed a written consent before undergoing the pretest and FBT and TUG tests. The participants were randomly divided into two groups based on their scores: 1) active video game balance exercise group and 2) traditional balance exercise group.

Active video game balance exercise. The participants played the active Zumba fitness video game by the Xbox 360 console with Kinect in the acquisition stage. Zumba was selected to be played since it consists of a variety of movements, including static and dynamic balance exercises. The game was played for four 5-min rounds, with a 2-min interval between the rounds. The participants stood in front of the Kinect camera and started playing once they saw the screen. The exercises were performed for four weeks, two sessions a week. The test took a total of eight weeks. The participants played for 20 min in each session.

Traditional balance exercise. The participants performed static and dynamic balance exercises. The static exercises included 1) standing on one foot for 10 s and then standing on the other foot (two rounds for each foot), (b) standing on the toes of both feet for four rounds, each round for 10 s, (c) standing on both feet with eyes closed and turning the head right and left for 10 s, (d) standing on both feet with eyes closed and turning the head up and down for 10 s, (e) swan balance exercise, standing on both feet for 10 s. The dynamic balance exercises, on the other hand, included (a) opening the hips to the side, each five times, (b) holding a small dumbbell in the hand and bending forward to bring the dumbbell onto contact with the ground while opening the hip to the back, side hip five times, (c) boxing the hips to the sides for four come-and-go rounds, (d) raising a hand and the opposite foot for both sides for ten times, and (e) touching the toes forward, sideward, backward, three times for each foot. The traditional balance exercise group has the same exercise duration as that of the active video game balance exercise group.

Statistical Analysis

To analyze the data, descriptive statistical methods were employed to calculate the centrality and dispersion indices. Concerning inferential statistics, the Shapiro–Wilk test was carried out to evaluate the natural distribution of the data, whereas the mixed-ANOVA was used to compare the two groups in the test and post hoc independent and dependent t-tests with modified α based on the Bonferroni method. The data were analyzed at a level of $p \leq 0.05$. The index η^2 was employed to measure the effect.

Results

Table 1 reports the means and standard deviations of height, age, body mass index (BMI), and physical activity level data of the participants in the two experimental groups (where XBX represents the active video game group, whereas TE stands for the traditional exercise group).

Table 2 provides the means and standard deviations of the dependent variables (i.e., static and dynamic balance) of the participants in the two groups for the pre-test and post-test stages.

The distribution of the data was evaluated using the Shapiro – Wilk test. It was found that the data had a normal distribution ($p > 0.05$). Then, Levene's test was performed to ensure examine

Table 1

Means (Standard deviations) of demographic indices of participants

Group	Height (CM)	Weight (Kg)	BMI	MET
XBX	161.83 (2.94)	59 (7.39)	22.49 (2.42)	< 600
TE	162.83 (3.15)	58.83 (7.62)	22.51 (2.41)	< 600

Note. XBX – Active video games, TE – Traditional exercise, BMI – Body mass index, MET – Metabolic equivalent.

the homoscedasticity of variance ($p > 0.05$). Therefore, it was found that parametric tests could be applied to verify the hypotheses.

Table 2

Means (Standard deviations) of static and dynamic balance scores in pre-posttest

	Static balance		Dynamic balance	
Group	Pre	Post	Pre	Post
XBX	5.55 (2.38)	9.42 (2.75)	8.46 (0.81)	5.52 (0.75)
TE	7.65 (2.86)	10.96 (3.46)	8.05 (2.11)	7.22 (2.20)

To study the static balance differences between the groups in the pre-test and post-test, a total of 2 (test stages) × 2 (groups) combined ANOVAs with repeated measure were carried out, as shown in Table 3.

As can be seen in Table 3, the main test effect ($p = 0.0001$) and the dual group×test interaction ($p = 0.07$) were found to be significant. To further investigate the interaction effect, the present study performed two independent t-tests for evaluating the differences between the groups in the pretest ($t_{(22)} = -1.94$, $p = 0.06$) and post-test ($t_{(22)} = -1.19$, $p = 0.24$) along with two dependent t-tests for examining the pretest-posttest differences of the active video game group ($t_{(11)} = -5.82$, $p = 0.0001$, MD = –3.86) and traditional exercise group ($t_{(11)} = -11.39$, $p = 0.0001$, MD = –3.31).

