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# A Cross-Sectional Comparative Study Of select Cognitive Functions in Adolescent Medical Students Engaged in Physical Activities and Video Gaming

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# A Cross-Sectional Comparative Study Of select Cognitive Functions in Adolescent Medical Students Engaged in Physical Activities and Video Gaming


## Abstract

**Background:** This study was conducted to compare the performance of cognitive function tests among adolescent students involved in physical activities, video-gaming, and board-gaming groups.

**Methods:** A cohort of 300 participants (150 males and 150 females) were included in the study. The participants were divided into 3 groups (50 boys and 50 girls each) who were engaged regularly in physical activity, video gaming activity and board gaming activity respectively. The participants of all the groups were tested on selected neurocognitive tests from Wechsler Memory Scale â€“ III (WMS â€“ III) and NIMHANS Neuropsychological Battery. After acquiring baseline data, they were instructed to continue their respective gaming activities for a minimum of 2 hours each day. After 30 days of respective gaming activity, the battery of cognitive tests was administered again, and the pre and post results compared.

**Results:** There was a statistically significant difference in the subset scores of Tests for Visual Presentation (Faces I and II) in the boys and girls of the Physical Activity group and gaming group independently. The AVLT scores showed statistically significant difference between girls and boys who were engaged in 30 days of board or video gaming activity.

**Conclusions:** Our study shows that in the short term, there are differences in the cognitive performances of participants of the 3 groups of activities. Along-term follow-up study will help to differentiate the effect of these 3 activities upon cognitive function. Cognitive functions of young adults of both gender is influenced by physical and gaming activity.



## Keywords

Medical Students, Cognitive function, Gaming.

## Introduction

Games are an integral part of human life. In every stage of life, we have great enthusiasm towards games. This has become an addiction to some, a hobby to some, or even a profession to others. Of late, there is a developing passion towards computer games among the different playing population.[1] The augmented reality in gaming shows both positive and negative prospects in the behaviours and social interactions among children and young adolescents.[2] Video games are a hybrid which interfaces indoor games with outdoor games.[3] These video games have become the popular pastime of the millennia. There is a great worry among parents that their children on exposure may get addicted to these video games.[4] They fear an adverse impact on their child's mental, physical, and emotional behaviour.

Memory is a crucial skill that allows us to make decisions and solve problems based on information and details from the past that we can recall. The principal objective of this study is to find an answer to the burning question- "Does Video Gaming Affect Your Memory?". Some often complain about Video Games for inculcating angst among Children.[5] According to some research, playing for a certain amount of time does not improve short term memory.[6] Although video games do not improve short term memory, they can affect visual - short term memory.[7] Video games have been shown to benefit certain cognitive systems related to visual attention and short-term memory. Gaming has been shown to stimulate another part of the brain called the caudate nucleus, more than the hippocampus. The region acts as a form of "autopilot" and regulates humans' understanding of reward.[8] The attention skills one learns in video gaming can be used in other activities as well.

Digital games have dramatically helped in the transformation of various areas such as education, entertainment and promoting social relationships.[9] Active video-game play is an attractive alternative to traditional forms of physical activity for non – exercisers. Even

though there are studies about the negative effects of video games, some studies favor video games and have found to have a positive impact on one's cognition, social, motivational, and emotional support.[10]

Commercial games have played a very innovative role in healthcare improvement or surgical training. Tailor – made games have made patients more adherent to treatment regimens and have helped train doctors in different clinical situations.[11] Video game users have shown a better and quick adaptiveness towards endoscopic modalities and robotic techniques.[12]

In this study, the memory of the individuals involved in video gaming and non- video gaming is assessed using certain tools of neuropsychological tasks. The baseline test scores and final test scores after engaging regularly in games and physical activities for 30 days were compared and analysed.

**Material & Methods**

The study was conducted after obtaining the Institutional Ethics Committee approval. For this cross – sectional comparative study a cohort of 300 participants studying in 1st and 2nd Year MBBS were chosen after getting written informed consent. These students were involved in any one of the following three- physical activities, board gaming activities, video gaming activities. This study was conducted for a duration of six months, from 1st June 2021 to 31st November 2021. As regular follow-up of students was required, every month, only 50 students were studied.

