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THE EFFECTS OF VIRTUAL REALITY TRAINING ON BALANCE AND SPEED-AGILITY IN OBESE CHILDREN: A RANDOMIZED CONTROLLED TRIAL

ORIGINAL ARTICLE

ABSTRACT

Purpose: The aim of the study was to examine the effects of virtual reality training on balance and speed-agility in obese children.

Methods: The study included 34 obese children at the ages of 9-11. Participants were divided into training and control groups using the simple randomization method. The participants in the intervention group (n=17) were taken into virtual reality training for 6 weeks. No treatment was applied on the control group (n=17). Balance was assessed by the Flamingo and Y balance tests. Speed-agility was assessed by the Bruininks-Oseretsky Test of Motor Proficiency-Brief Form-speed-agility sub-test. The physical activity enjoyment levels of the children in intervention group were assessed by the Short Form-Physical Activity Enjoyment Scale.

Results: Before the study, the groups were similar in terms of the investigated variables (p>0.05). Speed-agility scores and Y balance test anterior, posterior-lateral and mixed reaching distances of the children in intervention group significantly increased after the training in comparison to their pre-training results (p<0.05). While the Flamingo balance test results significantly increased from pre-training to post-training (p=0.001), considering along with the 95% CI, the increase was found to be insignificant (-0.42—7.42). In intervention group, except for the Y balance test anterior and posterior-medial reaching distances, static and dynamic balance and speed-agility clinical effects were large (r≥0.5). All participants in intervention group stated that they enjoyed virtual reality training to the highest degree (95% CI:25.0 —25.0).

Conclusion: Virtual reality training in obese children is effective in improvement of balance and speed-agility, and it is an enjoyable option of physical activity. The large randomized controlled studies with long-term trainings and follow-up are recommended.

Keywords: Postural Balance, Child, Obesity, Therapeutics, Virtual Reality

SANAL GERÇEKLİK EĞİTİMİNİN OBEZ ÇOCUKLARDA DENGE VE HIZ-ÇEVİKLİK ÜZERİNDEKİ ETKİLERİ: RANDOMİZE KONTROLLÜ ÇALIŞMA

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Çalışmanın amacı, obez çocuklarda sanal gerçeklik eğitiminin denge ve hız-çeviklik üzerindeki etkilerini incelemektir.

Yöntemler: Çalışmaya 9-11 yaşlarında 34 obez çocuk dahil edildi. Katılımcılar basit randomizasyon yöntemi ile eğitim ve kontrol grubuna ayrıldı. Eğitim grubundaki katılımcılar (n=17) 6 hafta boyunca sanal gerçeklik eğitimine alındı. Kontrol grubuna (n=17) herhangi bir tedavi uygulanmadı. Denge, Flamingo ve Y denge testleri ile değerlendirildi. Hız-çeviklik Bruininks-Oseretsky Motor Yeterlilik Testi-Kısa Form-hız-çeviklik alt testi ile değerlendirildi. Eğitim grubundaki çocukların fiziksel aktiviteden keyif alma düzeyleri Kısa Form-Fiziksel Aktiviteden Keyif Alma Ölçeği ile değerlendirildi.

Bulgular: Çalışma öncesinde, gruplar incelenen değişkenler açısından benzerdi (p>0,05). Eğitim grubundaki çocukların sürat-çeviklik skorları ve Y denge testi ön, arka-yan ve karışık uzanma mesafeleri eğitim sonrasında eğitim öncesine göre anlamlı olarak arttı (p<0,05). Flamingo denge testi sonuçları eğitim öncesinden eğitim sonrasına anlamlı olarak artarken (p=0,001), %95 GA ile birlikte değerlendirildiğinde artışın önemsiz olduğu görüldü (-0,42-7,42). Eğitim grubunda, Y denge testi anterior ve posterior-medial uzanma mesafeleri dışında, statik ve dinamik denge ve hız-çeviklik klinik etkileri büyüktü (r≥0,5). Eğitim grubundaki tüm katılımcılar sanal gerçeklik eğitiminden en yüksek derecede keyif aldıklarını belirtti. (%95 CI:25,0 -25,0).

