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Original Article

The Impacts of Video Games on Cognitive Function and Cortisol Levels in Young Female Volunteers

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Abstract

Objective: The aim of the present study was to investigate the effect of Football video game on cortisol levels and cognitive performance of female participants.

Materials and Methods: Thirty two female participants took part in the football video game. To measure the amount of cortisol hormone, saliva samples were collected before and after the game and assessed by enzyme-linked immunosorbent assay (ELISA) kit. Cognitive and perceptive performances were analyzed using PASAT test. The cognitive indices were evaluated including general mental health, response speed, sustained attention, and mental fatigue.

Results: Our findings showed that salivary cortisol concentration significantly increased following playing the game. The results of PASAT test also showed that response speed, sustained attention and mental health significantly increased in participants after the game in comparison with before that. In addition, the longest chain of wrong answers, index of mental fatigue, slightly decreased in volunteers after the game.

Conclusion: The present study indicated that video game can positively impact the hypothalamus-pituitary axis (HPA) axis and improved perceptual-cognitive functions of the volunteers.

Keywords: *Video Games, Stress, PASAT, Cortisol*

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Introduction

Video games are usual and dominant cultural issue in different countries. Similar to other human-made tools, video games are made as a response to what is attracting to the human and play an important role in daily life's skills [1, 2].

Studies have shown that computer games affect a wide range of cognitive and perceptive functions in individuals through modification of different parts of the brain functions. Different areas of brain are involved in the process of thinking and prefrontal cortex is one of the crucial region in perceptive cognitive and decision making processes [3, 4]. Thinking process includes creativity, decision making, esthetics, judgment and problem-solving [3, 5]. Well-oriented video games can inspire a healthy life style [1, 6]. Evidence showed that action game can improve brain function, response speed, concentration, attention, spatial cognition and life skills [2, 7]. On the other hand, scary and stressful games have negative effects on the cognition [8, 9].Changes in cognitive function including attention, mental fatigue, and general health are assessable using PASAT test [10].

Prior study on the effects of video games on human brain have indicated that playing computer puzzles can affect parts

of brain which are involved in thinking process and increase ability of problem solving, decision making and information processing [11].

Moreover, computer games can cause changes in stress factors leading to change in the brain's function. Several studies have shown that chronic stress by continuous stimulation of hypothalamus-pituitary-adrenal axis (HPA) leads to continuous and chronic increase of plasma cortisol levels [12, 13]. Previous studies have also shown that hippocampus, as an important structure in memory, is the main site of expression and activity of glucocorticoid receptors [14, 15]. Previous studies have shown that cortisol levels in male participants of Football computer game was reduced after the game [1, 6]. Extensive evidence has shown that short-term stress increases cortisol concentration rapidly, and leads to increase in cognitive abilities associated with the hippocampus. However, chronic stress, regardless of the kind of stress, impaired memory functions in individuals [14, 16]. Moreover, it has been shown that chronic stress not only decrease memory functions, but also disrupts mental processes associated with memory such as decision making and responding [17].

The aim of the present study was to investigate cognitive and hormonal changes of player following Football video game. By analyzing these changes we can reach a proper approach to assess, how video games affect different cognitive functions especially stress system in individuals.

Methods

Study design

As a cross-sectional study**,** **t**hirty two female volunteers, age 21-23 years old, registered in this study through an invitation from university students. The research questionnaire included personal information and questions about their favorite game, type of games, playing time during a day. The volunteers took part in a double tournament of Football video game and the instructions to play each game were given before playing the game. The game was played as a single knockout and genius index indicated to increase the quality of the results. Figure 1 shows a flowchart of the study.

Cortisol assessment

Before and after playing the game, saliva samples were collected from all the participants in falcon tubes of 10 mL volume and stored at -20 °C. For measuring saliva cortisol levels, the samples were melted at room temperature then centrifuged at 3000 rpm for 5 minutes. Salivary cortisol levels were measured using a human specific cortisol ELISA kit (Diagnostics Biochem Canada Inc, dbc) according to the manufacturer's instructions.

