Comparative analysis of cognitive functions in male college E-sport players and non-gamers

Análisis comparativo de las funciones cognitivas en jugadores universitarios de E-sports y no jugadores

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Abstract

Introduction: Electronic sports (E-sport) may improve cognitive function by using magnetic resonance imaging. There is limited data on evaluating cognitive functions in E-sport players by the cognitive tests.
Objective: To evaluate cognitive function in E-sport players by using a cognitive test.
Methodology: This was a cross-sectional study and enrolled male college students with an age of 18 years or older who agreed to participate the study and practiced any types of E-sport regularly at least three times/week for at least one year (E-sport) or no exercise (control). Eligible participants were evaluated for the cognitive test by using a computer-based program which was comprised of seven categories.
Results: There were 35 male college students enrolled in the E-sport group and the control group. The E-sport group had shorter reaction times of correct responses in simple reaction time test (266.94 vs 308.54 msec; p < 0.001) than the control group, but longer reaction times of correct responses in choice reaction time test (387.54 vs 316.23 msec; p < 0.001) and incongruent (471.69 vs 434.69 msec; p < 0.001) than the control group. For the accuracy of responses, the E-sport group had a significant higher percentage of accuracy responses in simple reaction time test (93.57% vs 61.54%; p < 0.001), choice reaction time test (82.60% vs 51.60%; p < 0.001), and congruent (89.34% vs 84.06; p = 0.040).
Conclusion: E-sport players may have better specific cognitive function in terms of speed and accuracy than the control group in male collegiate students.

Keywords

Simple reactive time test; choice reaction time test; trail making test.

Resumen

Introducción: Los deportes electrónicos (E-sport) pueden mejorar la función cognitiva mediante el uso de imágenes de resonancia magnética. Hay datos limitados sobre la evaluación de las funciones cognitivas en los jugadores de deportes electrónicos mediante las pruebas cognitivas.
Objetivo: Evaluar la función cognitiva en jugadores de E-sport mediante el uso de un test cognitivo. Metodología: Se trata de un estudio transversal en el que se inscribieron estudiantes universitarios varones de 18 años o más que aceptaron participar en el estudio y practicaron cualquier tipo de deporte electrónico con regularidad al menos tres veces por semana durante al menos un año (deporte electrónico) o sin ejercicio (control). Los participantes elegibles fueron evaluados para la prueba cognitiva mediante el uso de un programa informático que se componía de siete categorías.
Resultados: Hubo 35 estudiantes universitarios varones inscritos en el grupo E-sport y en el grupo control. El grupo de E-sport tuvo tiempos de reacción más cortos de respuestas correctas en la prueba de tiempo de reacción simple (266,94 vs 308,54 mseg; p < 0,001) que el grupo de control, pero tiempos de reacción más largos de respuestas correctas en la prueba de tiempo de reacción de elección (387,54 vs 316,23 mseg; p < 0,001) e incongruentes (471,69 vs 434,69 mseg; p < 0,001) que el grupo control. En cuanto a la precisión de las respuestas, el grupo E-sport tuvo un porcentaje significativamente mayor de respuestas de precisión en la prueba de tiempo de reacción simple (93,57% frente a 61,54%; p < 0,001), la prueba de tiempo de reacción de elección (82,60% frente a 51,60%; p < 0,001) y congruente (89,34% frente a 84,06; p = 0,040).
Conclusión: Los jugadores de deportes electrónicos pueden tener una mejor función cognitiva específica en términos de velocidad y precisión que el grupo de control en estudiantes universitarios masculinos.

Palabras clave

Prueba de tiempo reactivo simple; prueba de tiempo de reacción de elección; prueba de trazado de senderos.

Introduction

Electronic sports or E-sports, competitive videogaming, are very growing and addictive. At least 90% of American children play E-sports with a maximum of 10 hours of playing per day in professional E-sport athletes (Emara et al., 2020). There are several health issues in E-sport players including musculoskeletal disorders, visual fatigue, metabolic disorders, and psychological stress (Mi et al., 2025). Additionally, a study in collegiate E-sport players found that 40% of these college students did not have any physical activities (DiFrancisco-Donoghue et al., 2019). A review found that over 60% of E-sport players reported wrist/ hand pain or injuries and over 40% of the players had neck/ back pain (Schary et al., 2022).

In addition to physical health, psychological disorders are also the main concern in E-sport players. It is estimated that 2.2 billion people are active gamers and may have gaming disorder (Chung et al., 2019). A study conducted in E-sport players aged between 14 and 24 years found that internet gaming disorder was significantly associated with social anxiety and insomnia severity with a coefficient of 0.39 ($p < 0.01$) and 0.10 ($p = 0.04$), respectively (Solmaz et al., 2025). Cognitive skills are required for E-sport players for quick decision-making (He et al., 2025). There are several theories regarding the association between E-sport and cognitive skills such as attentional control theory (Zhang & Owen, 2023). This theory shows the improvement of E-sport ability under pressure particularly faster reaction times and multitasking. A systematic review found that extensive video game playing was associated with changes in cognitive function (Choi et al., 2021). However, that review used functional magnetic resonance imaging as a tool to detect cognitive function. There is limited data on evaluating cognitive function in E-sport players by the cognitive tests. Recent educational research also underscores the importance of assessing cognitive outcomes through direct testing, especially among university populations engaged in digital or screen-based activities (Abraldes & García-Rubio, 2023). Furthermore, Gallego-Lema et al. (2024) suggest that structured neurocognitive training interventions can positively influence academic performance, further emphasizing the need to understand the baseline cognitive profiles of e-sport participants. Therefore, this study aimed to compare cognitive functions between regular E-sport players and non-players.