Sonuç: Obez çocuklarda sanal gerçeklik eğitimi denge ve hız-çeviklik gelişiminde etkilidir ve fiziksel aktivite için eğlenceli bir seçenektir. Uzun süreli eğitim ve takip içeren geniş randomize kontrollü çalışmalar önerilmektedir.

Anahtar Kelimeler: Postüral Denge, Çocuk, Obezite, Terapötik, Sanal Gerçeklik

INTRODUCTION

The World Health Organization (WHO) defines obesity as "abnormal or excessive accumulation of fat in the body to an extent that would detriment health" (1). The incidence of childhood obesity is increasing in the entire world. According to the data of WHO, 15% of school age children in the region of Europe in 2010 were obese, while 40% were overweight (2). The prevalence of obesity and overweight in children and adolescents significantly increased in the period of 2000-2010 among school-age children in Northern Cyprus (3). It is known that obese children have poorer postural performance and lower motor skills in comparison to non-obese children. The changes in the body morphology of overweight individuals negatively affect postural stability by changing the center of mass of the body (4). With increased body weight, there are biomechanical restrictions in standing up straight, and in connection to this, there are significant degradations in static and especially dynamic balance. Falls due to weak balance control and related injuries are also seen frequently (5,6). Orthopedic problems and postural changes lead to a decrease in the mobility of the child and their ability to participate in physical activities (4-6). Poor physical capacity and low performance levels make physical activity less attractive for obese individuals (7). To participate in exercise and sports, the ability to control static and dynamic balance is important and necessary. Participation in physical activity plays a significant role in prevention and treatment of obesity in children (8).

The fight against childhood obesity usually fails due to reasons such as that obesity-related problems in childhood cannot be sufficiently explained to children, they are easily bored of the methods that are applied, parents are not adequately equipped regarding the severity of the problem and cultural effects (9,10). For this reason, in order to provide children with habits of physical activity and exercise through games and make these into a lifestyle, exergaming intervention are utilized. Exergaming Intervention (EI) is a three-dimensional simulation model that is created by computers and provides the sense of reality by allowing opportunities of interaction with a dynamic environment for its users. It was reported that EI speeds up motor learning, allows the person to transition from a passive state to an active state, contributes to solution of balance problems and is a source of fun and motivation for children (11). Although Exergaming Intervention (EI) has been used as a physical activity modality among various populations, the evidence regarding its effectiveness on balance and speed-agility outcomes in obese children remains unclear (12). The purpose of this study is to investigate the effects of EI on balance and speed-agility in obese children.

METHODS

Participants

The randomized controlled studied was carried out on children at the ages of 9-11 who had higher than the 95th percentile of body mass index (BMI) based on their age and sex who were enrolled at a primary education school in the Famagusta district of Northern Cyprus between March 2017 and June 2017 (13). The sample size was calculated based on the data of the study by Sheehan and Katz which investigated the effects of a 6-week exercise program on the balance of 4th-grade primary school students by using an iDance™ device (14). In the study by Sheehan and Katz, based on the postural stability pretest-posttest scores for the group where exergaming was applied, the effect size was calculated as d=1.53. In our study, under the assumptions that two-tailed Mann-Whitney U test would be used, $\alpha=0.05$, d=1.53 and $\beta=0.05$, and the cases would be equally distributed between the groups, the initial sample size was calculated as 26. Considering that some participants could drop out of the study, this sample size was increased by 30%, and the final sample size was determined as 34, so that there would be 17 participants in each group. The participants who were included in the study were randomly divided into two groups by simple randomization method using the "Random Allocation Software". EI was applied with the children who were included in the first group (intervention group=IG). The second group of children constituted the control group (CG), and no intervention was applied. Children whose cognitive skills were on a level where they could understand the instructions who had not participated in a particular sports program for at least the last 3 months were included in the study.

Children who had previously received a psychiatric diagnosis, had musculoskeletal disorders, neurological, orthopedic problems, heart and respiration problems, vestibular disorders, sight, hearing, speaking, eating and thyroid function disorders were excluded.

This study was approved by the Health Ethics Committee of Eastern Mediterranean University (decision dated 06.03.2017 and numbered 2017/39-13). The families of the children who participated in the study were informed in written form, and they signed voluntary consent forms.

