Clinical and Experimental Health Sciences

Comparison of Reaction Time, Manual Dexterity, and Working Memory Levels of Adolescent Video Game Players and Non-Players

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ABSTRACT

Objective: This study aims to examine differences between adolescent video game players and non-players in terms of their reaction time, manual dexterity, and working memory levels.

Methods: The sample of the study, which has a comparative cross-sectional design type, consists of 432 adolescents at the grades between 9 and 12. Non-video game players, and video game players were subjected to simple visual and auditory reaction time tests, manual dexterity tests, matrix, and digit span working memory test.

Results: Compared to non-video game players, video game players were found to have shorter visual and auditory reaction times. Also, several motor dexterity subtest skills of video game players were found to be lower, while working memory did not differ between the two groups.

Conclusion: Our findings support the idea that playing video games seem to improve some aspects of cognitive and motor skills but reduce several other aspects.

Keywords: adolescent, manual dexterity, reaction time, working memory, video game

1. INTRODUCTION

The video game industry, which constitutes an important part of the media with a consumption figure of $160 billion across the world, has continued to grow each passing day (1). Among the reasons for this growth are many factors such as interaction, and interactive communication, experiencing the feeling of power and success, and easy access. Although there are players from all age groups, the use of video games by children and young people has been increasing day by day, while the playing age has been decreasing (2). Particularly, there is a significant increase in the percentage of young people who follow up technological developments for using the technological tools and possessing them, and the games that contain physical activities have been replaced by passive/video games played while sitting at a desk.

In the literature, playing video games without overdoing has been considered normal as part of a healthy lifestyle and having positive effects such as emotional relaxation (3). However, in some studies, it is stated that playing video games intensely and uncontrollably causes problems in the individual's social and family relationships, academic performance, and psycho-social functions (4). Although there are several discussions in the literature about the effects of video games, there is no consensus (5).

Notably, the interest in the potential effects of these games on our daily lives, particularly, on cognitive skills has increased with the increasing popularity of video games. These studies focused particularly on how action and first-person shooter games change/affect the basic sensory and perceptual processes that support cognition (6-8). Some studies reported that video game players (VGPs) demonstrated better performance than non-video game players (NVGPs) in selective attention, working memory, visual-spatial attention, and attentional control tests (9-11). On the other hand, other studies stated that there was no difference between groups considering the comparison between the cognitive skill variables of VGPs and NVGPs (12, 13). Although several studies in the literature examined the relationship between playing video games and cognitive and

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motor skills, a clear perspective has not emerged. The data show that playing video games has positive effects on some cognitive functions while negative effects on others (13, 14).

Also, some researchers have emphasized that the studies comparing VGPs and NVGPs had some methodological and statistical problems. They reported that the possibility of Type 1 errors may be high since many of these studies were carried out with very small samples (e.g. groups with less than 7-8 samples) (13, 15). Moreover, Unsworth et al. (13) emphasize the importance of simultaneous measurement of multiple cognitive functions in their article, which examines the relationship between video game experience and cognitive skills. More research is needed to test whether there is a relationship between playing video games and cognitive functions (8,13). Due to the methodological inadequacies in the studies and their inconsistent results and since several cognitive skills have not been studied yet, there are large gaps on this issue in the literature (8, 9). This study compares adolescent video game players and non-players in terms of their reaction time, manual dexterity, and working memory levels. The present research seeks to find an answer to the following two questions: "Is there a difference between adolescent VGPs and NVGPs in terms of their reaction time, manual dexterity, and working memory levels?" and "Do time spent playing video games and the duration of regularly playing video games in years have a correlation with adolescents's reaction time, motor skill, and working memory levels?".