Cognitive perceptual activity

PASAT software was used to analyze cognitive perceptual activity of the participants before and after the game [1, 6, 10]. In this test, 61 random numbers from 1 to 9 were presented to the participants with three seconds intervals. The participant should add every two successive end numbers up together and answer their question before proposing a new number. For example, if numbers 2 and 6 were presented consecutively, the correct response would be 8. Each participant would give some correct responses in each test (the accuracy of the response) and their responses were compared before and after playing the game. The average time for answering (response speed), the longest chain of correct answers (sustained attention) and the longest chain of incorrect answers (mental fatigue) were also analyzed in this project.

Statistical analysis

Data are expressed as mean ± standard error of mean (SEM). All data analysis was performed with SPSS software (version 16). The paired sample t- test analysis was used to determine the significance of the difference between before and after playing the game. A value of $P<0.05$ was considered as significant.

Results

The effects of video game playing on the concentration of saliva cortisol

The results of paired sample t-test showed that the amount of cortisol significantly ($P=0.04$, Figure 2) increased after playing Football video game in comparison with before the game.

Figure 1. Flow chart of the study.

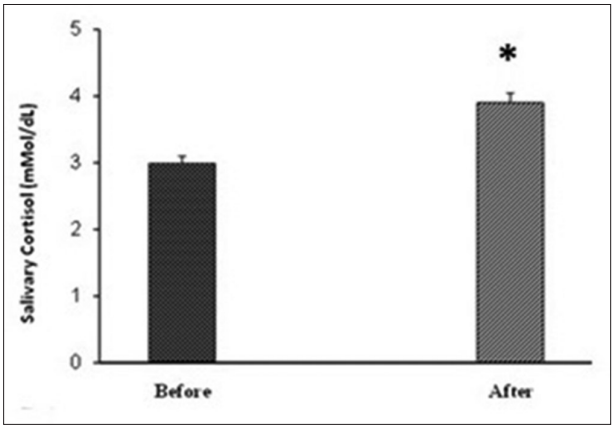

Figure 2. Changes in saliva cortisol concentration before and after playing Football game. Paired-sample t-test,*$P<0.05$.

The effects of video game playing on the number of correct answers in PASAT test

The results of PASAT test showed that the number of correct answers, index of mental health, was slightly increased after playing the game, although there were no significant differences between before and after the games (Figure 3).

The effects of video game playing on the response speed

The results of PASAT test also indicated that reaction time (response speed) of the volunteers significantly (P=0.038, Figure 4) increased after the game in comparison with before the game.

The effects of video game playing on the sustained attention

Our results showed that the longest correct answer chain (sustained attention) significantly (P=0.034, Figure 5) increased after the game in comparison with before the game.

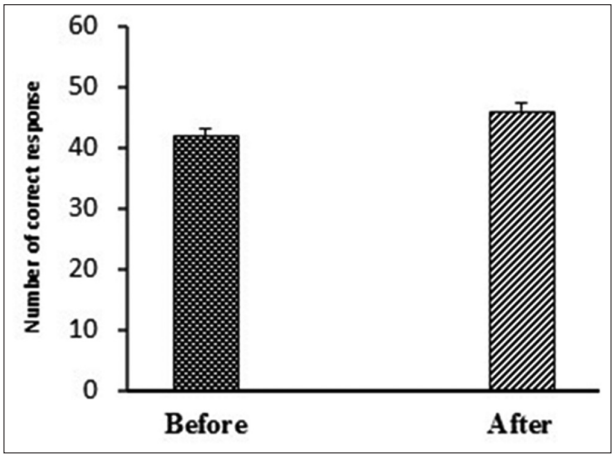

Figure 3. Changes in the number of correct answers (mental health) before and after playing Football game.

