The Effect of Telerehabilitation-Based Structured Exercise Program on Posture, Pain, Fine Motor Skill, Hand Reaction, and Handgrip Strength in Adults with Video Game-Addiction: A Randomized Controlled Trial*

Hikmet UÇGUN**, Kaan Taha ÇEKİÇ***, Özlem AYGÜN****, Doğa Nur ERKEK*****, Fetihan METE******, Beyzanur KORKUTATA*******, Onur Barış UKİL********, Erdem Can TÜRKCAN*********

Abstract

Aim: Playing video-games is characterized by a sedentary lifestyle and may cause many musculoskeletal problems. This study aimed to investigate the effect of telerehabilitation-based structured exercise program in adults with video-game addiction.

Method: Forty-four adults with video-game addiction were included in the study. The participants were randomly divided into experimental group (EG, n=22) and control group (CG, n=22). A telerehabilitation-based structured exercise program was given to EG and a brochure-based exercise program was given to CG. Both groups performed the exercises three days a week for 8-weeks. Posture, pain, fine motor skill, hand reaction, and handgrip strength were assessed before and after program.

Results: Both the EG and CG achieved significant improvements in enhancing posture and hand reaction and reducing pain ($p<0.05$). The improvements in hand reaction and pain were higher in the EG ($p<0.05$). The handgrip strength significantly increased only in the EG ($p=0.014$). Both the EG and CG failed to improve fine motor skill ($p>0.05$).

Conclusion: The present findings showed that a structured exercise program was effective in improving posture, pain, and hand reaction, but the telerehabilitation-based method was superior to the brochure-

Özgün Araştırma Makalesi (Original Research Article)
Geliş / Received: 08.08.2024 & **Kabul / Accepted:** 11.11.2024
DOI: https://doi.org/10.38079/igusabder.1529388

* This study has been derived from the project titled "The effect of telerehabilitation-based exercise program in video game-addicted adults" which was prepared with BSc. Kaan Taha ÇEKİÇ, BSc. Özlem AYGÜN, BSc. Doğa Nur ERKEK, BSc. Fetihan METE, BSc. Beyzanur KORKUTATA, BSc. Onur Barış UKİL, and BSc. Erdem Can TÜRKCAN under the supervision of Asst. Prof. Hikmet UÇGUN within the framework of the Biruni University Graduation Project Course in 2023.

** (Corresponding Author) Asst. Prof., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Atlas University, Istanbul, Türkiye. E-mail: hikmetucgun92@gmail.com ORCID https://orcid.org/0000-0002-7211-1805
*** BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: kaancekicc@gmail.com ORCID https://orcid.org/0009-0009-5183-0796
**** BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: ozlemaygun2509@gmail.com ORCID https://orcid.org/0009-0006-8179-4210
***** BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: doga608@gmail.com ORCID https://orcid.org/0009-0000-1194-3491
****** BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: fetihanmetee@gmail.com ORCID https://orcid.org/0009-0009-5352-1735
******* BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: beyzakrktt@gmail.com ORCID https://orcid.org/0009-0002-7240-5894
******** BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: onurbarisukil@gmail.com ORCID https://orcid.org/0009-0002-3712-5854
********* BSc., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University, Istanbul, Türkiye. E-mail: turkcanerdemcan@gmail.com ORCID https://orcid.org/0009-0006-4663-2304

ETHICAL STATEMENT: The study received approval from the Biruni University Ethics Board (Approval number: 2015-KAEK-76-23-05 approval date:08.03.2023)

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

based method in improving pain and hand reaction. Furthermore, only the telerehabilitation-based exercise program was found to be successful in improving handgrip strength.

Keywords: Telerehabilitation, exercise, technology addiction, posture, pain, reaction time

Video Oyunu Bağımlılığı Olan Yetişkinlerde Telerehabilitasyon Tabanlı Yapılandırılmış Egzersiz Programının Postür, Ağrı, İnce Motor Beceri, El Reaksiyonu ve El Kavrama Kuvveti Üzerine Etkisi: Randomize Kontrollü Bir Çalışma

Öz

Amaç: Video oyunları oynamak hareketsiz bir yaşam tarzıyla karakterizedir ve birçok kas-iskelet sistemi sorununa neden olabilir. Bu çalışma, video oyunu bağımlılığı olan yetişkinlerde telerehabilitasyon tabanlı yapılandırılmış egzersiz programının etkisini araştırmayı amaçlamıştır.

Yöntem: Çalışmaya 44 video oyunu bağımlılığı olan yetişkin dahil edildilmiştir. Katılımcılar rastgele deney grubu (DG, n=22) ve kontrol grubu (KG, n=22) olarak ayrıldı. DG'ye telerehabilitasyon tabanlı yapılandırılmış bir egzersiz programı ve KG'ye broşür tabanlı bir egzersiz programı verilmiştir. Her iki grup da egzersizleri haftada üç gün, 8 hafta boyunca yapmıştır. Postür, ağrı, ince motor becerisi, el reaksiyonu ve el kavrama gücü programdan önce ve sonra değerlendirilmiştir.