Measurements

Demographic characteristics

The participants' age, gender, height, body weight, BMI and dominant side were recorded. Body weight was recorded by an analysis monitor (Tanita SC-330) (15). Height was measured with bare feet on the Frankfurt plane with a non-flexible measurement tape fixed on the wall (16). The lower extremity dominant side was determined as the extremity with which a ball was kicked. For the participants in both groups, their average daily sleeping duration, their daily duration spent in front of the television or computer and weekly days spent in front of the television or computer were recorded.

Static balance

The static balances of the participants were evaluated with the Flamingo balance test. For the test, a wooden beam with the length of 50 cm and height of 4 cm and a stopwatch were used. The children were asked to remove their shoes and stand up with one foot as flamingos do for 1 minute in the middle of the long line. They were asked to flex their knee on the other side while one side was on the floor. The knee that was in flexion was held with the hand on the same side. A trial was made before the test so that the children would get used to the test. The test that started with the instruction to start was ended by stopping the stopwatch when the balance was broken, or in other words, when the other foot touched the floor. The test protocol was repeated after each contact of the other foot with the floor and continued until the end of the 1 minute. The child received a score based on how many trials they made within 1 minute. If the balance was broken more than 15 times within 30 seconds or the child fell, the test was stopped, and the child was given "0" points. The test was applied the same way for both feet (17,18).

Dynamic balance

The dynamic balances of the participants were evaluated with the Y balance test. For the Y balance test, to increase the repeatability of the measurements and standardize the performance in the test, instead of the 8-way Star Excursion Balance Test, its adapted version with 3 directions and 120° intervals was used (19). By taking the Y Balance Test Kit as an example, a wooden standing platform was used, and measuring tapes were fixed on pipes in three directions to measure the reaching distance. The participants tried to reach the farthest point with their other foot while their hands were on their waists, and they were trying to maintain balance with their dominant foot on the wooden platform. In compliance with the standardized test protocol, reaching distances were recorded with 3 repetitions each and 3 directions as anterior, posterior-medial and posterior-lateral. All tests and practices were carried out without shoes to prevent balance and stability contribution. To use in scoring, the dominant side lower extremity length was determined by measuring the distance between the iliac spine anterior superior and the medial malleolus. The mixed reaching distance was obtained with the formula: [(maximum anterior + maximum posterior-medial + maximum posterior-lateral) / (3 x lower extremity length)] x 100 (20).

Speed and agility

For assessing speed and agility in the study, the sub-test of "Stationary Jumping on Preferred Foot" of the Bruininks-Oseretsky Test of Motor Proficiency–Brief Form Second Version (BOT-2-BF) was used. For the test, the individual was asked to stand on their preferred foot by holding their hands on their waist, keep the other extremity with hips in neutral and knee at a 90-degree flexion and stand on the specified line. At this position, they were asked to jump to the right and left of the specified line on the floor for 15 seconds. A stopwatch was started and the number of correct jumps within 15 seconds was recorded. Separation of hands from the body or falling of the level of the foot was accepted as the criterion to end the test (21).

Enjoyment of physical activity

To measure the physical activity enjoyment levels of the participants in the intervention group, the Physical Activity Enjoyment Scale's Short Form (SF-PACES) was utilized. This is a 5-point Likert-type scale consisting of 18 items. SF-PACES consists of 5 items to reflect the objectives of exercise and determine enjoyment while continuing activities of exercise. The scoring changes between 1 and 5. While the items 2, 3 and 5 are scored in the form of 1=1, 2=2, 3=3, 4=4 and 5=5, the items 1 and 4 are inversely scored. The total score in the scale varies from 5 to 25. In each item in the scale, 5 points show that the individual absolutely agrees, while 1 point shows that they absolutely disagree. SF-PACES was tested for validity and reliability for 9-14-year-old Turkish children by Mirzeoğlu and Çoknaz (22).