Method

This was a cross-sectional study and enrolled male college students with an age of 18 years or older who agreed to participate the study. Participants were classified into two groups: the E-sport group and the control group. The E-sport group was defined as those who played video games competitively or recreationally at least three times per week, with each session lasting at least one hour, for a minimum duration of one year. The control group included individuals who had not participated in any form of structured exercise or E-sport gaming in the past 12 months. We excluded students with a history of brain injury or previously diagnosed or concurrently diagnosed as depression from the study. As there were sex differences of cognitive function and E-sport was popular in male students (Kheloui et al., 2021; Overå et al., 2024), this study included only male students. This study was a part of a cognitive project in sports at Roi Et Rajabhat University and had the same control group as other studies.

Eligible students were evaluated for baseline characteristics, and the cognitive test. The cognitive test was a computer-based program and comprised of seven categories including simple reaction test, choice reaction time test, trail making test, Flanker test, design fluency test, mental rotation test, and spatial visualization test. The measurements of each outcome were as follows: average reaction times of correct responses (msec) and accuracy of responses (%) for simple reaction time test and choice reaction time test; completion time of A and B test (sec), number of errors of A and B test (times), time difference between B and A test (sec), time spent ratio (B/A) for trail making test, congruent, incongruent, and average reaction times of correct responses (msec), and accuracy of responses (%) for Flanker test; number of correct designs, total score for design fluency test; total score for mental rotation test and spatial visualization test (Cojocariu & Abalasei, 2014; Pontifex & Hillman, 2007; Shepard & Metzler, 1971; Swanson, 2005; Vandenberg & Kuse, 1978). All tests were administered in a quiet, well-lit laboratory setting by trained research assistants following a standardized protocol. Reliability and validity of the cognitive tests were reported by using a pilot data of 20 subjects (Table 1).

Sample size calculation

Based on the effect size of 0.4, confidence of 95%, and power of 95%, the required sample size for two sample study groups was 35 participants in each group. This calculation was executed by using the program G*Power, version 3.1.9.7 (Cohen, 1988).

Statistical analyses

Descriptive statistics were used to compute baseline characteristics, body composition, and cognitive test and reported as mean (SD). A comparison of each variable and outcomes between the two groups was executed by using Wilcoxon Rank Sum test as data were not normally distributed. The analysis was executed using the STATA software version 18.0 (College Station, Texas, USA).

Results

This study showed that E-sport players had significantly better cognitive outcomes in simple reactive time test (266.94 msec vs 308.54 msec; $p < 0.001$), and trail making test (64.00 sec vs 94.58 sec; $p < 0.001$) than control group in college students except choice reaction time test and incongruent. As previously reported, two systematic reviews found that video gaming players had better cognitive function than control (Bediou et al., 2018; Wang et al., 2016). The previous systematic review also found that problem solving was the only domain that was not significant among seven domains of cognitive function (Bediou et al., 2018). These data may support our findings that the outcomes with simple task including simple reactive time test and trail making test were better the control (Boot et al., 2008; Dye et al., 2009), while more complex outcomes or choice reaction time test and incongruent were worse than the control. Previous studies showed that practice of E-sport may be enhanced by practice or intervention and related to physical activity performance (McNulty et al., 2023; Nuyens et al., 2019; Toth et al., 2020). Another study showed that experts had better game speed than the non-gamer ($p < 0.001$) (Boot et al., 2008). These results may be due to several factors including requirement of practice in more complex outcomes, cognitive stress, and stimulus overload.

Table 1. Reliability and validity of various tests for the computerized cognitive tests in the study.

Tests	Reliability coefficient	Validity coefficient
Simple reaction time test	0.80	0.70
Choice reaction time test	0.70	0.65
Trail making test	0.60	0.50
Flanker test	0.70	0.60
Design fluency test	0.60	0.50
Mental rotation test	0.80	0.70
Spatial visualization test	0.80	0.50

In addition to the reaction times, E-sport players also had better results in accuracy responses in simple reaction time test (93.57% vs 61.54%; $p < 0.001$), choice reaction time test (82.60% vs 51.60%; $p < 0.001$), trail making test (0 vs 4.17 times; $p < 0.001$), and congruent (89.34% vs 84.06%; $p = 0.040$) than the control group. These results may indicate that the E-sport players had fewer errors than the control group. The previous study found that practice of video game significantly improved accuracy from 45% to 52%; $p < 0.01$ (Boot et al., 2008).