Bulgular: Hem DG hem de KG, postür ve el reaksiyonunu iyileştirmede ve ağrıyı azaltmada önemli gelişmeler elde etmiştir ($p<0.05$). El reaksiyonu ve ağrıdaki gelişmeler DG'de daha yüksekti ($p<0,05$). El kavrama gücü yalnızca DG'de önemli ölçüde artmıştır ($p=0,014$). Hem DG hem de KG ince motor becerilerini geliştirmede başarısız olmuştur ($p>0,05$).

Sonuç: Mevcut bulgular, yapılandırılmış bir egzersiz programının postürü, ağrıyı ve el reaksiyonunu iyileştirmede etkili olduğunu, ancak telerehabilitasyon tabanlı yöntemin ağrıyı ve el reaksiyonunu iyileştirmede broşür tabanlı yöntemden üstün olduğunu göstermiştir. Dahası, yalnızca telerehabilitasyon tabanlı egzersiz programının el kavrama gücünü iyileştirmede başarılı olduğu bulunmuştur.

Anahtar Sözcükler: Telerehabilitasyon, egzersiz, teknoloji bağımlılığı, postür, ağrı, reaksiyon zamanı.

Introduction

Video gaming is a rapidly growing global industry, with nearly 3 billion players worldwide, including around 50% of the population in Europe and America[1,2]. Both the 11th revision of the International Classification of Diseases and the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders recognize gaming disorder, or video game addiction (VGA), as a pattern of uncontrolled gaming behavior. Adolescents and young adults using games to escape stress are particularly vulnerable to VGA, which can lead to physical and psychological health issues[3,4].

Video games are a screen-based activity, similar to watching TV or working at the computer, and such activities are characterized by long, continuous sitting times and physical inactivity. Such sedentary behavior is a well-known risk factor for morbidity, mortality, and non-communicable diseases[5]. In addition to prolonged sitting posture, playing video games requires fine motor skills, including repetitive movements of the arms, wrists, hands and fingers to maintain control of the game[6]. Physical inactivity, repetitive movements, long-term sitting and unilateral movements while sitting can lead to musculoskeletal disorders, especially in the upper limbs, trunk and neck[7]. It has also been shown that VGA may cause musculoskeletal and posture problems as well as emotional disturbances that impair reaction time[8].

Home exercise programs, including stretching, strengthening, and endurance exercises, have been reported to be effective in reducing neck pain and disability and improving functionality. It is also known that supervision contributes to improving adherence to the exercise program and that telerehabilitation can be an effective tool[9,10]. There are studies showing that telerehabilitation-based exercise programs reduce neck pain and improve function in musculoskeletal problems[11]. While studies on VGA mostly focus on investigating the effects of approaches such as behavioral therapy on addiction[12], a limited number of studies analyze the results of aerobic exercise or recreational activity programs in individuals with video game addiction[13,14]. Although it is reported in current reviews that gaming addiction is increasing and the effects of different therapeutic interventions should be studied[12,15], to the best of our knowledge, no study has investigated the effects of a telerehabilitation-based exercise program on adults addicted to video games. Given the prevalence of musculoskeletal issues commonly observed in adults with video-game addiction, it is anticipated that a structured exercise program emphasizing fundamental strengthening and stretching exercises may have a positive impact on outcome measures related to posture, pain, and dexterity[11-14].

We hypothesized that a structured exercise program delivered through telerehabilitation may result in greater improvements in posture, neck pain, fine motor skills, hand reaction, and handgrip strength compared to a home-based exercise program administered through a brochure in adults with video-game addiction. Therefore, the aim of this study was to examine the effects of a telerehabilitation-based structured exercise program on posture, neck pain, fine motor skill, hand reaction, and handgrip strength in adults with video-game addiction.