Exergaming intervention

The participants in Intervention Group (IG) received a total of 18 sessions consisting of 30-45 minutes of EI for 6 weeks and 3 days every week on Xbox 360 Kinect™. For the participants to get used to the equipment and the intervention protocol, sufficient numbers of trials were carried out. During the trials, the feedback given by the device was utilized in terms of which part of the body to move. In addition, verbal warnings such as 'you are doing great, you are doing well, pay attention, etc.' were given by the physiotherapist to minimize mistakes during the games. In the intervention, to improve balance, weight transfer, coordination and reaction time, the games River Rush, Reflex Ridge, 20.000 Leaks, Rally Ball, Space Pop, Knock Out Punch, Funnel Cakes, Skiing, Boxing, Gold Mountain Rush and Kinect Joy Ride were selected. For the games to be more enjoyable, the participants were taken into intervention in groups of two. Before the games, the participants were informed about the purpose of the game. The selected games contained various fun movements that could help increase balance. In the games, the children perform body movements as do the characters in the virtual World such as arm movements, stepping aside and bending. The body position is carried to the outside of the support surface limits. This way, balance intervention takes place. The games were divided into weeks based on their difficulty, and the difficulty was increased each week.

For the participants to play the games on a large screen and be more immersed in the virtual environment, the content was reflected onto a wall by a projection device. The intervention was carried out in an exercise room whose floor was covered with a non-slippery material and had dimensions of 24 m2 (6m x 4m). To minimize the potential risks related to the intervention protocol, all furniture in the room were removed. For the children to get used to the games and for preventing negative events that could be encountered during the games, the children were shown videos about the games beforehand. At the end of each week, participation and acknowledgement certificates were provided to encourage the participants. Acknowledgement certificates were also given to the participants in the control group for their participation in the study at the end of the 6 weeks.

Statistical Analysis

The data were analyzed by using the IBM SPSS Statistics V.20.0.0 software. Shapiro-Wilk test was utilized to test the normal distribution of the data. As the p-values obtained with this test were smaller than 0.05, it was decided that the data were not normally distributed, and non-parametric statistical tests were used in the statistical analyses.

The significance of the difference between the means in two independent samples was examined by Mann-Whitney U test. The significance of the difference between the means in two dependent samples was examined by Wilcoxon signed-rank test. Chi-Squared and Fisher's Exact tests were used to determine the significance of the difference between two percentages.

The study presents the continuous variables as mean ± standard deviation and categorical variables as frequency and percentage. Error probability was accepted as α=0.05. Arithmetic means are presented with 95% confidence interval (95% CI) lower and upper limit values. To determine whether or not the groups were different, both p-values and the 95% CI values were considered. Accordingly,

1. If $p<0.05$, and there is no overlap between the two groups' 95% CI lower and upper limits, the means are different.

2. If the 95% CI lower and upper limits of the difference between the two groups does not contain '0', the means are different (23).

The effect sizes of the interventions in the groups were calculated by using the formula $r=z/\sqrt{\square\square 2}$. It was interpreted that r = 0.1 referred to small, r = 0.3 referred to medium and r = 0.5 referred to large effect (24).

RESULTS

The mean age of the participants was 9.7 ± 0.6 in IG and 9.5 ± 0.6 in CG. Each group included 10 female (58.8%) and 7 male (41.2%) participants. The groups were statistically similar in terms of age, sex, body weight, height and BMI values ($p>0.05$). The dominant lower extremity was the right one for 16 participants (94.1%) in IG and 15 participants (88.2%) in CG. The dominant lower extremities in both groups were statistically similar ($p>0.05$) (Table 1).

The statuses of any physical activity before the study, average daily sleeping duration, duration spent per day in front of the television or computer and days spent per week in front of the television or computer were statistically similar in both groups ($p>0.05$) (Table 1).

Before the intervention, the groups were found to be statistically similar in terms of their static bal-

Table 1. Demographic Characteristics of the Participants, *(% 95CI)*, (N=34)

