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The Effects of Active Video Games on Physical Performance: Experimental Study

Aktif Video Oyunlarının Fiziksel Performans Üzerindeki Etkileri: Deneysel Çalışma

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This study was prepared based on the findings of Enes Gürcan's thesis study titled "Do Active Video Games Affect Physical Performance?" (Balıkesir: Balıkesir University; 2023).

ABSTRACT Objective: We designed this study to investigate whether active video games affect physical characteristics in sedentary adults. **Material and Methods:** Nineteen healthy adults aged 40-60 years were included in the study. The participants classified as sedentary according to the International Physical Activity Questionnaire. Participants were divided into 3 groups: "active video games" (n=7), "walking" (n=6), and "control" (n=6). All participants underwent stork balance, maximum muscle strength were applied before the intervention and after 4 weeks of training. **Results:** There were no significant differences between groups in age, height, body weight, and body mass index before the intervention. After the intervention, a significant decrease in body weight and body mass index was observed in the active video game group (p≤0.04). Regarding the muscle strength, maximum flexion and extension strength values increased significantly in both legs in the walking group (flexion: p≤0.001, p≤0.01; extension: p≤0.05, p≤0.02), while in the active video game group, significant increases in flexion and extension strength were observed in the left leg (flexion: p≤0.001, extension: p≤0.03). The muscle endurance, a slight increase was observed on the right side in the active video game group (p≤0.05). Balance time improved significantly only in the walking group, particularly in the left leg (p≤0.05). **Conclusion:** Active video games may be a possible option for increasing physical activity, particularly in sedentary adults, compared to traditional walking.

Keywords: Active video games; physical performance; sedentary

ÖZET Amaç: Aktif video oyunlarının, egzersiz yapmayan erişkin bireylerde fiziksel özellikleri etkileyip etkilemediğini araştırmak amacıyla bu çalışmayı planladık. **Gereç ve Yöntemler:** Uluslararası Fiziksel Aktivite Anketi'ne göre sedanter olarak sınıflandırılan 40-60 yaş aralığında 19 sağlıklı erişkin çalışmaya dâhil edildi. Katılımcılar, 3 gruba ayrıldı: "aktif video oyunları" (n=7), "yürüyüş" (n=6) ve "kontrol" (n=6). Tüm katılımcılara stork denge, maksimum kas kuvvet testleri uygulama öncesi ve 4 hafta çalışma sonrası tekrarlandı. **Bulgular:** Gruplar arası karşılaştırmalarda, uygulama öncesi yaş, boy, vücut ağırlığı ve beden kitle indeksi açısından anlamlı bir fark yoktu. Uygulama sonrası, aktif video oyunu grubunda vücut ağırlığı ve beden kitle indeksinde anlamlı bir azalma bulundu (p≤0,04). Kas kuvveti açısından yürüme grubunda, fleksiyon ve ekstansiyon maksimum kuvvet değerleri hem sağ hem de sol bacakta anlamlı şekilde arttı (fleksiyon: p≤0,001, p≤0,01; ekstansiyon: p≤0,05, p≤0,02); aktif video oyunu grubunda ise sol bacakta fleksiyon ve ekstansiyon kuvvetinde anlamlı artışlar görüldü (fleksiyon: p≤0,001; ekstansiyon: p≤0,03). Kas dayanıklılığı açısından aktif video oyunu grubunda, sağ tarafta hafif bir artış gözlendi (p≤0,05). Denge süresi sadece yürüme grubunda, özellikle sol bacakta anlamlı şekilde iyileşti (p≤0,05). **Sonuç:** Aktif video oyunları, geleneksel yürüyüşe göre özellikle sedanter erişkinlerde fiziksel aktiviteyi artırmak için uygulanabilir bir seçenek olabilir.