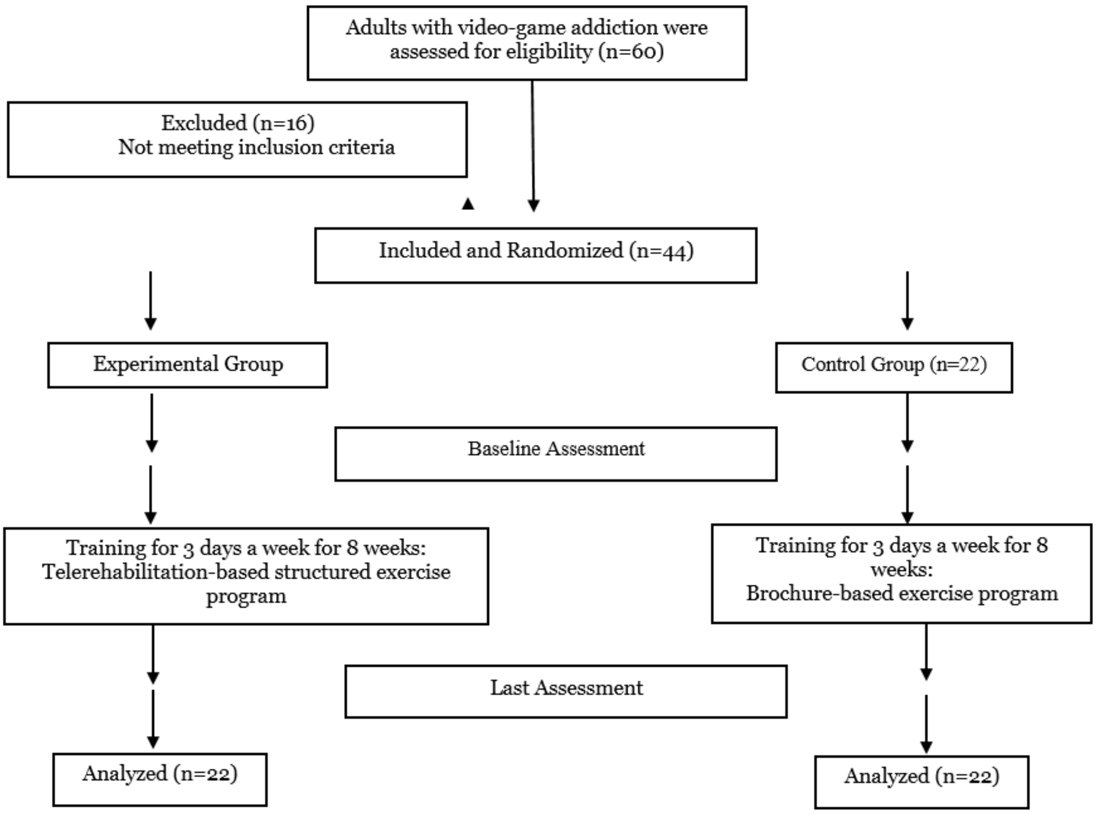
Material and Methods

Study design and participants

This was a prospective, single-blinded, randomized controlled study conducted between February and October 2023. The study was announced on the social media accounts of the authors, and letters of application were received from social media. Inclusion criteria were being between 18 and 40 years old, who scored ≥30 on the Game Addiction Inventory for Adults (GAIA), having high-speed internet, a camera, and a microphone, and volunteering to participate in the study. Exclusion criteria were having a neurological/orthopedic condition that would prevent exercise, having a cognitive impairment, and having a vision or hearing loss. The diagnosis of video game addiction employed in this study does not constitute a formal medical diagnosis but is instead defined as a pattern of uncontrolled gaming behavior. Individuals who achieved a GAIA score of 30 or higher were classified as exhibiting video game addiction. A total of 98 adults who play video games regularly were screened, of whom 60 adults with video-game addiction according to GAIA score were assessed for eligibility. Sixteen of them were excluded, and 44 volunteers were included in the study (Figure 1).

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Figure 1. Flow chart of the study



The participants were randomly assigned to either the experimental group (n=22) or the control group (n=22). This randomization was carried out using a computer-based random number table by an author who was not involved in the assessments or exercise programs of the participants. A computer-based randomization program (random.org) randomly divided numbers from 1 to 44 into two columns. The numbers in the first column represented the participants in the experimental group, and the numbers in the second column represented those in the control group. Each number from 1 to 44 was placed in opaque and identical envelopes, which were then sealed. Each participant was asked to choose one of the envelopes, and their group assignment was determined based on the number in the envelope they selected.

The study received approval from the Biruni University Ethics Board (approval number: 2015-KAEK-76-23-05, approval date:08.03.2023), and the study was registered to the ClinicalTrials.gov website (registration number: NCT06079489). It was conducted in accordance with the ethical principles for human research as outlined by the Declaration of Helsinki, and written informed consent was obtained from all participants.

Outcome Measures

All assessments were conducted face-to-face by the physiotherapists participating in the study in the Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Biruni University. The physical activity (PA) levels of the participants were assessed with the short form of the International Physical Activity Questionnaire (IPAQ)[16] included in the demographic and clinical information form. The PA levels were classified as follows: low (<600 MET-min/week), moderate (600-3000 MET-min/week), and high (>3000 MET-min/week).

Video Game-Addiction Assessment: Video-game addiction was assessed using the GAIA. The scale was developed to determine the game addiction of adults over the age of 18 and consists of 31 questions on a five-point Likert scale. It is scored between 0 and 4 as "(0) strongly disagree and (4) strongly agree" and the highest score that can be obtained from the scale is 124. Participants with a score of 30 and above are considered to be video-game addicted[17].

Postural Assessment: Posture assessment was performed in 2 directions, anterior-posterior and lateral, with the PostureZone v.1.6 (©BodyZone LLC, 2017)[18], a postural assessment software, using the photography analysis of the participants, which proved to be highly reliable[19,20]. The angles of deviations from the standard static posture were recorded with measurements made from 5 points of anterior-posterior analysis including head, trunk, and pelvis (right and left) and from 3 points of lateral analysis including head, trunk, and pelvis.

Pain Assessment: The intensity of neck pain was rated subjectively on a 10-cm visual analog scale (VAS), where 0-cm indicated “no pain” and 10-cm indicated “worst possible pain”[21].

Fine Motor Skill Assessment: Fine motor skill assessment of the patients showing hand and finger dexterity was performed with 9-Hole Peg Test (9HPT)[22]. The patients were asked to randomly place nine wooden pins on a 9-hole wooden block as fast as possible and then remove the pins one by one from the wooden block and place them in the storage section. The elapsed time was measured with a stopwatch and recorded in seconds.

Hand Reaction Assessment: Nelson Hand Reaction Test (NHRT) was performed by asking the participant, seated in a forearm-supported chair, while looking at a black dot in the center of a ruler, after the command "Ready", the ruler was released at a random moment and grab the ruler as soon as possible[23]. Twenty repetitions were performed, the 5 highest and lowest results were subtracted and the average of the remaining 10 measurements was recorded and he reaction time was calculated in seconds[24].