Variable	Groups		
	Intervention Group n = 17	**Control Group n = 17**	**P Value**
Age, Year, x ± sd	9.7 ± 0.6 *(9.4 — 10.0)*	9.5 ± 0.6 *(9.2 — 9.8)*	0.536*
Gender, n (%)			1.000**
Female	10 (58.8) *(0.4 — 0.8)*	10 (58.8) *(0.4 — 0.8)*	
Male	7 (41.2) *(0.2 — 0.6)*	7 (41.2) *(0.2 — 0.6)*	
Height, m	1.4 ± 0.1 *(1.3 — 1.5)*	1.4 ± 0.1 *(1.3 — 1.5)*	0.173*
Body Weight, kg	51.5 ± 8.0 *(47.4 — 55.6)*	47.9 ± 6.9 *(44.4 — 51.4)*	0.310*
Body Mass Index, kg/m^2	24.4 ± 2.2 *(23.3 — 25.5)*	23.9 ± 2.8 *(22.5 — 25.3)*	0.408*
Dominant Lower Extremity, n (%)			1.000***
Right	16 (94.1) *(0.7 — 0.9)*	15 (88.2) *(0.7 — 0.9)*	
Left	1 (5.9) *(0.0 — 0.3)*	2 (11.8) *(0.0 — 0.3)*	
Prior Regular Physical Activity, n (%)			0.732**
Done	8 (47.1) *(0.3 — 0.7)*	9 (52.9) *(0.3 — 0.7)*	
None	9 (52.9) *(0.3 — 0.7)*	8 (47.1) *(0.3 — 0.7)*	
Sleep Time, Hours/Day, x ± sd	9.2 ± 0.6 *(8.9 — 9.5)*	8.8 ± 0.7 *(8.4 — 9.2)*	0.084*
TV-PC, Hours/Day, x ± sd	2.2 ± 0.9 *(1.7 — 2.7)*	0.7 ± 1.2 *(0.1 — 1.3)*	0.470*
TV-PC, Day/Week, x ± sd	6.5 ± 0.8 *(6.1 — 6.9)*	6.7 ± 0.9 *(6.2 — 7.2)*	0.194*

*: Mann-Whitney U Test, **: Chi-Square Test, ***: Fisher's Exact Chi-Square Test, TV:Television, PC:Personal Computer

Table 2. Comparison of Before and After Training Values of the Groups

	Before Training				After Training			
Balance and Speed-Agility	Intervention Group	Control Group	p *	Mean Differences % 95 CI	Intervention Group	Control Group	p*	Mean Differences % 95 CI
Flamingo Balance Test, Number of Falls/60sec	15.7 ± 5.9	16.5 ± 6.5	0.70	*-5.14—3.54*	12.2 ± 5.3	15.9 ± 5.9	0.10	-7.62 — 0.22
BOMYT-2BF Speed-Agility Score	4.4 ± 2.9	5.5 ± 2.9	0.24	*-3.13—0.93*	7.8 ± 4.1	6.3 ± 3.8	0.14	-1.26 — 4.26
Y Balance Test Reach Distance, cm Score								
Anterior	48.6 ± 3.3	47.1 ± 4.4	0.39	*-1.22— 4.22*	51.9 ± 3.9	46.0 ± 4,9	**0.00**	***2.81 — 8.99***
Posterior-Medial	50.7 ± 3.5	53.5 ± 5.1	**0.04**	*-5.86—0.26*	53.2 ± 5.9	50.4 ± 5.7	0.21	*-1.25 — 6.85*
Posterior-Lateral	41.1 ± 9.5	46.8 ± 7.5	0.11	*-11.68—0.28*	49.3 ± 9.5	48.1 ± 6.8	0.35	*-4.57 — 6.97*
Composite	60.4 ± 6.6	64.4 ± 7.2	0.06	*-8.83—0.83*	65.9 ± 7.9	62.5 ± 6.2	0.08	*-1.56 — 8.36*

BOMYT-2BF: Brief Form Second Edition of Bruininks-Oseretsky Motor Proficiency Test, *: Mann-Whitney U Test, 95% CI: 95% Confidence Interval, Bolded numbers indicate that the results are statistically significant.

ance and speed-agility scores (p>0.05) (Table 2). Before the study, although there was a significant difference in the reaching distance of the groups in the posterior-medial direction in the Y balance test (p=0.036), there was no significant difference in the other directions and the mixed reaching distance (p>0.05). It was determined that the difference between the two means of the posterior-medial reaching distance in the Y balance test covered '0' in its 95% CI. Therefore, the difference was insignificant (Table 2).