Anahtar Kelimeler: Aktif video oyunları; fiziksel performans; sedanter

Physical inactivity has become widespread in countries with a high level of prosperity and poses a significant public health problem in terms of health.[1] Studies have shown that physical inactivity in adults increased by 28% from 2001 to 2016 and this increase will reach dangerous dimensions in terms of health. Physical inactivity and sedentary lifestyle negatively affect health and cause an increase in cardio-

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vascular diseases and diabetes.[2,3] The increase in such diseases also increases the mortality rate due to inactivity.[4] In a study, it was reported that 2.2 million people spend most of their time sitting and playing traditional video games (mobile games, web-based games, computer games, home entertainment games...).[5] Traditional video games increase the time spent sitting and cause the development of sedentary behaviour. Unlike traditional video games, "active video games" or "exergames" increase the physical activity level of the person because they include activities such as running, dancing, jumping, skipping and cycling.[6] Active video games aim to improve the player's exercise performance through immediate visual and auditory feedback such as entertainment and motivation.[7] Previous studies have reported that active video games increase energy expenditure, increasing the metabolic work rate from 1.5 MET to 6 MET and improving maximal oxygen consumption (max VO_2).[8,9] It is stated that traditional seated video games do not significantly affect these physiological parameters.[10] Similarly, in another study, it was reported that during the "Action-Racing" active video game, which included activities such as sitting, standing, standing, jumping and swimming in different age groups (25-75 years), the average heart rate, oxygen consumption value, lactate value and energy consumption increased and these values did not differ significantly in the comparison of age groups.[11] In addition, it has also been reported that active video games have a healing effect against the balance disorder that occurs in the elderly and diseases developing due to old age.[12]

As a result of these studies, the idea that active video games can improve physical performance has become widespread. As it is known, physical activities at different levels, walking, cycling, body exercises and running improve physical performance. However, it is not known to what extent active video games improve physical performance compared to exercises performed with traditional methods. In addition, there are some minor differences in the operation of home-based game consoles [Nintendo Wii (Nintendo, Japan), PlayStation Move (Sony Interactive Entertainment, Japan), Microsoft Kinect (Microsoft, Washington, USA)] that run active video games. Therefore, as a result of the literature review, the majority of the research has focused on Nintendo Wii and Microsoft Kinect game consoles and the relationship of PlayStation Move game console with physical performance has not been focused much. For this reason, due to the similarity of Nintendo Wii and Sony PlayStation Move game consoles, PlayStation Move game console was used in our study and the effect of active video games on physical performance was aimed to be evaluated by comparing with walking exercisers and non-active (inactive) individuals.

MATERIAL AND METHODS

This study was designed as an experimental prospective randomized controlled study and a sample was selected. Nineteen healthy men and women aged 40-60 (years) were included in this study. The International Physical Activity Questionnaire Short-Form was applied to volunteers who participated in the study. According to the International Physical Activity Questionnaire Short-Form results, those with a total physical activity score below 600 MET-min/week were included in the study. The volunteers participating in the study (n=19) were randomly divided into 3 groups: active video game (n=7), walking (n=6) and control group (n=6). The volunteers assigned to the research groups were given exercise programmes planned for a total of 30 minutes, consisting of a 5-minute warm-up, 20 minutes of exercise, and a 5-minute cool-down phase, 4 days a week for 4 weeks. Especially, the active video game group was introduced to the programmes, shown how to use them, and given a trial run and practice session before starting the exercise. This group played exercise-based active video games [Racket Sports (Ubisoft, France) and Move Fitness (Sony Computer Entertainment, Japan)] on the PlayStation Move console, which required simultaneous movement of the upper and lower extremities. The walking group performed individually own pace walking exercise, while the control group continued their daily routines and did not engage in any exercise during this period.