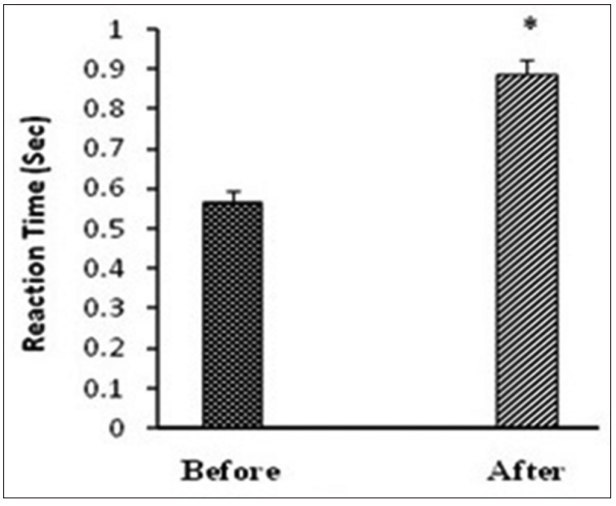

Figure 4. The reaction time (response speed) in participants before and after playing Football game. Paired sample t-test,* P<0.05.

The effects of video game playing on mental fatigue

Paired t-test analysis revealed that the longest wrong answer chains (mental fatigue) of the volunteers slightly decreased after Football game, however the result were not significant in comparison with before that (Figure 6).

Discussion

Our finding revealed that playing Football game increased saliva cortisol levels in the female players. Moreover, this game improved mental health, response speed and sustained attention, and decreased mental fatigue indicating improved cognitive functions of player.

Cortisol is an end-product of activation the HPA axis. Studies have shown that primary stress improves mental capabilities including attention, speed of processing and decision making. Furthermore, short- term stress induces a sense of competition and excitement which is related to the function of amygdala in excitement and attention. Conversely, chronic stress disrupts mental capabilities [14, 16]. Stress hormones particularly cortisol in long-term reduce the intracellular communication in the prefrontal cortex and hippocampus and deteriorates decision-

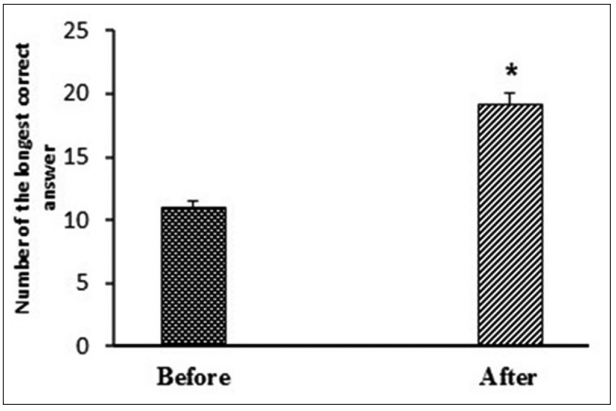

Figure 5. Sustained attention (the longest correct answer chain) in the volunteers before and after playing Football game. Paired sample t-test,*P<0.05.

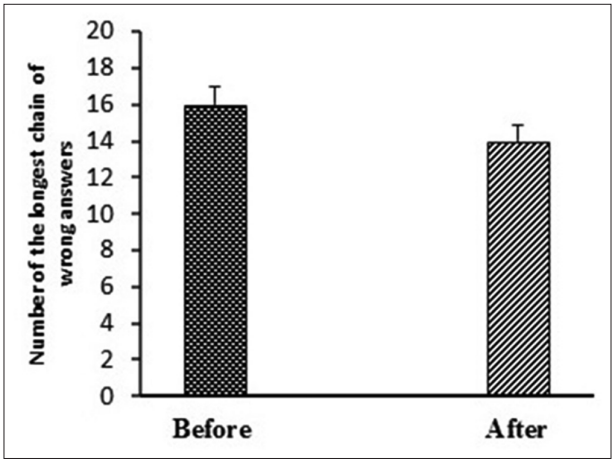

Figure. 6. Mental fatigue (the longest chain of wrong answers) in participants before and after playing football game.