When the groups were compared after the study in terms of their static and dynamic balance and speed agility test results, there was a significant difference only in the anterior reaching distance in

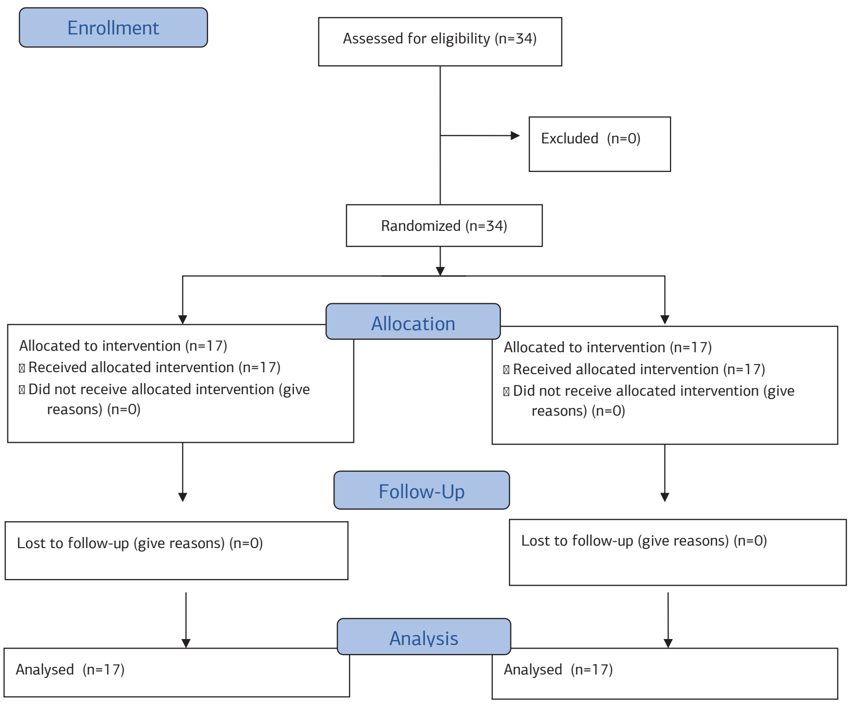

Figure 1. Flow chart of the study

Table 3. Comparison of Pre-Test and Post-Test Values of the Groups

Balance and Speed-Agility	Intervention Group (n=17)					Control Group (n=17)				
	Pre-Training	Post-Training	P *	Mean Differences % 95CI	r **	Pre-Training	Post-Training	P *	Mean Differences % 95CI	r **
Flamingo Balance Test, Number of Falls/ 60sec	15.7 ± 5.9	12.2 ± 5.3	**0.00**	-0.42 — 7.42	**0.6**	16.5 ± 6.5	15.9 ± 5.9	0.49	-3.74 — *4.94*	0.1
BOMYT-2BF Speed-Agility Score	4.4 ± 2.9	7.8 ± 4.1	**0.00**	**-5.88 — -0.92**	**0.6**	5.5 ± 2.9	6.3 ± 3.8	0.12	-3.16—*1.56*	0.3
Y Balance Test Reach Distance, cm										
Anterior	48.6 ± 3.3	51.9 ± 3.9	**0.01**	***-5.82 — -0.78***	0.4	47.1 ± 4.4	46.0 ± 4.9	0.24	-2.15—*4.35*	0.2
Posterior-Medial	50.7 ± 3.5	53.2 ± 5.9	0.14	*-5.99 — 0.79*	0.3	53.5 ± 5.1	50.4 ± 5.7	**0.01**	*-0.68—6.88*	0.4
Posterior-Lateral	41.1 ± 9.5	49.3 ± 9.5	**0.00**	***-14.84 — -1.56***	**0.6**	46.8 ± 7.5	48.1 ± 6.8	0.19	*-6.30—3.70*	0.2
Composite	60.4 ± 6.6	65.9 ± 7.9	**0.00**	***-10.59 — -0.41***	**0.5**	64.4 ± 7.2	62.5 ± 6.2	0.12	*-2.79—6.59*	0.3

BOMYT-2BF: Brief Form Second Edition of Bruininks-Oseretsky Motor Proficiency Test, *: Wilcoxon Sign Test, 95% CI: 95% Confidence Interval, **: Rosenthal Effect Size, Bolded numbers indicate that the results are statistically significant.

the Y balance test (p=0.001, 95% CI: 2.81 — 8.99). However, no significant difference was found for all other directions (p>0.05) (Table 2).