Handgrip Strength Assessment: To assess the handgrip strength a hand-held hydraulic JAMAR dynamometer (Model 5030 J1, Bolingbrook, IL, USA) was used. The measurement was made in the standing position with the upper limb straight at the elbow joint[25]. The best result obtained from 3 repetitions was selected for analysis. The results were recorded as kilograms (kg)[26].

Interventions

The control group received a brochure-based exercise program 3 days a week for 8 weeks. The brochure-based exercise program consisted of upper and lower extremity, neck and back stretching exercises[27] and calisthenic exercises for large muscle groups[28], which are recommended for healthy adults and can be easily performed at home. Each exercise session consisted of 10 minutes of warm-up-cool-down and 40 minutes of specific exercises. Correct sitting and standing positions and ergonomic materials were also explained in detail in the brochure. The participants were instructed to keep a diary for home sessions to improve adherence to brochure-based exercise program, and it was controlled at the end of the 8 weeks.

The experimental group received a telerehabilitation-based structured exercise program via synchronous video conferences with supervision of a physiotherapist 3 days a week for 8 weeks. Each exercise session consisted of 10 minutes of warm-up-cool-down and 40 minutes of specific exercises. Exercises were selected from the upper and lower extremities, neck and back stretching exercises[27] and calisthenic exercises for large muscle groups[28] which are recommended for healthy adults, and progressed by changing the frequency, duration, and variety within the program. Correct sitting and standing positions and ergonomic materials were also explained in detail at the first session and, if necessary, reminded in other sessions. Flexible session schedules were applied to ensure that participants attended all sessions and did not skip sessions as much as possible. Adherence (%) of both groups was defined as the ratio of the completed sessions to total sessions, which was calculated as "(completed sessions)/(total sessions) multiplied by 100."

Statistical analysis and sample size

Statistical analysis was performed using IBM SPSS v.26 (SPSS Inc.). The normality of the data distribution was assessed using the Shapiro–Wilk test. Categorical variables were compared between groups using the $\chi2$ test. For within-group comparisons, either the Paired Sample T-test or the Wilcoxon test was employed. For between-group comparisons, the Independent Samples T-test or the Mann-Whitney U test was used, depending on the distribution characteristics of the data. Cohen's d effect sizes were calculated for differences between groups. Results were deemed significant with p-values < 0.05.

The G*Power 3.1 (Universitaet Dusseldorf, Germany) software was used for the sample size calculation[29]. Based on the results of a study in the literature[30], we estimated a sample size of 20 adults for each group. The sample size calculation was made at 95% power and a two-tailed α level of 0.05 with the 1.176 effect size based on a comparison of the changes in the neck pain VAS values between the groups. Participants were included in the study by calculating the 10% increase in sample size adjusting for the drop-out rate.

Results

A total of 44 participants were randomized and divided into two groups: experimental group (n=22; 24.32±5.24 years) and control group (n=22; 24.91±7.54 years). Demographics and clinical characteristics of participants are shown in Table 1. Both groups' weekly video game play time and GAIA scores were similar. Adherence (%) to exercise program was 96.2±20.3 in experimental group and 94.4±13.1 in control group, with no between-group difference (p=0.782).

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Table 1. The demographic and clinical characteristics of the participants.

	Experimental Group (n=22)	Control Group (n=22)	p value
Age (years)	24.32±5.24	24.91±7.54	0.595
Gender			
Female	10 (45.5%)	10 (45.5%)	1.000
Male	12 (54.4%)	12 (54.4%)	
Body composition			
Weight (kg)	70.64±11.93	72.23±13.28	0.724
Height (cm)	171.77±8.37	174.59±9.28	0.264
Body mass index (kg/m²)	23.90±3.68	23.21±3.68	0.392
Smokers			
Yes	13 (59.1%)	19 (86.4%)	0.088
No	9 (40.9%)	3 (13.6%)	
Occupation			
Student	15 (68.2%)	14 (63.6%)	0.596
Employee	7 (31.8%)	7 (31.8%)	
Non-employee	0	1 (4.5%)	
Physical Activity Level			
High	1 (4.5%)	0	0.607
Moderate	20 (91%)	19 (86.4%)	
Low	1 (4.5%)	3 (13.6%)	
Weekly Video Game Play Time (hours)	16.14±11.39	21.50±16.57	0.280
GAIA Score	62.05±21.34	71.64±15.93	0.082

Data are presented as mean ± standard deviation or n (%).

Abbreviations: cm: centimeter; GAIA: Game Addiction Inventory for Adults; kg: kilogram.

The comparison of the baseline values in postural assessment, pain assessment, fine motor skill assessment, hand reaction assessment, and handgrip strength assessment between experimental and control groups are presented in Table 2. There was no significant difference between the baseline values of the groups ($p>0.05$).

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Table 2. Comparison of the baseline values in the assessment of posture, pain, fine motor skill, hand reaction, and handgrip strength between experimental and control groups.