2. METHOD

2.1. Design and Participants

The study, which has a comparative cross-sectional design type, population consists of 17 schools affiliated to the Provincial Directorate of National Education in Tekirdağ, Turkey. These schools are listed by numbering. These schools are listed by numbering. Then, a school was determined by random selection from these schools using the https://www.random.org/ online program. In this school, 1122 students' study at the grades between 9 and 12. The study included 487 students whose families gave explicit consent. The students, who voluntarily participated in the study, had no neurological or orthopedic disease, and no upper extremity injuries or surgeries. Existing vision and hearing problems of students may prevent them from showing their real performance in the tests to be done in the research. For this reason, before starting the study, the eyes test with the Snellen Chart, the whisper test and the hearing test with the Rinne test were applied to the students. Fifty-five students were excluded from the study based on the results while students whose problems were not detected in these tests were included in the study. The video-game playing time of the remaining 432 students was determined using a sociodemographic and gaming-related behaviors survey form. Students were asked the following questions: "How many hours do you have to play on a weekday?" and "How many hours do you play games in a weekend day? According to the answers, students were grouped as VGPs and NVGPs. Those who played seven hours a week or more (277 students – 62 females and 215 males) were classified as VGPs. On the other hand, those playing one hour a week or less (155 students – 134 females and 21 males) were classified as NVGPs. Students who played between 1-7 hours a week (as the VGP cutoff values determined by several previous studies (16,17) were not included in the study. Recruitment and testing took place between January-June 2019.

2.2. Instruments

Sociodemographic and Gaming-Related Behaviors Survey Form: The form was created by researchers by examining the relevant literature (16,17). The form includes questions about the student's age, gender, daily video game playing time on weekdays and weekends, and the duration of regularly playing video games in years.

Simple Visual and Auditory Reaction Time: The participants' visual reaction time (VRT) and auditory reaction time (ART) were determined using special online applications developed for reaction time measurement (VRT: www.humanbenchmark.com; ART: cognitivefun.net) (as used in several previous studies: Brewin et al. (18); Pancar et al. (19). In the visual reaction time measurement, the participants were asked to turn off the light by pressing the mouse with the index finger of the dominant hand as soon as possible when a green color was displayed on the screen. In the measurement of auditory reaction time, the participants were asked to press the mouse as soon as they heard the sound. Five tests were carried out to measure both reaction times, and the average time was recorded in milliseconds as per Brewin et al. (18), and Pancar et al. (19).

Manual Dexterity Test: Manual dexterity of the participants was evaluated using the Purdue Pegboard Test (Layfayette instruments, model 3202). The Purdue Pegboard Test, which was developed by Tiffin and Asher, measures the pin placement speed and the number of hands and fingers used to determine the manual dexterity level. In this study, the following four manual dexterity subtests were used 1 – right hand (30 sec.), 2 – left hand (30 sec.), 3 – both hands (30 sec.), and 4 – assembly (60 sec.). The right-hand and left-hand subtest requires the participant to place as many pins as possible in the slot within thirty seconds. The score indicates the number of pins correctly placed. The final score is the number of pins inserted. In both hands subtest, the time is limited to thirty seconds, and the left and right hands are used simultaneously to insert pins into the slots in both columns. The score shows the number of pin pairs inserted. The total time for the assembly subtest is one minute and the participant is required to assemble four parts to complete the assembly. This score represents the number of pieces assembled (i.e., pin, washer, collar, second washer). The implementation of the tests was carried out according to the principles in the user manual (retrieved from http://www.limef.com/downloads/MAN-32020A-forpdf-rev0.pdf).

Working Memory Test (WM): The computer-aided online Matrix Memory Test and Digit Span Test were used to determine the working memory capacity of the participants (www.humanbenchmark.com). Matrix memory test is used to measure visual-spatial working memory relying on passive storage. A computerized version (www.humanbenchmark.com) of the matrix memory task was included. White and black grid patterns are displayed in a random order for 1000 milliseconds each. The participants are required to remember the locations of the black squares. Subsequently, the black squares disappear before the grid appears. Then, the participants are required to determine whether black squares are located in the same positions. The evaluation is completed when they cannot remember the pattern correctly (they have the right to make 3 mistakes); then, the test level of the participant is determined. A high level indicates that visual-spatial working memory is high (20). On the other hand, the Digit Span Test is used to measure working memory's number storage capacity. Participants see a sequence of numerical digits and are tasked to recall the sequence correctly. They are tested with increasingly longer sequences in each trial. The participant's span is the longest number of sequential digits that s/he can accurately recall (https://www.cambridgebrainsciences.com/science/tasks/digit-span).