DATA COLLECTION TOOLS

International Physical Activity Questionnaire-Short Form

The questionnaire was designed to determine the physical activity levels of the participants. The ques-

tionnaire was developed by Craig et al.[13] The validity and reliability study was conducted by Öztürk.[14] The questionnaire assesses the number of times physical activity was performed in the last 7 days and the duration for each day. The first section includes vigorous physical activities, the second section includes moderate physical activities, the 3rd section includes walking, and the last section includes time spent sitting (not moving) on a daily basis. The total score is calculated by multiplying the minutes, days and MET values of the activities and the result is obtained as "MET-minutes/week". Vigorous physical activity is multiplied by 8 METs, moderate physical activity by 4 METs and walking by 3.3 METs. Physical activity levels are classified as physically inactive (<600 MET min/week), minimally active (600-3,000 MET min/week) and active (>3,000 MET min/week).[14]

Leg Muscle Strength Test

Commonly used to determine one's maximum muscle strength 1 RM method is a method that finds the maximum weight (kg) that can be lifted in one repetition and this is a test that directly measures strength. In this method, firstly, the person can lift a default weight is selected. If he/she cannot lift the selected weight, the weight is reduced and tried again. If he/she lifts the reduced weight for more than one repetition, the weight is increased or if he/she cannot lift it at all, the weight is reduced and retried. The process continues like this until the maximum weight can be lifted at a time.[15] In order to determine the muscular endurance of the person, 60% of the maximum weight (kg) that the person can lift in one repetition is taken with the 1 RM method and the number of repetitions until the person gets tired is recorded and the muscular endurance is evaluated with this test method. In this study, leg extension and leg curl fitness machines were used to measure right and left leg knee flexion and extension maximum muscle strength and muscular endurance of the participants. Participants rested for 5 minutes before and after each measurement.

Stork Balance Test

This test is a test to measure a person's static balance. Bare feet are placed on the floor, hands on both feet on the waist, and the body is positioned facing straight ahead. The leg to be measured is placed on the ground and the other leg is bent at the knee and placed slightly below the knee of the leg to be measured and the heel of the foot on the ground is lifted into the air with the command and the time is started. If the hands leave the waist, the feet and legs are separated from each other and the heel touches the ground, the time is stopped. The test is performed for both legs and the time to balance is recorded. After 3 repetitions, the best test score is obtained.[16]

Active Video Games

Move Fitness: "Move Fitness" is a new fitness programme that works on the PlayStation 3 game console is an active video game with options. In the game, there is a virtual trainer who demonstrates, performs and assists the movements. This trainer instructs users on how to perform exercise movements. In this way, users can virtually shoot baskets, try to cut incoming discs with a sword or perform exercises such as unilateral boxing on an inanimate mannequin. In addition, basic exercise movements that move the upper and lower extremities together (cross punching, lunges, triangle, jump squats, etc.) are available in the game content. In our study, people who played this game were given a special exercise programme planned as 2 sets and 20 minutes. During the exercise, the exercise movements "cross punching, lunges, triangle, jumping jacks, jump squats and jump squats switch" in the game content were performed for 1 minute in order. Rest time was 2 minutes between sets and 30 seconds between each movement.

Racket Sports: "Racket Sports" is a game that runs on the PlayStation 3 game console with 1 or 2 people is an active video game that simulates a realistic racket sport. This one in the game, 5 different racket sports can be played: tennis, badminton, squash, beach tennis and table tennis. In our research, people playing this game were made to play one of the random racket sports simulated in accordance with the rules of real competition and exercised for 20 minutes.

STATISTICAL ANALYSIS

The measurements obtained from the volunteers participating in the study were analysed using the SPSS

25 software package. Descriptive statistical analysis was performed based on the pre- and post-exercise scale scores of the research groups. The results of the Shapiro-Wilk test indicated that the data met the normality assumption ($p \geq 0.05$), and the skewness and kurtosis values were between +1.5 and -1.5, suggesting that the data followed a normal distribution. Therefore, parametric tests were applied.

To compare the intra-group differences between pre- and post-exercise measurements, the paired sample t-test was used. For comparing inter-group differences, analysis of variance was conducted. In cases where significant differences were found, the source of the differences was identified using the "post hoc" Bonferroni test. The measurement results were presented as mean and standard deviation, and the significance level for data evaluation was set at $p \leq 0.05$.