	Experimental Group (n=22)	Control Group (n=22)	p	95% CI
	Baseline	**Baseline**		
Postural Assessment				
Anterior-Posterior Analysis				
Head (°)	1.01±1.01	0.89±0.59	0.832	-0.38 - 0.67
Trunk (Right) (°)	7.55±2.32	7.87±1.85	0.605	-1.59 - 0.96
Trunk (Left) (°)	8.69±1.42	8.42±1.71	0.622	-0.68 - 1.23
Pelvis (Right) (°)	9.26±2.67	9.48±2.32	0.769	-1.74 - 1.30
Pelvis (Left) (°)	9.64±2.21	9.97±2.28	0.907	-1.35 - 1.38
Lateral Analysis				
Head (°)	1.56±1.22	1.29±0.83	0.681	-0.36 - 0.91
Trunk (°)	2.09±1.41	2.65±1.65	0.213	-1.49 - 0.38
Pelvis (°)	1.41±1.02	1.45±1.34	0.823	-0.76 - 0.69
Pain Assessment				
VAS (0-10)	5.27±1.77	4.59±2.48	0.399	-0.63 - 1.99
Fine Motor Skill Assessment				
9-Hole Peg Test (s)	15.36±2.15	15.50±2.36	0.981	-1.51 - 1.24
Hand Reaction Assessment				
Nelson Hand Reaction Test (s)	14.02±2.96	14.86±2.70	0.565	-1.78 - 2.30
Handgrip Strength Assessment				
Jamar Handgrip Strength (kg)	35.38±15.77	38.22±20.54	0.842	-14.00 - 8.32

Data are presented as mean±SD.

Abbreviations: °: degree; CI: confidence interval; kg: kilograms; s: second; VAS: Visual Analogue Scale.

The comparison of in-group and inter-group changes in in the assessment of posture, pain, fine motor skill, hand reaction, and handgrip strength between experimental and control groups are given in Table 3. No significant improvement was achieved in post-treatment scores of fine motor skill assessment in any group ($p>0.05$). A significant difference was found in the post-treatment values of anterior-posterior trunk and pelvis scores and lateral trunk score in both the experimental and control groups after compared to the pre-treatment values ($p<0.05$). However, the changes on postural problems of both two groups were not superior to each other.

A significant improvement was detected in assessment scores of pain and hand reaction in both groups. However, the improvement in pain and hand reaction were significantly higher in the experimental group compared to the control group, having a medium effect size for the difference ($p=0.044$; $d_{cohen}=-0.72$; $p=0.022$; $d_{cohen}=-0.49$, respectively). The

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

handgrip strength increased significantly only in the experimental group (p=0.014) and was significantly higher with a medium effect size compared to the change in the control group (p=0.037; d_{cohen}=-0.36).

Table 3. Comparison of in-group and inter-group changes in in the assessment of posture, pain, fine motor skill, hand reaction, and handgrip strength between experimental and control groups

	Experimental Group (n=22)				**Control Group (n=22)**				**Inter-group Change (Δ)**	**Effect Size**
	Pre-treatment	**Post-treatment**	**In-group Change (Δ)**	**p**	**Pre-treatment**	**Post-treatment**	**In-group Change (Δ)**	**p**	**p**	**Cohen's d**
Postural Assessment										
AP Analysis										
Head (°)	1.01±1.01	1.05±1.04	0.03±0.22	0.528	0.89±0.59	0.86±0.66	-0.02±0.27	0.518	0.481	0.08
Trunk (Right)(°)	7.55±2.32	5.59±2.52	-1.96±2.10	**<0.001**	7.87±1.85	6.44±1.98	-1.43±0.67	**<0.001**	0.459	-0.24
Trunk (Left) (°)	8.69±1.42	7.43±1.40	-1.26±0.83	**<0.001**	8.42±1.71	6.82±2.08	-1.59±1.82	**<0.001**	0.972	0.21
Pelvis (Right)(°)	9.26±2.67	8.39±3.00	-0.86±2.57	**<0.001**	9.48±2.32	8.78±2.88	-0.70±2.13	**0.020**	0.471	-0.06
Pelvis (Left) (°)	9.64±2.21	9.38±2.13	-0.26±0.39	**0.007**	9.97±2.28	9.36±2.41	-0.26±0.45	**0.002**	0.501	0.15
Lateral Analysis										
Head (°)	1.56±1.22	1.69±1.23	0.12±0.83	0.861	1.29±0.83	1.20±0.74	-0.08±0.35	0.431	0.785	0.20
Trunk (°)	2.09±1.41	1.09±0.92	-1.00±0.59	**<0.001**	2.65±1.65	1.64±1.34	-1.00±0.64	**<0.001**	0.760	0.01
Pelvis (°)	1.41±1.02	1.46±0.85	0.05±0.31	0.240	1.45±1.34	1.48±1.23	0.02±0.26	0.553	0.619	0.01
Pain Assessment										
VAS (0-10)	5.27±1.77	1.64±1.17	-3.83±1.70	**<0.001**	4.59±2.48	2.55±2.40	-3.00±1.96	**<0.001**	**0.044**	**-0.72**
Fine Motor Skill Assessment										
9-Hole Peg Test (s)	15.36±2.15	15.20±2.19	-0.15±1.73	0.485	15.50±2.36	15.49±1.76	-0.00±1.68	0.733	0.742	-0.06
Hand Reaction Assessment										
Nelson Hand Reaction Test (s)	14.02±2.96	12.07±2.99	-1.47±0.30	**0.001**	14.86±2.70	13.77±3.70	-0.90±0.95	**0.041**	**0.022**	**-0.49**
Handgrip Strength Assessment										
Jamar Handgrip Strength (kg)	35.38±15.77	36.91±16.21	1.52±2.62	**0.014**	38.22±20.54	38.60±20.45	0.38±1.96	0.289	**0.037**	**0.36**

Data are presented as mean±SD.