**Survey Administration:**

Selected neurocognitive tests from Wechsler Memory Scale – III (WMS-III$^{IND}$) and NIMHANS Neuropsychological Battery were used to assess the cognitive functions of the participants. The tests were selected to include measurement of attention, verbal memory, and

visual memory in consultation with a clinical psychologist. The participants were divided into three groups. The first group of participants engaged regularly in physical sports activity only. The second group of participants engaged regularly in board games only. The third group engaged regularly in playing video games only. 'Engaging regularly' was defined as minimum 2 hours of engagement of that activity exclusively for a minimum of 5 days in a week. After acquiring baseline cognitive function data, they were instructed to continue their respective activities for a minimum of 2 hours each day each week. The participants reported their activities on a weekly basis. On the 30th day of baseline testing, the participants were called, allowed to engage in their activities for 2 hours. The tests were repeated, and the scores were noted. English was the preferred mode of administration, and the tests were administered independently to each of the participant in a calm environment.

**Assessment Tools:**

A checklist was used to assess 'socio-demographic profile' of the participants, such as Age, Sex, Height, Weight, and other correlates required for the study. General Health Questionnaire (GHQ – 12) was administered to all participants as a screening tool to identify any major mental health morbidity.

**Different subsets of tests from WMS-III$^{IND}$ used for assessing different cognitive functions are:**

a. Tests For Auditory Presentation:

Tests for Verbal Learning and Memory - Logical Memory I and Logical Memory II were administered.

Tests for Attention - Digit Span Test

b. Tests For Visual Presentation:

The test for visual presentation is done to assess the visual specific memory of the person.

Tests to measure immediate and Delayed Memory: Faces I and Faces II

Tests to measure immediate and Delayed Memory Along with Assessment of Motor Functions: Visual Reproduction I and Visual Reproduction II

**Test used from NIMHANS Neuropsychological Battery are:**

Test to Measure the Learning and Memory for Word Lists: Rey's Auditory Verbal Learning Test (AVLT).

English version of the worksheets adapted for Indian setting were used. The approximate time taken to administer the above neurocognitive tests for one person in one sitting was around 2 hours with adequate intervals after each test.

**Statistical Analysis:**

SPSS statistics software by IBM was used to perform statistical analysis. Mean, standard deviation for various socio-demographic correlates was assessed. Paired difference t-test was done to test significance for pre- and post- interventional scores. The statistical significance was set at $P<0.05$.

**Results**

Table 1 shows the socio-demographic data of the participants. Previous gaming experience was also noted, with predominantly yes [n = 150 (50%)], followed by maybe [n = 90 (30%)] and no previous experience in games [n = 60 (20%)]. The mean score of GHQ-12 was 17.6 (standard deviation = 5.62). The group was found to be normally distributed.

Assessment of cognitive functions from WMS – III is based on Auditory Presentation and Visual Presentation. Under Auditory presentation tests two tests were done – Test for verbal learning and memory was done using Logical Memory (I and II) and Tests for Attention.

There was no statistical difference between boys and girls in the Physical Activity group in these tests (Table 2).

However, there was a statistically significant difference in few subset scores of Tests for Visual Presentation (Faces I and II) in the boys and girls of the Physical Activity group, namely in Pre and Post recognition Total Score of Faces I and the Post Percent Retention of the Faces II. (Table 3)

In the Board gaming activity group, there was a statistical significance in the pre-thematic total score of Logical Memory II. However, there was significant difference in the Recall total score, Recognition total score and thematic Total Score in the girls of this group (Table 2). In the video gaming activity group, there was statistically significant difference in the logical memory test scores of the Logical Memory II subset only among the girls. There was no statistical difference in (a) Logical Memory I, (b) Tests for attention and (c) the tests for visual presentation in this group (Table 2,3).

Tests to measure Learning and Memory for Word Lists were administered from NIMHANS Neuropsychological battery.

Rey's Auditory Verbal Learning Test (AVLT): In this neurocognitive test, a statistical significance was seen in the pre- and post- interventional learning score in video-gaming boys ($p=0.004$) and board-gaming girls ($p=0.005$). There was no variation seen in the pre- and post- interventional Memory Score and Long-Term Percent Retention among the different groups (Table 4).