ETHICAL STATEMENT

The study was approved by the Clinical Research Ethics Committee of the Faculty of Medicine, Balıkesir University, with decision number 2021/278 (date: December 22, 2021). The tests and exercise programs to be performed, the purpose, benefits and risks of the study were explained to each participant, and signed "voluntary consent form" were obtained from each participant. The study was conducted within the principles of the Declaration of Helsinki.

RESULTS

Table 1 presents a comparison of participants' physical characteristics, such as height, age, weight, and body mass index (BMI), before and after the intervention. The physical characteristics of the active video games (n=7), walking (n=6), and control (n=6) groups are summarized in Table 1. The mean values for age, height, body weight, and BMI were compared between groups before and after the exercise program. No significant differences were found between groups ($p > 0.05$). When comparing the pre- and post-exercise measurements within each group, it was found that body weight and BMI significantly decreased in the active video games group ($p \leq 0.04$).

Table 2 presents a comparative analysis of participants muscular characteristics, including maximum strength and endurance values for the right and left leg extensors and flexors, before and after the intervention. In Table 2, the mean values for maximum knee flexion and extension muscle strength were significantly different between groups before and after exercise ($p \leq 0.05$). The active video games group showed higher values for right and left leg knee flexion and extension maximum muscle strength compared to the walking group (pre-exercise; flexion $f=8.68$, $p<0.00$; $f=5.58$, $p<0.01$, extension $f=2.76$, $p<0.00$; $f=8.58$, $p<0.00$, post-exercise; flexion $f=5.25$, $p<0.01$; $f=6.29$, $p<0.01$, extension $f=4.73$, $p<0.02$;

TABLE 1: Comparison of the physical characteristics of study group

		Pre-intervation				Post-intervation			
	Groups	$\bar{X}$	SD	f	p value	$\bar{X}$	SD	f	p value
Age	Active video game	49.42	7.95	0.34	0.71	49.42	7.95	0.34	0.71
	Walking	48.50	3.83			48.50	3.83		
	Control	51.50	6.41			51.50	6.41		
Height (cm)	Active video game	177.71	13.42	1.50	0.25	177.71	13.42	1.50	0.25
	Walking	166.50	11.18			166.50	11.18		
	Control	172.00	9.65			172.00	9.65		
Weight (kg)	Active video game	**95.62***	16.00	2.65	0.10	**94.52***	15.46	2.84	0.08
	Walking	76.28	14.25			74.91	12.45		
	Control	80.43	17.76			80.83	17.51		
BMI (kg/m^2)	Active video game	**30.29***	3.96	1.81	0.19	**29.93***	3.68	1.71	0.21
	Walking	27.40	2.59			26.97	2.44		
	Control	26.97	3.53			27.11	3.49		

SD: Standard deviation; BMI: Body mass index; *Paired t-test results (*$p \leq 0.05$)