2.3. Data Collection

A free and quiet room that would not distract students was arranged to apply the tests. The students participating in the study were accepted to room one by one. Students first completed reaction-time and working-memory tests. These tests were controlled by a PC attached to a 17-inch monitor (96 dpi with a refresh rate of 120 Hz). Participants were seated approximately 0.5 m from the screen. They were informed about the implementation of each test and asked to try it once. The test was completed after three inaccurate responses, and the average visual and auditory reaction times were determined in milliseconds. Participants were allowed to take a short break (maximum 5 min) between tests. In the second stage, the participant moved to the area where the Purdue Pegboard Test would be performed. Each subtest (30 sec for right/left hand and both hands; 60 sec for assembly subtest) was performed using a stopwatch. After each test, participants were told how many pins s/he had placed. Then, the researchers recorded the results.

2.4. Data Analysis

The data were analyzed using IBM SPSS Statistics 22 software package for Windows. Descriptive statistics, mean comparisons, and bivariate correlations were conducted. The normality of the parameters was evaluated using the Kolmogorov-Smirnov Test and Shapiro-Wilk Test. Since the sample was found to be normally distributed, the Student's t-test was carried out to analyze the possible significant differences between the groups. The correlations between variables, such as video game playing time, duration of regularly playing video games in years, visual and auditory reaction time, manual dexterity, visual working memory, were analyzed using Pearson`s product-moment correlation coefficient. The significance level was set p = .05.

2.5. Ethics

After ethical approval was granted by the Namik Kemal University Faculty of Medicine Ethical Committee (Project Date/Number: 2018.177.12.11), permission to carry out the study was given by the Provincial Directorate of National Education. The researchers and the students who participated in the study did not know which VGP or NVGP group they were in.

3. RESULTS

The average age of VGPs (n=277) is 15.71±1.20, 77.6% of them are male (n=215), and their average playing time is 5.13±3.07 h per day. The average duration of regularly playing video games is 5.18±3.32 years. On the other hand, the average age of NVGPs (n=155) is 15.93±1.21, 86.5% of them are female (n=134), and their average playing time is .004±.03 h per day. No significant difference was found between groups in terms of the age variable (*t: 1.778, p=.076*, N.S.) (Table 1).

Comparing the reaction time, working memory, and motor skills of adolescents, a significant difference was found in favor of VGPs for visual (341.21±36.73, t = 3.942, p < .01) and auditory reaction time (214.97±44.06, t = 3.368, p < .01*).* Manual dexterity subtest scores of NVGPs were found to be significantly higher than those of VGPs right hand (14.92±1.81, t = 3.057, p < .05) and both hands (22.43±3.02, t = 2.220, p < .05) (Table 2). No significant difference was found between groups according to matrix memory test (t = – .991, p = .322, N.S.), digit span test *(t* = – 1.600, p = .110, N.S.), and left hand *(t* = .766*, p* = .444*,* N.S.) and assembly manual dexterity subtest (t = 1.573*, p* = .116*,* N.S.).

A negative correlation was found between the average time that adolescents devote to playing video games per day, and the subtest scores of VRT (r(430) = – .112, p < .05) and ART (r(430) = – .146, p < .01*),* right hand (r(430) = – .173, p < .01) and both hands (r(430) = – .123, p < .05) motor dexterity. Adolescents' duration of regularly playing video games in years was found to have negative correlations with their subtest scores of visual (r(430) = – .156, p < .01) and auditory reaction times (r(430) = – .118, p < .05), right hand (r(430) = – .114, p < .05), both hands (r(430) = – .160, p < .01), assembly (r(430) = – .140, p < .01), and motor dexterity. Moreover, a positive correlation was found between WM-Matrix Memory test (r(430) = .102, p < .05) scores and the duration of regularly playing video games in years by adolescents (Table 3).