It was found that the pretest-posttest mean differences of both groups were significant ($p = 0.0001$) in favor of the post-test; that is, both groups improved in static balance performance. As can be seen, the traditional exercise group had a significant mean static balance score difference between the pretest (7.65) and posttest (10.96) ($p = 0.0001$). Furthermore, the difference in the mean static balance score was significant ($p = 0.0001$) between the pretest (5.55) and post-test (9.42) for the traditional exercise group. Overall, no significant difference in static balance was found between the two intervention groups (i.e., XBX and TE). However, both groups showed higher performance in the posttest than in the pretest.

To evaluate the dynamic balance difference between the groups in the pretest and posttest, a total of 2 (groups) × 2 (test stages) ANOVAs with frequent measurement were performed, as shown in Table 4.

As can be seen in Table 4, the main effect ($p = 0.001$) and dual group × test interaction ($p = 0.0001$) were found to be significant. To further evaluate the interaction effect, the present work performed two independent t-tests to measure the differences between the two groups in the pretest ($t_{(14/21)} = 0.63$, $p = 0.53$) and posttest ($t_{(13/56)} = -2.53$, $p = 0.02$) along with two dependent t-tests to examine the difference between the pretest and posttest for the active video game group ($t_{(11)} = 11.49$, $p = 0.0001$, MD = 2.94) and the traditional exercise group ($t_{(11)} = 6.08$, $p = 0.0001$, MD = 0.82). It should be noted that variance inequality statistics were used for the data

Table 3

The results of mixed-ANOVA 2 × 2 for considering of differences between two groups in two stage tests on static balance task

	SS	df	MS	F	Sig.	η_p^2
Test	177.06	1	177.06	184.56	0.0001	0.89
Test × Group	3.33	1	3.33	3.47	0.07	0.13
Error (Test)	21.10	22	0.95			
Group	51.31	1	51.31	3.33	0.08	0.13
Error (Group)	338.35	22	25.38			

Note. Here and in Table 4 SS – Sum of squares, df – Degrees of freedom, MS – Mean of squares, η_p^2 – Square of partial eta.

Table 4

The results of mixed-ANOVA 2 × 2 for considering of differences between two groups in two stage tests on dynamic balance task

	SS	df	MS	F	Sig.	η_p^2
Test	42.54	1	42.54	169.20	0.0001	0.88
Test × Group	13.40	1	13.40	53.32	0.0001	0.70
Error (Test)	5.53	22	0.25			
Group	4.98	1	4.98	0.99	0.33	0.04
Error (Group)	110.52	22	5.02			

reported in Table 4 since Leven's test showed significance (i.e., the variance equality presumption was rejected). The difference between the two groups was insignificant in the pretest ($p = 0.53$) and significant in the posttest ($p = 0.02$). This suggests a significant difference between the two intervention methods in improving dynamic balance performance. According to the mean scores (Table 2), it can be said that the active video game group had higher performance (52.5) than the traditional exercise group (22.7).

Moreover, the mean score differences of both groups between the pretest and posttest were significant ($p_s = 0.0001$) (posttest > pretest). That is, both groups improved in dynamic balance performance from the pretest to the posttest. As can be seen, the difference in the mean static balance score between the pretest (8.05) and posttest (7.22) was significant for the traditional exercise group (0.0001) (posttest > pretest). Furthermore, the difference in the mean dynamic balance score between the pretest (8.46) and posttest (5.52) was found to be significant for the traditional exercise group ($p = 0001$) (posttest > pretest). Overall, there was a significant difference in dynamic balance between the two intervention groups (i.e., XBX and TE). Both groups improved in performance from the pretest to the posttest. Also, the active video game group outperformed the traditional exercise group.