Table 2. Baseline characteristics and body compositions in E-sports players and control *(*n = 70*)*.

Factors	E-sports *(*n = 35*)*	Control *(*n = 35*)*	p value
Age *(*Years*)*	19.43 ± 1.00	19.74 ± 1.12	0.219
Body Weight (Kg)	69.99 ± 13.99	72.44 ± 15.00	0.414
Height (Cm)	174.63 ± 5.39	173.63 ± 3.77	0.570
Body mass index *(*Kg/m^2*)*	22.89 ± 4.12	23.00 ± 4.54	0.997
Heart rate (times per minute)	72.88 ± 8.92	82.71 ± 13.40	0.002
Body fat percentage (%)	17.73 ± 9.31	17.26 ± 8.92	0.672
Level of Visceral fat	5.97 ± 4.03	5.74 ± 3.60	0.891
Body age (Year)	27.14 ± 9.96	26.67 ± 8.97	0.984
Basal metabolic rate (Kcal)	1639 ± 201	1622 ± 172	0.813

Subcutaneous whole body (%)	36.29 ± 4.20	31.74 ± 8.90	0.024
Skeletal whole body (%)	29.24 ± 6.38	32.75 ± 6.35	0.018

Data are presented as means ± standard deviation

There are some limitations in this study. First, data on specific types of E-sport was not collected from participants as well as the frequency of E-sport practices. Second, not all outcomes were significantly different between both groups. These results may imply that E-sport may not be able to improve all aspects of cognitive function. Finally, our data may not be applicable to other age groups or female college students. Further studies may be required to confirm the results of this study particularly in other settings. The results of this study may be used to apply in the curriculum as the intervention program in college students. However, excessive use of video game on cognitive function should be awared (Aliyari et al., 2018; Ghaffari et al., 2024). Additionally, several factors may be associated with cognitive function and E-sport training and motivation (Estrada-Araoz et al., 2024; Sánchez et al., 2023).

Table 3. Results of a comparison of computerized cognitive tests in E-sports players, and control (n = 70).

Factors	E-sport	Control	p value
1.Simple reaction time test			
Average reaction times of correct responses, msec	266.94±59.73	308.54±12.29	<0.001
Accuracy of responses, %	93.57±16.07	61.54±24.93	<0.001
2. Choice reaction time test			
Average reaction times of correct responses, msec	387.54±67.04	316.23±11.64	<0.001
Accuracy of responses, %	82.60±24.22	51.60±20.85	<0.001
3. Trail making test			
A Completion time, sec	30.73±8.00	30.72±7.25	0.795
A Number of Errors, times	0	4.17±10.75	<0.001
B Completion time, sec	64.00±23.17	94.85±11.78	<0.001
B Number of Errors, times	6.11±10.17	13.83±16.67	0.138
B-A time difference, sec	33.83±19.42	34.90±22.45	0.828
B/A time spent ratio	2.10±0.64	2.15±0.66	0.668
4. Flanker test			
Congruent			
Average reaction times of correct responses, msec	398.89±74.45	396.54±47.99	0.694
Accuracy of responses, %	89.34±19.75	84.06±19.17	0.040
Incongruent			
Average reaction times of correct responses, msec	471.69±87.96	434.69±19.17	0.021
Accuracy of responses, %	75.66±25.63	76.09±23.57	0.804
5. Design fluency test			
5.1 Filled dots: no. of correct-unique designs	7.09±3.82	7.40±4.20	0.791
5.2 Empty dots: no. of correct-unique designs	8.34±4.24	8.77±4.17	0.603
5.3 Switching dots: no. of correct-unique designs	3.29±3.81	3.89±4.06	0.494
5.4 Total score: no. of correct-unique designs	18.71±9.02	20.66±9.67	0.199
6. Mental rotation test: total score	7.86±5.17	8.46±3.98	0.343
7. Spatial visualization test: total score	10.57±5.36	12.46±5.54	0.132

Discussion

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Conclusions

E-sport players demonstrated enhanced cognitive performance in specific domains, particularly in processing speed, visuomotor coordination, and response accuracy. These advantages were evident in tasks requiring rapid decision-making and attentional focus, such as simple reaction time and trail-making tests. However, their reduced performance in complex tasks involving cognitive interference suggests potential weaknesses in executive control functions, such as inhibitory processing and cognitive flexibility.

These findings highlight both the potential benefits and limitations of e-sports engagement in terms of cognitive functioning. Structured cognitive training programs that incorporate both game-based elements and executive function tasks may offer a more balanced approach to cognitive enhancement.

Further studies are warranted to explore the long-term effects of e-sport activities across diverse populations, including different age groups and genders, and to evaluate the applicability of video game–based interventions in educational and clinical settings.

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Ethical approval

The study protocol was approved by the Roi Et Rajabhat University Ethics and Research Committee (approval No 010/2567) and adhered to the Declaration of Helsinki.

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