**Table 1: Socio-demographic data of the participants (n=300; 150 boys and 150 girls)**

| VARIABLES | VALUES |
|---|---|
| **Age** (in years) | 19.8 ± 0.61* |
| **Sex** | |

| | |
|---|---|
| Male | 150 (50) |
| Female | 150 (50) |
| **Height** (in cms) | 168.4 ± 8.53* |
| **Weight** (in kgs) | 65.3 ± 12.46* |
| **Time spent for academics per day (in hours)** | |
| <1 | 50 (16.7) |
| 1-2 | 70 (23.3) |
| 2-3 | 80 (26.7) |
| >3 | 100 (33.3) |
| **Time spent in digital platforms per day (in hours)** | |
| <1 | 100 (33.3) |
| 1-2 | 60 (20) |
| 2-3 | 130 (43.4) |
| >3 | 10 (3.3) |
| **Time spent for sleeping per day (in hours)** | |
| 4-5 | 20 (6.7) |
| 5-6 | 60 (20) |
| 6-7 | 220 (73.3) |
| **Time spent for physical activities per day (in hours)** | |
| <1 | 40 (13.3) |
| >1 | 260 (86.7) |
| **Previous gaming experience** | |
| Yes | 150 (50) |
| No | 60 (20) |
| Maybe | 90 (30) |
| **General Health Questionnaire - 12 (GHQ-12)** | 17.6 ± 5.62* |

*- Mean ± Standard Deviation, Values within brackets represent percentage.

**Table 2: WMS - IV Scores correlates of participants [Mean ± Std. deviation (t)]**

| TESTS/SUBTESTS | PHYSICAL ACTIVITY | | VIDEO-GAMING ACTIVITY | | BOARD-GAMING | |
|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls |
| **Tests for Auditory Presentation** | | | | | | |
| **(i) Tests for Verbal Learning and Memory** | | | | | | |
| **Logical Memory I** | | | | | | |
| Pre-Recall Total Score – Post-Recall Total Score | -1.2±3.56 (-0.753) | 0.6±4.22 (0.318) | 1±3.32 (0.674) | -3.4 ± 3.5 | -1.2 ± 3.11 | -1.8 ± 4.49 |
| Pre-Thematic Total Score – | -1 ± 5 (-0.447) | -0.4±4.0 4 | 1.2 ± 4.55 | -2.6 ± 3.21 | -3.6 ± 3.36 | -3.4 ± 2.97 |
| Pre 1st Recall Total Score – | -2.6 ± 4.16 | -0.6 ± 5.41 | 0.8 ± 3.77 | -4.8 ± 5.54 | -2.8 ± 3.49 | -3.4 ± 6.73 |
| Pre-Learning Slope 1 – Post-Learning Slope 1 | 3.6 ± 5.5 (1.462) | -0.6 ± 6.8 | -2.2 ± 5.36 | 3.8 ± 5.31 | 0.6 ± 4.16 | 3.2 ± 8.2 (0.873) |
| **Logical Memory II** | | | | | | |
| Pre-Recall Total Score – Post-Recall Total Score | -1 ± 3.32 (-0.674) | 0.6 ± 2.89 | 0 ± 2.83 (0) | -2.2 ± 1.3 | -1 ± 3.74 (-0.598) | -2.2 ± 2.17 |
| Pre-Recognition Total Score – | -1.4 ± 1.67 | 1.6 ± 3.91 | 1.8 ± 4.76 | -1.2 ± 3.83 | -1 ± 2.45 (-0.913) | -1.8 ± 1.3 |
| Pre-Thematic Total Score – | -1 ± 2.83 (-0.791) | -0.4 ± 1.67 | -0.2 ± 1.09 | -2 ± 1.58 | -2.2 ± 1.48 | -2.2 ± 1.48 |
| Pre-Percent Retention – Post-Percent Retention | -1.2 ± 2.17 | 0 ± 0.71 (0) | 0.6 ± 4.77 | 0 ± 3.54 (0) | 1 ± 2.35 (0.953) | -0.8 ± 2.39 |
| **(ii) Tests for Attention** | | | | | | |
| **Digit Span Test** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-Total Score – Post-Total Score | -1.2 ± 3.42 | 0 ± 2.35 (0) | -0.6 ± 3.65 | -0.2 ± 3.96 | -0.2 ± 2.68 | -0.4 ± 2.3 |