Abbreviations: °: degree; AP: anterior-posterior; kg: kilograms; s: second; VAS: Visual Analogue Scale.

Discussion

The present study showed that both the experimental group who received the telerehabilitation-based structured exercise program and the control group who received the brochure-based exercise program achieved significant improvements in enhancing posture and hand reaction and reducing pain. The improvements in hand reaction and pain were higher in the experimental group compared to the control group. Moreover,

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

only the experimental group showed significant improvement in handgrip strength, whereas both the experimental and control groups failed to improve fine motor skill.

It has been shown that poor neck, spine, and pelvis posture are frequently seen in individuals with VGA, smartphone users, and esports players[4,31]. However, the number of studies investigating the effect of exercise-based approaches on posture problems in individuals with VGA is limited. Several systematic reviews have revealed that exercise applications are effective in improving postural problems in both healthy individuals and smartphone users[32,33]. Harman et al. showed that a structured home-based exercise program including stretching and strengthening exercises was effective in improving postural disorders in the neck and trunk[34]. Similarly, Proskura et al. reported that an individualized exercise program was effective in improving posture in individuals with lumbar and pelvic disorders who were working in a seated position[35]. The authors conclude that, considering the relationship between postural problems and prolonged sitting in poor posture, weakened and shortened muscles play a primary role in the emerging of these problems. Our findings showing that a structured exercise program including specific stretching and strengthening exercises was effective in the improvement of posture are consistent with the literature. The fact that the telerehabilitation-based approach did not provide an additional benefit may be associated with the high and similar adherence to the exercise program of both groups.

The complaint of neck pain is common among individuals who play video games for a long time, with a reported incidence of approximately 35% to 42%[36]. Considering that chronic musculoskeletal pain with a VAS value between 3.5 and 7.4 is defined as moderate pain[37], the fact that the baseline VAS value of the participants included in our study was approximately 5 confirms that neck pain is a major problem in adults with video-game addiction. In recent studies in which telerehabilitation-based structured exercise programs were given to individuals with chronic neck pain, significant improvement in neck pain was obtained, but the telerehabilitation was not found to be superior to other unsupervised methods[38,39]. On the other hand, in another two randomized controlled studies investigating the effect of telerehabilitation-based exercise program in office workers and adults with chronic neck pain, telerehabilitation was found to be effective in reducing neck pain and superior to other home-based interventions[40,41]. Among these studies that are methodologically similar to each other and to our study, it is seen that telerehabilitation is superior to other home-based programs in those that include correct posture and ergonomics recommendations. In this study, reminding the participants in the experimental group of the importance and implementation of relevant recommendations in the sessions they needed may have played a role in the telerehabilitation-based structured exercise program having further improvement, especially in relieving neck pain related to poor posture.

Video game players need to react as quickly and accurately as possible to different visual and auditory stimuli. An incorrect or delayed reaction can lead to the player's defeat within a few seconds. Therefore, it is essential for players to have improved fine motor skills and reaction times so that they can perform better[42,43]. In a recent study, it was revealed that reaction time was prolonged in adolescents who played video games for a long time, and regular physical activity was effective in reducing reaction time[44].

Likewise, a current review reported that various exercise programs were effective in improving performance parameters, including reaction time, in e-sports players and that performing the exercises with high motivation and participation played a key role[45]. Similarly, a structured exercise program was found to be effective in improving hand reaction, and telerehabilitation, which increased motivation and participation, was shown to provide further enhancement in the present study.

Borecki et al. reported that computer games have a positive effect on psychomotor function and are effective in the improvement of fine motor skills and movement coordination in adults who play computer games for a long-time[6]. The effect of different types of exercise on fine motor skill has been investigated in a limited number of studies and is still inconclusive[46]. Exercise programs involving stretching and strengthening mostly have positive effects on grip strength, while specific exercises, including task-oriented activities to improve cognitive function and motor coordination, are needed to improve fine motor skills[46,47]. The lack of any improvement in fine motor skills in both groups in our study may be attributed to both exercise programs that did not include any hand-dexterity-specific activity and the participants with developed motor skills.

To improve handgrip strength, it is essential that individuals perform upper limb strengthening exercises repetitively. The ability of intense, repetitive, and task-orientated exercises to increase grip strength is based on the principles of neuroplasticity[48]. Consistent with the studies showing that telerehabilitation is more effective than home-based and paper-based applications[49-51], handgrip strength improved only in the experimental group in the present study. Digital delivery of exercise programs may lead to greater improvement compared to home-based practices as it facilitates access, ensures continuity, increases participation and motivation[48,52]. Additionally, the supervised nature of the telerehabilitation sessions may have facilitated explaining, observing, guiding, and correcting movements through lively dialogues.

Given that studies investigating the effect of exercise in adults with video game addiction are limited, the lack of a third group that was not given any exercise program is a limitation of the present study. Another limitation is that this study did not include long-term follow-up, which would be important to investigate in future studies.