The BOT-2-BF speed-agility scores and the Y balance test anterior, posterior-lateral and mixed reaching distances of the participants in IG significantly increased after the intervention in comparison to their preintervention values (p<0.05). While the Flamingo balance test result also significantly increased in this group in comparison to the pre-intervention values (p=0.001), when the 95% CI results were examined, this increase was found to be insignificant (-0.42—7.42). The effect sizes for these variables were in the range of 0.3-0.6 (Table 3).

There was no statistically significant difference between the pre-intervention and post-intervention Flamingo balance test and BOT-2-BF scores of the participants in CG (p>0.05). The effect sizes for these variables were in the range of r=0.1-0.4. In terms of the Y balance test reaching distances, there was a significant difference only in the posterior-medial reaching distance (p<0.05). However, when the posterior-medial reaching distance was considered with the 95% CI, it was seen that the lower and upper limits were overlapped, and the difference between the two means covered the value of ‘0’. This is why the difference that was obtained was insignificant. For the other directions, the intragroup comparisons revealed no significant difference (p>0.05) (Table 3).

All participants in IG stated that they enjoyed EI very much. All participants gave the highest score for EI, which was 25 (95% CI: 25.0 —25.0).

DISCUSSION

As a result of the study, it was determined that EI that was applied for 6 weeks with 9-11-year-old obese children by using the Xbox 360 Kinect™ device improved static and dynamic balance and speed-agility. All children that received EI had high levels of satisfaction with the intervention. Balance is a complex process that contains multidirectional sensorimotor and biomechanical components. Complicated systems such as the somatosensorial and sensorimotor systems are dominant in achieving postural control. During normal standing up straight, postural control is primarily obtained from visual sources and proprioceptive feedback coming from the lower extremities. As sensory information decreases, postural control also decreases (25). Studies have revealed that postural release is increased in obese children, and projected acts cannot be modulated fast (7,26). McGraw et al. used a strength platform for postural stability analysis and made center of pressure (COP) measurements. During standing, there are a higher rate of reduction in postural stability in obese prepubertal males in comparison to non-obese ones. In the COP measurement in obese prepubertal males, it was seen that especially instability in the medio-lateral direction significantly increased (27). During EI, children see their own virtual profiles on the screen and move accordingly. At this point, children constantly make adjustments in their center of gravity to be able to reach their goals, and this contributes substantially to the change that occurs in relation to balance (28). The study by Beaulieu-Boire et al. included three adult subjects with balance problems. In addition to the physiotherapy program of 10 weeks including 2 days per week for 30 minutes each season, EI was applied with games that aimed to improve balance named 'Kinect Games, Kinect Sports, Kinect Adventures, Your Shape Fitness Evolved and Carnival'. As a result, it was reported that EI applied with Xbox 360 Kinect™ significantly contributed to improvement of balance (29). In our study, there was an improvement in static and dynamic balance and increase in speed-agility among the obese children who received EI. In our study, no statistically significant change was found in the posterior-medial reach distances in the Y balance test in the EI group after the intervention. Performance in the Y balance test is affected by trunk and lower extremity kinematics. Especially hip flexion is the best predictor of performance in the posterior direction. In our study, there were no data on hip flexion and trunk kinematics. This may have had an effect on our results. Therefore, it is recommended that trunk and lower extremity kinematics should also be analyzed during Y balance test in future studies (30). However, the lack of change in posterior-medial access distance may also be due to the games used. Therefore, it may be useful to use different games in future studies.