Discussion

The present study sought to explore the effects of active video game-based balance exercises on static and dynamic balance among female students. The results revealed that active video game exercises influenced the static and dynamic balance of female students. The findings were found to be in agreement with Cheung, Maron, Tatla and Jarus [10], Demir and Akin [14], and Wang, Wang and Shadiev [44]. According to the results, virtual reality-based exercises improved static balance since the participants adjusted their gestures based on the feedback of the system [44, 46]. According to Brumels, Blasius, Cortright, Oumedian, and Solberg [7], video game-based balance programs are less difficult and more attractive and entertaining than traditional exercises. On the other hand, there is an increasing concern that children and adolescents are sedentary and have insufficient activity to be healthy. Considering sedentary behaviors as a changeable risk factor for lifestyle-related disease, the development of video games may encourage physical activity in sedentary time [30]. Based on the model of smooth performance through playing games, a theoretical framework can be established to ensure the cognitive and emotional engagement of a participant in the game, which is necessary to successfully perform video games in training curriculums [38]. However, the findings were observed to be inconsistent with Chanpimol [9], who suggested that their observations may might have been influenced a potential ceiling effect. Moreover, vestibular disorders such as vertigo, clumsiness, and imbalance are common with high frequency and intensity among people with chronic brain damage [17]. Active video games train complicated movements that require high acceleration, coordination, and carefulness [41]. However, as mentioned, people with chronic brain damage suffer from vestibular disorders and are likely not to properly play active video games that require high coordination. The present study showed that exercises based on active video games improved dynamic balance among sedentary female students. This finding is consistent with Kim, Son, Ko and Yoon [22], Szturm, Betker, Moussavi, Desai and Goodman [39], and Ustinova et al. [41]. Deci and Ryan [13] suggested that immediate, positive feedback during participation in an activity could lead to increased intrinsic competence and motivation. Physical activity is more likely to be continued by people with higher self-confidence. Based on observational learning theory [1], individuals imitate the pattern observed on the screen by cognitive evaluation. Thus, learning can occur when observing a behavior and its outcomes. Also, Vernadakis, Derri, Tsitskari and Antoniou [42] and Brumels et al. [7] concluded that the enjoyment score was higher in the Xbox group than in the traditional exercise one. Therefore, they found that Xbox-based balance programs were more enjoyable than traditional exercises. Bieryla and Dold [5] showed that a course of exercises based on active video games did not improve dynamic balance, which is inconsistent with the finding of the present study that a course of active video game exercises improved dynamic balance. They suggested that this insignificance may have arisen from the ceiling effect. Also, they employed Nintendo Wii Fit for the active video game group. They suggested that Wii Fit may not improve dynamic exercise since the participants had to put their feet on the balance plate. This static foot situation may not lead to more dynamic activity. Also, they argued that participants may not completely challenge themselves during the exercise due to the fear of rushing into the lead.

The present study found that traditional exercises improved static balance. This finding is in agreement with Yaggie and Campbell [47]. Improved static balance may be attributed to the fact that the central nervous system receives information from different neuroreceptors (e.g., sensory receptors, visual system, and vestibular system) and integrates them to make the best possible response. Moreover, exercise-increased nervous consistency (e.g., enhanced nervous system activation, enhanced synaptic communications, and reorganization in the somatosensory cortex), decreased neuroinhibitor reflexes, and diminished impulse transmission resistance in neural pathways are other explanations for improved static balance. They improved static balance among female students in traditional exercises in the present study. It was also found that the traditional exercises improved dynamic balance. This finding well agrees with Cerrah et al. [8]. Gurkan et al. [20] suggested that long-term training in healthy adolescents improved dynamic balance. They argued that this improvement could have stemmed from the increased muscular power. Improved balance is valuable for not only public health but also for preventing domestic and sports injuries. The findings revealed no significant difference in static balance between active video game exercises and traditional exercises. This finding is consistent with Vernadakis et al [43]. An explanation can be the fact that Xbox balance programs are task-based and require solving a problem. These characteristics increase behavioral changes and physical power growth in adolescents. Another possible explanation can be the fact that Xbox enables students to be active participants in the exercise [43]. Moreover, the characteristics and frequency of Xbox feedback to students on awareness of performance and awareness of the outcomes can be another contributor to balance. Added feedback has been known as awareness of performance or awareness of outcomes to learn motor skills [37]. Static balance improved in both the video game and traditional exercise groups, but the groups were unexpectedly found to have no difference in static balance. This can be attributed to the fact that Xbox trains complicated movements that require higher acceleration, coordination, and accuracy than standing activity [41]. Thus, the video game group seems to more improve in dynamic balance as compared to the traditional exercise group that improves in static balance. As a result, video game exercises can lead to a greater improvement in dynamic balance than in static balance.