Conclusion

To our knowledge, this is the first study to examine the impact of a telerehabilitation-based structured exercise program on adults with video-game addiction. The present findings showed that a structured exercise program was effective in improving posture, pain and hand reaction, but the telerehabilitation-based method was superior to the brochure-based method in improving pain and hand reaction. Furthermore, only the telerehabilitation-based exercise program was found to be successful in improving handgrip strength. Future studies may focus on comprehensive assessment of individuals with VGA and longer-term follow-up.

Acknowledgments

The authors thank all the participants who volunteered to participate the study.

Funding Information

This study has not received any funding.

REFERENCES

1. Wittek CT, Finserås TR, Pallesen S, et al. Prevalence and predictors of video game addiction: a study based on a national representative sample of gamers. *Int J Ment Health Addict*. 2016;14(5):672-686.
2. Limone P, Ragni B, Toto GA. The epidemiology and effects of video game addiction: A systematic review and meta-analysis. *Acta Psychol (Amst)*. 2023;241:104047.
3. Saunders JB, Hao W, Long J, et al. Gaming disorder: Its delineation as an important condition for diagnosis, management, and prevention. *J Behav Addict*. 2017;6(3):271-279.
4. Satish Kumar CR, Sharma MK, Amudhan S, et al. Digital gaming, musculoskeletal, and related health hazards among adolescents and young adults. *Indian J Psychiatry*. 2023;65(6):698-700.
5. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*. 2017;14(1):75.
6. Borecki L, Tolstych K, Pokorski M. Computer games and fine motor skills. *Adv Exp Med Biol*. 2013;755:343-348.
7. Jalink MB, Heineman E, Pierie JP, ten Cate Hoedemaker HO. Nintendo related injuries and other problems: review. *BMJ*. 2014;349:g7267.
8. Weinstein AM. Computer and video game addiction a comparison between game users and non-game users. *The American Journal of Drug and Alcohol Abuse*. 2010;36(5):268-276.
9. Zronek M, Sanker H, Newcomb J, Donaldson M. The influence of home exercise programs for patients with non-specific or specific neck pain: a systematic review of the literature. *J Man Manip Ther*. 2016;24(2):62-73.
10. Bachmann C, Oesch P, Bachmann S. Recommendations for improving adherence to home-based exercise: a systematic review. *Physikalische Medizin, Rehabilitationsmedizin, Kurortmedizin*. 2018;28(01):20-31.
11. Cottrell MA, Galea OA, O'Leary SP, et al. Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: a systematic review and meta-analysis. *Clin Rehabil*. 2017;31(5):625-638.
12. Chen Y, Lu J, Wang L, Gao X. Effective interventions for gaming disorder: A systematic review of randomized control trials. *Front Psychiatry*. 2023;14:1098922.

13. Maden Ç, Bayramlar K, Arıcak OT, Yagli NV. Effects of virtual Reality-Based Training and aerobic training on gaming disorder, physical activity, physical fitness, and anxiety: A randomized, controlled trial. *Mental Health and Physical Activity*. 2022;23:100465.
14. Mumcu HE, Yazici ÖF, Yilmaz O. Effect of 12-week recreational activity program on digital game addiction and peer relationships qualities in children. *Acta Medica*. 2021;37:2919.
15. Danielsen PA, Mentzoni RA, Låg T. Treatment effects of therapeutic interventions for gaming disorder: A systematic review and meta-analysis. *Addict Behav*. 2023;149:107887.
16. Saglam M, Arikan H, Savci S, et al. International physical activity questionnaire: reliability and validity of the Turkish version. *Percept Mot Skills*. 2010;111(1):278-284.
17. Wong U, Hodgins DC. Development of the game addiction inventory for adults (GAIA). *Addiction Research & Theory*. 2014;22(3):195-209.
18. BodyZone. PostureZone. https://bodyzone.com/posturezone/. Published 2017. Accessed 25 August 2024.
19. Pausić J, Pedisić Z, Dizdar D. Reliability of a photographic method for assessing standing posture of elementary school students. *J Manipulative Physiol Ther*. 2010;33(6):425-431.
20. Boland DM, Neufeld EV, Ruddell J, et al. Inter- and intra-rater agreement of static posture analysis using a mobile application. *J Phys Ther Sci*. 2016;28(12):3398-3402.
21. Huskisson EC. Measurement of pain. *Lancet*. 1974;2(7889):1127-1131.
22. Oxford Grice K, Vogel KA, Le V, et al. Adult norms for a commercially available Nine Hole Peg Test for finger dexterity. *Am J Occup Ther*. 2003;57(5):570-573.
23. Nelson RJ, McCandlish CA, Douglas VD. Reaction times for hand movements made in response to visual versus vibratory cues. *Somatosens Mot Res*. 1990;7(3):337-352.
24. Ángel Latorre-Roman P, Robles-Fuentes A, García-Pinillos F, Salas-Sánchez J. Reaction times of preschool children on the ruler drop test: a cross-sectional study with reference values. *Percept Mot Skills*. 2018;125(5):866-878.
25. Hillman TE, Nunes QM, Hornby ST, et al. A practical posture for hand grip dynamometry in the clinical setting. *Clin Nutr*. 2005;24(2):224-228.
26. Rantanen T, Guralnik JM, Foley D, et al. Midlife hand grip strength as a predictor of old age disability. *JAMA*. 1999;281(6):558-560.
27. Hess JA, Hecker S. Stretching at work for injury prevention: issues, evidence, and recommendations. *Appl Occup Environ Hyg*. 2003;18(5):331-338.
28. Thompson PD, Arena R, Riebe D, Pescatello LS. ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription, ninth edition. *Curr Sports Med Rep*. 2013;12(4):215-217.
29. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39(2):175-191.