Table 1. *Features of adolescents about sociodemographic and gaming-related behaviors of VGPs and NVGPs (n=432)*

	VGPs		NVGPs				
	n(%)	Mean±SD	n(%)	Mean±SD	*t*	*p*	*d*
Age		15.71± 1.20		15.93± 1.21	*1.778*	*0.076*	*0.18*
Gender							
Female	62 (22.4%)		134 (86.5%)				
Male	215 (77.6%)		21 (13.5%)				
Video game playing time (hours per day)		5.13± 3.07		.004 ±.03	-28.07	.000	-22,80
Duration of regularly playing games (years)		5.18± 3.32		0	-17.83	.000	-5.07

** p < .05, ** p < .01, t: Independent t-test. NVGPs: non-video game players; VGPs: video game players*

Table 2. *Comparison of VGPs and NVGPs in terms of their reaction time, memory and motor skills. (VGPs n=277, NVGPs. n=155).*

	NVGPs Mean±SD	VGPs Mean±SD	*t*	*p*	*d*
Visual Reaction Time (ms)	356.41±41.29	341.21±36.73	3.942	**.000**	.39
Auditory Reaction Time (ms)	231.97±53.50	214.97±44.06	3.368	**.001**	.35
WM-Matrix Memory Test (Score)	8.70±1.23	8.82±1.29	-.991	.322	.10
WM-Digit Span Test (Grade)	7.95±1.23	8.16±1.32	-1.600	.110	.16
MD-Right Hand[a]	14.92±1.81	14.38±1.72	3.057	**.002**	.31
MD-Left Hand[a]	13.70±1.64	13.57±1.65	.766,	.444	.08
MD-Both Hands[a]	22.43±3.02	21.78±2.86	2.220	**.0027**	.22
MD-Assembly[a]	29.26±4.42	28.57±4.32	1.573	.116	.16

** p < .05, ** p < .01, t: Independent t-test*

[a] Number of pins placed in 30 sec is reported for left, right, and both hands' motor dexterity test, and the number of pins placed in 60 sec for assembly motor dexterity test. NVGPs: non-video game players; VGPs: video game players; WM: working memory; MD: motor dexterity; ms: milliseconds

Table 3. *The correlation of duration of regularly playing video games in years and the playing time per day with adolescents' reaction time, and memory and motor skills (n=432)*

	Visual Reaction Time	Auditory Reaction Time	WM-Matrix Memory Test	WM-Digit Span Test	MD-Right Hand	MD-Left Hand	MD-Both Hands	MD-Assembly
Duration of regularly playing video games in years	-.156**	-.118*	.102*	.012	-.114*	-.073	-.160**	-.140**
Video game playing time per day	-.112*	-.146**	,066	.026	-.173**	-.071	-.123*	-.090

** p < .05, ** p < .01, Pearson`s correlation coefficient*

WM: working memory; MD: motor dexterity

4. DISCUSSION

In particular, whether people learn anything useful from playing video games is an important question in the context of many children and adolescents who play video games for a long time. A clear conclusion cannot be confirmed due to inconsistencies in previous studies, which often involve the correlation between playing video games and cognitive and motor skills. The present research was conducted to determine whether there were differences between VGP and NVGP adolescents in terms of their visual and auditory reaction times, manual dexterity, and working memory levels. In contrast to previous studies with small sample size, the results obtained in this study are noteworthy due to the high sample size. Age and gender are two important factors that affect playing video games. In this study, while there was no difference between VGP and NVGP groups in terms of their age, the groups have a significant difference in terms of gender distribution. Several studies have revealed that males played video games more than females (e.g.; 2,4,7, 21). In the sample of the study, the VGP group predominantly consists of males while the NVGP group predominantly consists of females, which is in line with the literature. Contrary to studies reporting that gender does not affect executive functions (22), there are also studies reporting that males have faster and less variable reaction times compared to females (23).

When adolescents were asked the names of the games they preferred to play in their daily lives, they stated that they played many types of games. Thus, in this study, the groups were not compared by classifying them based on game types. Unlike previous studies, one of the most distinctive aspects of this research is that it focuses on the adolescents' experience of playing all types of video games throughout their lives, rather than a certain video game genre.