*- t value of significance, $p<0.05$

**Table 3: WMS - IV Scores correlates of participants [Mean ± Std. deviation (t)]**

| TESTS/SUBTESTS | PHYSICAL ACTIVITY | | VIDEO-GAMING ACTIVITY | | BOARD-GAMING | |
|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls |
| **Tests for Visual Presentation** | | | | | | |
| **(i) Tests to measure Immediate and Delayed Memory** | | | | | | |
| **Faces I** | | | | | | |
| Pre-Recognition Total Score – | -4 ± 2.55 (-3.508) | -4.4 ± 1.95 | -3.6 ± 3.36 | -2.8 ± 3.42 | -2 ± 3.39 (-1.319) | -1.2 ± 4.55 |
| **Faces II** | | | | | | |
| Pre-Recognition Total Score – | -2.6 ± 2.40 | 0.4 ± 2.88 | 2.8 ± 5.45 | -1.2 ± 2.28 | 1.2 ± 3.19 | -1.8 ± 2.28 |
| Pre-Percent Retention – Post-Percent Retention | 0.4 ± 4.28 | 4.6 ± 3.13 | 3 ± 6.36 (1.054) | 2.4 ± 4.28 | 5.4 ± 5.98 | 1.8 ± 3.7 (1.087) |
| **(ii) Tests to measure Immediate and Delayed Memory along with Assessment of Motor** | | | | | | |
| **Visual Reproduction I** | | | | | | |
| Pre-Recognition Total Score – | -1.2 ± 2.68 | -0.6 ± 1.34 | - | -1.8 ± 2.68 | 1.6 ± 2.88 | -1.2 ± 2.68 |
| **Visual Reproduction II** | | | | | | |
| Pre-Recall Total Score – Post-Recall Total Score | -1.4 ± 2.6 | -0.6 ± 1.34 | -0.2±0.447 | -2 ± 2.55 | -0.2±0.447 | -1.4 ± 2.6 |
| Pre-Recognition Total Score – | -0.8 ± 2.28 | -3.8 ± 3.35 | -2 ± 2.12 (-2.108) | -3.8 ± 3.35 | -1.6 ± 1.67 | -4 ± 5.83 (-1.534) |
| Pre-Copy Total Score – Post-Copy Total Score | - | -1.2 ± 2.68 | - | -1.2 ± 2.68 | - | - |
| Pre-Discrimination Total Score – | - | -0.6 ± 0.89 | - | -0.6 ± 0.89 | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-Percent Retention – Post-Percent Retention | - | - | - | - | - | - |

*- t value of significance, p<0.05

| Tests/subtests | Physical Activity | | Video-gaming | | Board-gaming | |
|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls |
| **Tests to measure Learning and Memory for Word Lists** | | | | | | |
| **Rey's Auditory Verbal Learning Test (AVLT)** | | | | | | |
| Pre-Learning Score – Post-Learning Score | 1.4 ± 7.09 | -11.6±17 .39 | -16.4 ±6.19 | -13.8±12 .74 | -14 ± 8.03 | -18 ± 7.21 |
| Pre-Memory Score – Post-Memory Score | -3.8±3.5 64 | -5.6 ± 6.69 | -3 ± 4 (-1.677) | -5.6 ± 7.16 | -1 ± 1.23 (-1.826) | -3 ± 4.69 (-1.430) |
| Pre-Long Term Percent Retention – | 0 ± 9.19 (0) | -2.6±10. 74 | 1.6 ± 8.08 | 0.2 ± 13.7 | 5.8 ± 9.94 | -0.2 ± 7.26 |

*- t value of significance, p<0.05

**TABLE 4: Correlation of the NIMHANS Neuropsychological Battery Scores and type of activity [Mean ± Std. deviation (t)]**