30. Tunwattanapong P, Kongkasuwan R, Kuptniratsaikul V. The effectiveness of a neck and shoulder stretching exercise program among office workers with neck pain: a randomized controlled trial. *Clin Rehabil*. 2016;30(1):64-72.

31. Lam WK, Liu RT, Chen B, et al. Health risks and musculoskeletal problems of elite mobile esports players: a cross-sectional descriptive study. *Sports Med Open*. 2022;8(1):65.

32. Kim H. Exercise rehabilitation for smartphone addiction. *J Exerc Rehabil*. 2013;9(6):500-505.

33. Bayattork M, Sköld MB, Sundstrup E, Andersen LL. Exercise interventions to improve postural malalignments in head, neck, and trunk among adolescents, adults, and older people: systematic review of randomized controlled trials. *J Exerc Rehabil*. 2020;16(1):36-48.

34. Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. *Journal of Manual & Manipulative Therapy*. 2005;13(3):163-176.

35. Proskura P, Rutkowska-Kucharska A, Sobera M. Evaluation of the effects of a novel exercise program in the treatment of low back pain in women working in a seated position: A randomized trial. *J Back Musculoskelet Rehabil*. 2023;36(4):845-859.

36. Palanichamy T, Sharma MK, Sahu M, Kanchana DM. Influence of Esports on stress: A systematic review. *Ind Psychiatry J*. 2020;29(2):191-199.

37. Boonstra AM, Schiphorst Preuper HR, Balk GA, Stewart RE. Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. *Pain*. 2014;155(12):2545-2550.

38. Özel M, Kaya Ciddi P. The effectiveness of telerehabilitation-based structured exercise therapy for chronic nonspecific neck pain: A randomized controlled trial. *J Telemed Telecare*. 2022:1357633x221095782.

39. Özden F, Özkeskin M, Tümtürk İ, Yalın Kılınç C. The effect of exercise and education combination via telerehabilitation in patients with chronic neck pain: A randomized controlled trial. *Int J Med Inform*. 2023;180:105281.

40. Özlü A, Ünver G, Tuna H, Erdoğan A. Effects of interactive telerehabilitation practices in office workers with chronic nonspecific neck pain: randomized controlled study. *Telemed JE Health*. 2024;30(2):438-447.

41. Abadiyan F, Hadadnezhad M, Khosrokiani Z, et al. Adding a smartphone app to global postural re-education to improve neck pain, posture, quality of life, and endurance in people with nonspecific neck pain: a randomized controlled trial. *Trials*. 2021;22(1):274.

42. Jiang C, Kundu A, Claypool M. Game Player Response Times versus Task Dexterity and Decision Complexity. *In: Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play*. 2020:277-281.

43. Kowal M, Toth AJ, Exton C, Campbell MJ. Different cognitive abilities displayed by action video gamers and non-gamers. *Computers in Human Behavior*. 2018;88:255-262.

44. Klasnja A, Milenovic N, Lukac S, et al. The effects of regular physical activity and playing video games on reaction time in adolescents. *Int J Environ Res Public Health*. 2022;19(15): 9278.
45. McNulty C, Jenny SE, Leis O, et al. Physical exercise and performance in esports players: an initial systematic review. *Journal of Electronic Gaming and Esports*. 2023;1(1):1-11.
46. Brorsson S, Nilsdotter A, Thorstensson C, Bremander A. Differences in muscle activity during hand-dexterity tasks between women with arthritis and a healthy reference group. *BMC Musculoskelet Disord*. 2014;15:154.
47. Knatauskaitė J, Pukėnas K, Trinkūnienė L, Budde H. Effects of different types of exercise training on fine motor skills and testosterone concentration in adolescents: a cluster randomized controlled trial. *Int J Environ Res Public Health*. 2021;18(16): 8243.
48. James S, Conrad M, Sengupta S. Development of an innovative telerehabilitation system to improve handgrip strength. *Int J Telerehabil*. 2022;14(2):e6497.
49. Turan Z, Topaloglu M, Ozyemisci Taskiran O. Is tele-rehabilitation superior to home exercise program in COVID-19 survivors following discharge from intensive care unit? - A study protocol of a randomized controlled trial. *Physiother Res Int*. 2021;26(4):e1920.
50. Kenis-Coskun O, Imamoglu S, Karamancioglu B, et al. Comparison of telerehabilitation versus home-based video exercise in patients with Duchenne muscular dystrophy: a single-blind randomized study. *Acta Neurol Belg*. 2022;122(5):1269-1280.
51. Suero-Pineda A, Oliva-Pascual-Vaca Á, Durán MR, et al. Effectiveness of a telerehabilitation tablet app in combination with face-to-face physiotherapy for people with wrist, hand or finger injuries: A pragmatic multicentre clinical trial. *J Telemed Telecare*. 2023:1357633x231172245.
52. Costa F, Janela D, Molinos M, et al. Impacts of digital care programs for musculoskeletal conditions on depression and work productivity: longitudinal cohort study. *J Med Internet Res*. 2022;24(7):e38942.