TABLE 2: The leg strength and endurance test results

Parameters		Groups	Pre-intervation				Post-intervation			
			X̄	SD	f	p value	X̄	SD	f	p value
Maximal strength (kg) (flexors)	Right leg	Active video game	42.14	9.94	8.68	**0.00**	44.28	9.75	5.25	**0.01**
		Walking	**19.00****	5.62			**25.00****	7.74		
		Control	34.16	13.19			33.33	14.02		
	Left leg	Active video game	**42.14****	9.94	5.58	**0.01**	**47.14****	9.94	6.29	**0.01**
		Walking	**21.83***	6.64			**26.66***	7.52		
		Control	31.83	14.83			32.50	14.05		
Maximal strength (kg) (extensors)	Right leg	Active video game	45.14	15.02	2.76	**0.05**	50.85	12.14	4.73	**0.02**
		Walking	**29.33***	5.95			**31.50***	7.52		
		Control	40.50	13.33			40.50	13.33		
	Left leg	Active video game	**51.00***	9.59	8.58	**0.00**	**57.28***	9.53	10.79	**0.00**
		Walking	**28.00***	6.87			**30.83***	8.15		
		Control	42.33	12.80			42.33	12.80		
Muscular endurance repetitions (flexors)	Right leg	Active video game	**18.00***	6.92	0.21	0.81	**22.42***	10.17	1.62	0.22
		Walking	16.00	9.65			15.00	6.06		
		Control	15.16	7.80			15.83	7.38		
	Left leg	Active video game	22.00	5.03	1.74	0.20	19.14	8.78	0.19	0.82
		Walking	13.66	5.98			16.16	7.35		
		Control	18.00	11.81			16.83	10.68		
Muscular endurance repetitions (extensors)	Right leg	Active video game	12.28	5.08	1.23	0.31	10.00	3.51	0.00	0.99
		Walking	9.50	4.18			10.16	2.78		
		Control	8.83	2.99			10.00	3.52		
	Left leg	Active video game	12.28	3.03	2.01	0.16	11.71	0.95	1.75	0.20
		Walking	10.16	3.31			10.33	2.50		
		Control	8.66	3.50			9.00	3.79		

SD: Standard deviation; *Paired t-test results (*p≤0.05)

f=10.79, p<0.00). However, no significant difference was found between the active video games and control groups.

When comparing pre- and post-exercise values within each group, the active video games group showed a significant increase in left leg knee flexion and extension maximum muscle strength (flexion: p≤0.001, extension: p≤0.03). In the walking group, significant increases were observed in right and left leg knee flexion and extension maximum muscle strength (flexion: p≤0.001, p≤0.01; extension: p≤0.05, p≤0.02).

Regarding knee flexion and extension muscular endurance (repetitions), no significant differences were found between groups before and after exercise (p>0.05). However, within-group comparisons revealed a significant increase in right leg knee flexion muscular endurance repetitions in the active video games group (p≤0.05).

Table 3 presents the participants' right and left leg balance scores, before and after the intervention. In Table 3, the mean values for balance time in the study groups showed no significant differences between groups before and after exercise (p>0.05). However, when comparing pre- and post-exercise values within groups, a significant increase in left leg balance time was observed in the walking group (p≤0.05).

DISCUSSION

In the literature search, Comeras-Chueca et al., reported in their study that after 5 months of active video gaming, performed 3 times a week, knee ex-

TABLE 3: The Stork Balance Test results

			Pre-intervation				Post-intervation			
Parameters		**Groups**	**X̄**	**SD**	**f**	**p value**	**X̄**	**SD**	**f**	**p value**
Balance duration (s.)	Right leg	Active video game	3.49	1.93	1.39	0.27	3.40	1.68	0.51	0.60
		Walking	2.25	0.51			2.95	1.40		
		Control	2.80	0.99			2.60	1.07		
	Left leg	Active video game	3.75	1.91	1.98	0.16	3.59	1.69	1.34	0.28
		Walking	**2.03***	0.96			**2.76***	1.11		
		Control	2.90	1.54			2.40	1.05		

SD: Standard deviation; *Paired t-test results (*p≤0.05)

tension maximal isometric strength increased by 4.22 kg, showing significant improvement ($p<0.01$).[17] In a similar study by Sato et al., using exergames once or twice a week for a total of 24 sessions improved lower extremity muscle strength ($p<0.01$).[18] Another study by Yu et al., found that after 10 weeks of exergame (Kinect) sessions, lasting 50 minutes 3 times a week, leg muscle strength significantly increased ($p<0.001$).[19] In yet another study, participants in the active video game group, who played on a moving platform (Sensamove) for 60-minute sessions 3 times a week for 6 weeks, showed significant improvements in lower extremity muscle strength and reaction times after the 6th week ($p<0.001$, $p<0.008$).[20]