The findings demonstrated a significant difference in dynamic balance between active video game exercises and traditional exercises (Xbox had a higher dynamic balance). This finding is in agreement with Cho, Lee and Song [11], and Yang, Hsieh, Chen, Yang, and Lin [48]. According to Brumels et al. [7], improved dynamic balance in the traditional exercise group may have stemmed from a training effect of these activities [7]. According to previous studies, balance skill improvement can be suggestive of the occurrence of learning mechanisms with characteristics such as diverse and repeated sensory feedback in the virtual environment [49]. Moreover, performance and feedback have been reported as the most important indicators of motor improvement [25]. You et al. [49] reported changes in the central nervous system following virtual reality interventions. They found evidence of increased activity in the somatosensory cortex and reduced activity in other areas after video game exercises. These findings support the theory of smooth performance in games that players immerse in the video game and perform tasks for their intrinsic motives. Smooth performance enhances self-confidence and self-efficacy. According to Bandura's self-efficacy theory, individuals with higher self-efficacy are more committed to their exercises than others [2].

Overall, it can be concluded that active video games improve static and dynamic balance performance among sedentary female students. In contrast to traditional exercises that induced poor motivation to continue exercising, active video games are very entertaining, appealing, affordable, and accessible. Due to the Covid-19 pandemic, a huge number of individuals adopted domestic entertainment and began playing video games to avoid pandemic stress and have fun in 2020. From March 16 to March 22, 2020, a total of 158 physical games were sold in the world. This 82% rise in the sales of games in a week stemmed from the increased use of popular active video games [19]. The World Health Organization (WHO) detected this significant interest in active video games and evaluated these games to prevent the spread of the virus. Today, WHO has begun broadcasting messages with the large, international game industry to reduce the spread rate of Covid-19 [32]. These recommendations indicate that this large international organization keeps the game industry under close observation.

The present study encountered limitations in the timely cooperation of all the participants at the scheduled times. The study was conducted under all relevant preventive protocols due to the Covid-19 pandemic. Furthermore, the effects of participant characteristics, such as high excitement and boredom, could not be completely controlled by the author.

Finally, considering the positive effects of active video games on static and dynamic balance, sports mentors and trainers are recommended to incorporate such games into their curriculums to improve static and dynamic balance. Also, researchers are recommended to measure the effects of this intervention method on static and dynamic balance using a large sample size. Since balance is crucial for children and the elderly, it is suggested that future works conduct similar studies on these age ranges. Moreover, since balance evaluation using advanced laboratory equipment would yield more accurate and more reliable results, it is suggested that equipment such as force plates and the Biodex balance system is employed in order to measure balance.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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ВЛИЯНИЕ УПРАЖНЕНИЙ С ИСПОЛЬЗОВАНИЕМ ВИДЕОИГР НА СТАТИЧЕСКОЕ И ДИНАМИЧЕСКОЕ РАВНОВЕСИЕ У СТУДЕНТОК, ВЕДУЩИХ МАЛОПОДВИЖНЫЙ ОБРАЗ ЖИЗНИ

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Цель. Целью исследования было изучить влияние упражнений с использованием видеоигр на статическое и динамическое равновесие у студенток, ведущих малоподвижный образ жизни. **Материалы и методы.** Данное исследование носит полуэкспериментальный характер и требует регистрации показателей участников до и после выполнения экспериментальных упражнений. В исследовании приняли участие 24 студентки г. Изе в возрасте от 18 до 29 лет, ведущие малоподвижный образ жизни. После выполнения входного тестирования все студентки были поделены случайным образом на две равные группы в зависимости от характера используемых упражнений: упражнения на основе видеоигр (Xbox) или традиционные упражнения на равновесие. Продолжительность программы упражнений в каждой группе составила 4 недели (2 раза в неделю, 20 минут, всего 8 занятий). В группе Xbox упражнения были выполнены с использованием устройства Kinect 360, контрольная группа занималась по стандартной программе с использованием традиционных упражнений на развитие равновесия. Статистический анализ выполнен на уровне значимости $p \leq 0,05$. **Результаты.** Данные, полученные внутри групп, продемонстрировали улучшение показателей статического и динамического равновесия в обеих группах. Межгрупповое сравнение не позволило обнаружить статистически значимые различия показателей статического равновесия, при этом статистически значимые различия были зарегистрированы для показателей динамического равновесия, которое было лучше у участников группы, выполнявших упражнения с использованием Xbox. **Заключение.** По результатам настоящего исследования можно сделать вывод, что использование упражнений с применением технологий виртуальной реальности может рассматриваться как новый и технически привлекательный метод развития навыков равновесия, в особенности динамического равновесия.

Ключевые слова: *подвижные видеоигры, статическое равновесие, динамическое равновесие, виртуальная реальность.*

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