In the present research, visual and auditory reaction times of VGPs were found to be significantly shorter than those of NVGPs. Moreover, it was found that the increases in the duration of regularly playing video games in years and the playing time were correlated with the decrease in reaction times. This result is consistent with previous studies revealing that VGPs have faster reaction times than NVGPs (24-27). In a video game, several visual and auditory events can occur almost simultaneously, such as popping balls appearing on the screen, driving vehicles fast without hitting any obstacles, or defending against suddenly emerging enemies/creatures, etc. As a result, player's various perceptual, cognitive, and motor skills such as the speed of perceiving potential threats, problem-solving skills, planning, and visuomotor coordination can develop.

Some studies suggest that video games improve working memory (10, 11, 29), whereas others do not report this effect (13). Previous studies that suggest a strong correlation between video game experience and cognitive abilities highlight the need to efficiently store and change information about video game rules in working memory for a successful game. In this study, although there was no difference between the groups, it was found that adolescent's WM test scores increased with an increase in the duration of regularly playing video games in years. This finding is consistent with the findings of Unsworth et al.(13), Green et al.(30), and Waris et al. (31).

The impact of video games on adolescents' fine manual dexterity and bimanual coordination is not definitive either. Another important finding of this study is that NVGPs have higher/ better motor dexterity subtest skills (right hand and both hands) compared to VGPs. This result can be attributed to the fact that activities such as real-life games, music, sports, and arts require more muscle strength, coordination, and dexterity than virtual actions in video games. Increased time spent by children due to screen exposure may cause them to limit the time they allocate to other activities, and to physical activity (2, 32), which may result in reduced dexterity. Also, according to the results of the correlation analysis conducted in the study, it was found that some motor skills (right hand, both hands, and assembly) weakened with the increase in the duration of regularly playing video games in years and the playing time. This finding can be interpreted as the increase in the frequency and duration of playing video games leads to an increase in the interest and sensitivity to visual information, rather than tactile information, which results in a decrease in manual dexterity.

As a result, it was found that VGPs had shorter visual and auditory reaction times, and there was difference between the two groups. Also, some motor dexterity subtest skills were lower in high-school adolescents with normal development. Besides, the duration of regularly playing video games in years and the total time allocated for playing video games have a negative correlation with reaction time and some motor dexterity subtests. On the contrary, there is a positive correlation between working memory test scores and the duration of regularly playing video games in years. On the other hand, our cross-sectional study cannot provide causal inferences, and longitudinal and experimental studies are needed for strong recommendations.

5. CONCLUSION

In this study, it can be seen that video games can improve some aspects such as reaction time of cognitive and motor skills but weaken other aspects such as motor dexterity. As a result, the impact of playing video games on cognitive and motor skills is more complex than the positive/negative distinction with definitive limits. Personality structure, environmental stimuli, playing time, and experience of the player can affect this relationship. Adolescents are interested in video games, also, their playing time is quite remarkable. For this reason, ex post facto or experimental studies should be conducted to determine the possible effects of video games on the development of cognitive and motor skills. Thus, the selection of instructional and constructive video games used in different applications such as education, entertainment, and sports may contribute to the motor and cognitive development. Also, future studies are required for additional research on the correlation between physical activity, playing video games, and motor skills. Experts working in this field should be vigilant about children and adolescents who use video games uncontrollably, and it may be advisable to provide counseling to both children and families on positive and negative cognitive effects.

Limitations

This research has several limitations. As in similar studies in the literature, VGPs consisted of more male participants, and the NVGPs was composed of more female adolescents. It is important to note that the disproportionate gender distribution is consistent with previous studies and reflects the differences in population similarly. Another limitation is that the specified playing time and duration in years are based on the participants' statements. Moreover, differences such as the individual's past learning, skills, personality structure, and individual interests may affect the speed of cognitive and motor skills. These factors were not considered in the study. The research findings can only be generalized to the high schools that are included in the population of this study.

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