The results of our study are consistent with the findings in the literature and support our test results. According to our findings, the active video game group showed a numerical increase in knee flexion and extension maximum muscle strength values for both the right and left legs. However, a statistically significant increase was found in the left leg only, while no significant difference was observed in the right leg. This could be due to the dominance of the right leg in participants in the active video game group, or the exercise intensity of the active video games not being sufficient to achieve a significant effect on the right leg. Therefore, further detailed studies are needed. As in other studies, the results of this research also support the idea that active video games reduce body weight in proportion to the time spent playing.[21-23] The literature review suggests that active video games improve both static and dynamic balance performance.[18,24-26]

According to test results, the post-exercise application group showed greater improvement in both left and right leg static balance compared to the control group ($p<0.009$, $p<0.03$).[27] Another study examined the effects of Wii Fit games on static balance and motor proficiency in obese and non-obese women. Over 6 weeks (2 sessions per week), the active groups played Wii Fit games, while the control groups continued their daily routines. Pre- and post-test results showed significant improvements in static balance for both obese and non-obese groups compared to the control groups ($p<0.04$, $p<0.004$).[28] Furthermore, In a meta-analysis study conducted to analyse the effects of active video games on the physical functions of elderly people living in different societies, an analysis of 22 randomised controlled trials (all participants aged ≥55 years) involving a total of 1,208 participants found that playing active video games provided significant benefits in the 6-minute walk test and the time-up-and-go test. No significant difference was found when compared to traditional exercise in the 6-minute walk test, 30-second sit-to-stand test, Berg Balance Score, and knee extension strength.[29] In another meta-analysis study involving 1,428 older adults (≥60 years), active video games were found to increase muscle strength and cardiovascular fitness compared to the control group, but had no significant effect on body composition and flexibility. It was also reported that these beneficial effects were more pronounced in sessions lasting longer than 12 weeks and 60 minutes.[30] A meta-analysis of 20 studies conducted on elderly individuals (aged 60 and above) living in nursing homes found

that active video games significantly reduced the risk of falls and improved balance performance.[31] However, meta-analysis studies have also shown that they have a moderate effect on walking performance and sitting and standing performance, or show promise in improving balance and functional mobility.[32] In our study, similar results were not found, except for the left leg in the walking group. Because of the walking biomechanics may be influenced by internal and external factors such as the ground. In this context, we did not use a scientific method that could explain the reason for the result. Studies assessing balance performance have used tools such as the Wii Balance Board, Berg Balance Scale, and Timed Up and Go test. Additionally, exergames were conducted using Wii, Kinect, and other gaming consoles.[33-35] In our study, balance performance was assessed using the Stork Balance Test, and participants exercised with the PlayStation Move console, using Racket Sports and Move Fitness active video games. The lack of improvement in static balance in our research could likely be attributed to the type of test used or the differences in the equipment used for the exercise program. Therefore, further detailed studies are needed.

CONCLUSION

In conclusion, regular exercise using active video games, specifically "Racket Sports" and "Move Fitness" on the PlayStation Move console, was administered to sedentary, low-activity healthy adults. The results showed an increase in left leg knee extension and flexion strength, a reduction in body weight and BMI, and the potential for these games to serve as an alternative to traditional exercise. However, no significant improvements were observed in static balance and muscular endurance (except for right leg knee flexion).

We recommend that further studies should be planned, including genders, age groups, and chronic disease groups as well.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Enes Gürcan;* ***Design:*** *Enes Gürcan, Zekine Pündük;* ***Control/Supervision:*** *Zekine Pündük;* ***Data Collection and/or Processing:*** *Enes Gürcan, Zekine Pündük, Ertuğrul Çelik;* ***Analysis and/or Interpretation:*** *Enes Gürcan, Zekine Pündük;* ***Literature Review:*** *Enes Gürcan, Zekine Pündük, Ertuğrul Çelik;* ***Writing the Article:*** *Enes Gürcan, Zekine Pündük;* ***Critical Review:*** *Zekine Pündük.*

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