**Discussion**

Gaming and Physical Activities play an important role in the life span of adolescents offering various physical and mental health benefits.[13] Exposure to physical activity in adolescence may contribute to the development of healthy adult lifestyles and is also helpful in reducing chronic disease incidence.[14] Even a short duration of video-game play can account significantly to children achieving the recommended daily volume of physical activity.[15] Digital games have also enhanced cognitive, affective, behavioral, and social learning.[16] In the study conducted by Buelow MT et al executive functions of college students involved actively in playing video games for about 30 minutes showed improved decision making and problem solving.[17] Some studies have shown that video games can also have a negative effect on affect and behavior, but their relation on cognition has always been a mixed one. However, video games have shown both positive and negative effects on attention, memory and other cognitive abilities including very little evidence on working memory.[17] Hence, this study was planned to study the effects of games among medical students. The main objective of the present study was to determine the influence of gaming activities on the cognition of adolescent medical students who were involved in regular physical and gaming activities. We also tried to see if there is any gender difference in the cognitive abilities of male and female participants.

There is relatively less attention paid to the positive effects of engaging in video gaming. Compared to non-gaming counterparts, medical students who have an ongoing gaming experience have superior laparoscopic skills for stimulated tasks in terms of time of completion, improved efficiency and fewer errors was proven in studies conducted by Ou, Yanwen, et al.[18] However, this study was restrained to laparoscopic stimulators and was not experimented on operating table. In some studies, video games have proven to be a potential

adjunctive training in surgical skill education, in areas of robotic surgeries and laparoscopic procedures.[19]

In our study, a cohort of 300 students, who were doing their undergraduate medical course participated. The sample was chosen such that 150 boys and 150 girls would form the study group. Students who were habitually engaged in physical games or board games or video games were selected and encouraged to continue their respective activities. The selected cognitive tests were given in a pre- and post- gaming format and the results analyzed and compared.

The GHQ – 12 of the participants was planned as a screening tool to exclude any psychopathology. GHQ showed a mean score of 17.6, highlighting that the students were affected by psychological stress during their course of medical education amidst a raging COVID-19 Pandemic. However, it did not reflect in their cognitive performances, reflecting their resilience.

Studies conducted by P.A. Lowe et al have used Test of Memory and Learning (TOMAL) to study the gender differences in memory test performance among children.[20] Alternatively, they have also suggested Wechsler Scales can be used to study gender differences. The study conducted by E.C. Bell et al suggests that males and females differ in brain activation during cognitive tasks.[21] In the present study, in many of the sub-sets of the tests, differences were noted, though these did not attain statistical significance.

In the logical memory II tests, there was a significant difference between the Pre-Thematic and Post Thematic test scores in girls who were engaged in video games. Similarly in the FACES I test for Visual Specific memory, there was a statistically significant difference between the Pre-Recognition Total score and Post Recognition total score, in girls who were

engaged in Physical activity. The visual reproduction subsets I and II also showed statistically significant difference when compared across boys and girls engaged in the three activities. When the learning and memory tested using AVLT was analyzed, it showed that there was a significant difference between the pre and post learning scores in those who were engaged in 30 days of regular board games. Surprisingly the pre and post learning score in AVLT showed statistically significant difference in the pre and post learning scores of boys who were engaged in 30 days of video games. However, the learning percent retention when calculated, did not show any statistical significance. This shows that probably the engagement of different games has different effects on the sub-domains of the cognitive abilities of the male and female brain. Nevertheless, even if through different neural networks, it ultimately has same effect on enhancing the cognitive abilities in both genders. This aspect needs to be studied further in detail to discriminate the neural pathways, mechanisms and cognitive schemas that give this result.

Studies have shown that the cognitive process is different among males and females.[21] Probably this is reflected in our findings of gender difference. This difference between adolescent boys and girls is also worthy of further study. Cognitive functions of a person depend on various factors and do not solely depend on whether he/she is involved in physical or gaming activities or both.[22] There may be other compensatory factors that are in play to maintain the integrity of the cognitive functions at a macro level. These will need further study in future.

**Conclusions and Limitations**

The present study was done in adolescent medical undergraduates to study the short-term effect of physical activity, board games and video gaming on cognitive functions. Hence it

may not be generalizable to all adolescents universally. A long-term study would throw more light into this research area.

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