In our study, there was an improvement in static and dynamic balance and increase in speed-agility among the obese children who received EI. The clinical effects were moderate-large. In CG, which received no intervention, the clinical effect of the change was small-moderate for static and dynamic balance and moderate for speed-agility. In other words, there were also improvements in the balance and speed-agility of the children who did not receive any intervention, although these changes were smaller. If children are encouraged to learn motor skills, their motor skills show a faster development stage than what is expected of their age (31). In this context, it may be stated that, with exergaming games that increase postural stability and control as a result of biomechanical effects, both balance and speed-agility skills may be improved better. Van Bijon et al. used the short version of the Bruininks-Oseretsky Competence test for motor competence in 30 overweight and obese children. The study group received a 6-minute active video intervention using Nintendo Wii for 30 minutes per session, 3 days a week. There were two control groups in the study. One of the control group played traditional video games and the other group was asked to continue their daily life activities without any intervention. The study group that played active video games showed improvements in motor competence, especially in terms of agility and speed (32). Similarly, in our study, Exergame was applied for a total of 6 weeks, and the control group was asked to continue their daily lives without any intervention. When examined in terms of speed and agility in our study group, it was determined that there were both statistically and clinically significant improvements. Although statistical significance was not detected in the control group, the fact that a small-moderate clinical effect was found may be a result of continuing their daily physical activities. This result indicates that active video games are an effective tool in correcting speed and agility, which is one of the indicators of motor competence in children and adolescents. Therefore, it can be used as an alternative tool to traditional exercises to improve health during childhood. Moreover, clinical effect may be increased by longer-term intervention strategies (33). The main change in dynamic balance took place in the mixed, anterior and posterior-lateral directions. The requirement of the games to move fast and immediately and have coordination and their characteristics may have been affective on the outcomes. However, to reach a precise judgement, biomechanical analyses on games should be carried out. When the results of our study were analyzed, it was found that the difference between the groups in the Y balance test was found only in the anterior reach distance. Reach distances in the Y balance test may be affected by various factors. There are studies showing that the reach distance especially in the anterior direction is related to the normal range of motion and flexibility of the ankle joint (34,35). The fact that no evaluation was made for these in our study prevents us from making a judgment in this direction. However, we think that it would be useful to examine flexibility and range of motion values in the lower extremity when Y balance test results are analyzed in future studies. The nature of the games used in our study may also have had an impact on our results.

Nowadays, posturography measurement is accepted as the gold standard measurement for balance assessments. Computerized posturography was to provide a detailed and quantitative assessment of the motor system and the central processing of inputs from the vestibular, visual, somatosensory systems related to postural stability. However, posturography measurements were not used in our study because they are expensive and not available in our university.

Sheehan and Katz reported that traditional physical activity programs and active video games that aimed to improve balance, agility and coordination in 3rd-grade primary school students had similar effects in improving balance. Based on this result, the authors stated that Wee Fit +™ helped improve balance (36). Daniel et al. reported that comparing traditional treadmill exercise training with exercise game in university students, higher enjoyment of exercise game and less perceived exercise rating. Based on this result, the authors stated that exergaming is an attractive and effective option for students to participate in physical activity (37).

Studies have reported that, when obese children take part in physical activity through active video games, they enjoy the physical activity more (38,39). In our study, it was seen that the children who participated in EI were satisfied with the intervention to the maximum extent. In this context, it is believed that EI's are a highly motivating physical activity option to direct obese children towards physical activity. Based on this reality, applying exergaming in an integrated way with routine physiotherapy programs may contribute to the solution of problems related physical inactivity. Additionally, it may help planning the treatment process by providing the physiotherapist with a new point of view.

The most important limitation of our study was that the participants were not selected from a population containing obese children based on the national health and population data. This prevents the generalization of the results. Nevertheless, to the best of our knowledge, there is no such pool of data in the Northern Cyprus.

Although the time spent passively (such as TV and computer time) was similar in both groups, the fact that physical activity levels were not determined is a limitation of our study. In this context, it is thought that it will be useful to determine the level of physical activity in future studies in order to make a definite judgment.

Another limitation of the study is the lack of normative values of the Y balance test for the measurement of lower extremity dynamic balance for children aged 9-11 years participating in our study. This makes it difficult to interpret the results obtained from the Y balance test. Therefore, obtaining normative values for children in this age group in future studies will lead to a more objective interpretation of the results. Therefore, more detailed information can be obtained by using computerized posturography measurements for balance assessment.

In our study, Bruininks-Oseretsky Motor Proficiency Test was used to measure speed and agility. In this test, only the ability to jump to the right and left of a line drawn on the ground for 15 seconds is tested. Therefore, it is recommended to use other tests to get detailed information about speed and agility.

6 weeks of EI applied on obese children is effective in improving static and dynamic balance and speed-agility. Considering in this context, EI may be recommended for improving balance to be used as a part of physical education courses and spare time activities based on the interests of children in their pre-adolescent period.

Additionally, as EI is a physical activity that is enjoyed by children, it is a good alternative for directing obese children to physical activity. Furthermore, it should be kept in mind that turning physical activity into a lifestyle requires longer intervention duration. For this reason, the large randomized controlled studies with long-term interventions and follow-up are recommended.

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