making ability and short-term memory [18, 19]. Moreover, stress leads to disruptions in the amygdala activity and increases anti-social behaviors such as fear and anger [12, 20]. The comparison of the amount of cortisol before and after the game in participants showed a significant increase in saliva cortisol levels after the game in comparison with before that (Figure 1). In this study the increase in the concentration of saliva cortisol after the game is probably related to the emotional-stress system of the participants [20, 21]. Our result is in contrast with previous studies reported a decrease in cortisol levels in male participants. This difference is possibly related to the gender and quick activity of amygdala in response to excitement and emotions in comparison with the boys [1, 6]. Stimulation of stress system activates sympathetic (or parasympathetic) responses in individuals [20-22] which results in increase the activity of adrenergic system in saliva gland and increase secretion of saliva enzyme (salivary alpha amylase). Therefore, increase in the concentration of salivary alpha amylase enzyme, as a plain and non-aggressive biological index, is used for the measurement of the activity of sympathetic nervous system [12, 15].

PASAT test is a cognitive test which is regularly used by neuropsychologists to analyze the alertness processing of patients. This test is a tool for measuring the role of immediate memory and attention in which stimulus is presented through visual or auditory ways. Moreover, PASAT test analyzes the effects of brain damages on cognitive function of the brain of patients with a wide range of neuro-psychological syndromes [10]. Several studies showed that the results gained from this test is not only based on the activities of every individuals nervous system, but also gender is an effective factor in the result of the test [1, 6, 10].

General mental health is related to correct mental functioning of individuals and a sign of correct communication between different parts of the nervous system related to cognitive functions such as memory, learning and fluent verbal skills. Since these connections in the nervous system have been programmed in a harmonious and integrated manner any factor which disturbs this harmony or reduces its quality, can affect the output of the nervous system [1, 6, 10]. In the current study the effects of video games on general mental health (the number of correct answers in PASAT test) before and after the game showed that the number of correct answers slightly increased after the game, although the result was not statically significant.

Moreover, the results of response speed indicated that the response speed increased after playing the game. In the PASAT test response speed is related to short-term memory. In addition to emotion, amygdala is involved in adjusting and balancing different cognitive functions such as attention, perception and explicit memory [23]. Studies in the video game field show that games like action video game can affect visual short-term memory, spatial cognition, multitasking and some aspects of performance [24, 25].

Furthermore, the effect of computer games on the sustained attention, the longest chain of correct answers in PASAT test, is examined. The results showed that sustained attention significantly increased after playing the game in the female participants. These results are in contrast with the results of male participants in the previous study. This difference is possibly related to differences of gender and function of frontal cortex, which has an important role in short-term memory and decision making [1, 6]. Decision making is associated with active memory and includes mental processing related to handling and memorizing information for a short time [26]. This memory activates for a short time and focuses our attention on a specific subject, removes annoying information and leads to decision. A problem in active memory results in impairments in performance, learning calculations and in solving complicated problems. Active memory is also essential for controlling attention [24, 25, 27]. It seems that playing Football game increases sustained attention possibly through improving short-term memory.

In the present study the longest chain of wrong answers, as a symptom of mental fatigue, showed no significant change in the participants after the game. Increasing the number of wrong answers is possibly owing to reduces the brain ability to provide correct and acceptable answers [10] possibly due to background stress which decreases the ability of hippocampus [4, 13, 14, 16]. Previous studies have demonstrated that stress can reduce decision making ability in animals or human models and disturbs different kinds of memory [15, 28].

Conclusion

Eventually, in order to clarify the positive and negative effects of the video games on the nervous system, more studies with different aspects are needed. Since the results of video games can be affected by age, gender, duration and type of game, the involvement of enthusiastic researchers from different fields with different point of view are necessary for interpretations of data.

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Conflict of Interest

The authors declare no conflict of interest.

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