VOLUME - 12, ISSUE - 01, JANUARY - 2023 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Physiology

EFFECT OF VIDEO GAMING ON HEART RATE VARIABILITY, AUTONOMIC CHANGES, VISUAL EVOKED POTENTIAL AND COGNITION OF MEDICAL STUDENTS IN TERTIARY TEACHING INSTITUTE

Franc Oumanath	Study Design, Data Collection, Critical revision, Department of Physiology, Aarupadai Veedu Medical College and Hospital, Cuddalore Main Road, Kirumam pakkam Bahour Commune Panchayat, Puducherry-607402.
Lakshmi Jatiya	Approval, and Revision, Department of Physiology, Aarupadai Veedu Medical College and Hospital, Cuddalore Main Road, Kirumam pakkam Bahour Commune Panchayat, Puducherry-607402.
R. Latha	Literature Review, proofreading, Sri Venkateshwaraa Medical College Hospital and Research centre, Ariyur, Puducherry 605107.
J. Janifer Jasmine	Analysis, manuscript preparation, Government General Hospital.

ABSTRACT

Aims To identify the effect of Video Gaming on Heart rate variability, Autonomic Changes, Visual Evoked Potential, Cognition, and the effect of long hours of video game playing **Method** This study is an observational study conducted among the volunteered medical students studying at **Sri Venkateshwaraa Medical College Hospital and Research centre, Ariyur, Puducherry** in the year from 2018 to 2021, who are playing video games, and the study was conducted from January 2021-December-2021. The study subjects were interviewed individually, anthropometric parameters, electrocardiogram, Heart Rate (HR), Blood Pressure (BP), Body Mass Index (BMI), Heart rate variability (HRV), Visual Evoked Potential (VEP), Cognition test using Mini-mental status examination (MMSE) 27 were done and data were collected, recorded, and analyzed. **Results** Out of 400 study population, males: females (183 (45.8%): 270 (54.2%) with a median age of 20.605 ± 0.9702 based on video games played intermittently in 24 hours students were divided into 3 categories, The 1st category played games for ≤ 3 hours (n= 223), 2nd category who played 4-6 hours (n=123), and students played > 6 hours were 54. 311 students played video games using mobile and 89 students used Laptops there was a statistical significance among the categories. **(0.00007) (Chi-square - 19.0763)** Among 400 students playing games 145 students' BMI was ≥ 25, 47 students' heart rate was abnormal among them 33 showed Bradycardia 14 showed Tachycardic and there was statistical significance among the categories. **(<0.00001) (Chi-square - 48.0334),** 193 students' BP was low, 79 students' BP was high and there was a statistical significance among the categories **(0.0314) (Chi-square –10.6033).** Among the 400 student's Heart Rate Variability results, <50 milliseconds (unhealthy value) of SDNN was found in 44 students and there was a statistical significance among the categories **(0.00001)(Chi-square – 206.655),** below and above the normal range of 53.5-82 milliseconds (unhealthy value) of RMSSD for males was found in 59 students and below and above the normal range of 22-79 milliseconds (unhealthy value) of RMSSD for females was found in 53 students there was a statistical significance among the categories **(0.0422)(Chi-square – 13.053)**, <50 milliseconds (unhealthy value) of PNN-50 was found in 58 students and there was a statistical significance among the categories **(<0.00001)(Chi-square – 129.0331)**. Out of 400 Students >0.4 milliseconds (unhealthy value) of Total Power was found in 115 students and there was a statistical significance among the categories **(0.0471) (Chi-square – 6.1101),** >0.4 milliseconds (unhealthy value) of Ratio of High and Low-Frequency Powers of heart rate variability was found in 137 students and there was a statistical significance among the categories **(0.0176) (Chi-square – 8.0746)**. Among the 400 students' Visual Evoke Potential results, >100 milliseconds (unhealthy value) of were found in 118 students >100 milliseconds (unhealthy value) of N145 were found in 124 students, and there was a statistical significance among the categories **(0.00005) (Chi-square- 19.7573)**, >100 milliseconds (unhealthy value) of P100 were found in 108 students, and there was a statistical significance among the categories **(<0.00001) (Chi-square – 23.6437)**. Below and above the normal range of 3.9-8.3microVolt (unhealthy value) of N75-P100 amplitude for the right eye was found in 48 males, below and above the normal range of 5.9-12.3 microVolt (unhealthy value) of N75-P100 amplitude for the right eye was found in 49 female students there was a statistical significance among the categories **(<0.00001) (Chi-square – 121.8749)**. Below and above the normal range of 3.6-8.0microVolt (unhealthy value) of N75-P100 amplitude for the left eye was found in 34 males, below and above the normal range of 5.1-11.5microVolt (unhealthy value) of N75-P100 amplitude for the left eye was found in 44 female students there was a statistical significance among the categories **(<0.00001) (Chi-square – 93.632)**. Among the 400 student's Mini-Mental Status Examinations (MMSE) for cognition results, the delayed response was given for all 5 sections of MMSE by the students who played the games for > 6 hours. **Conclusions** The results clearly explain that students playing games increases body weight, brings abnormality in heart rate, blood pressure, abnormal heart rate variability markers showing decreased Autonomic Nervous System functions, abnormal visual evoke potential markers showing visual impairment, and delayed responses in MMSE showing lesser cognitive capacities leading to poor quality of life, hence this study will enlighten the knowledge of medical students (study population), and other medical students, psychiatrist, counselors counseling kids, and youths who attempted suicide due to failure in video games, and other health care workers.

KEYWORDS : Video Gaming, Body Mass Index (BMI), Heart rate variability (HRV), Visual Evoked Potential (VEP), Cognition, Mini-Mental Status Examination (MMSE), Autonomic Changes.

INTRODUCTION

In the current decades, video games (VGs) enterprise has increased to the factor of turning into one of the biggest multimedia financial sports in the world[1]. VGs have emerged as right now an extraordinarily famous entertaining event amongst kids, youth, and adults[2]. Games seemed for the primary time spent in the recent era, while Steve Russell created Spacewar, the first actual VG of history, with important pix and luminous dots shifting at the display. As days passed, specifically the way towards the improvement of technological evolution, video games were ever greatest immersive and became a wealthy advent, and several contributions made video games essential like food and water to kids and youths[3].

Such an amazing fulfillment of video gaming enterprise, collectively with the reality that it has become one of the maximum famous leisure sports practiced through kids and youth[4]. Common and probable causes of sleep problems with possible effects on cognition and human playing of VGs publicity were reported frequently[5]. Recent research confirmed that in western industrialized international locations, many kids and youth play VGs for a long term at some point in the day[6].

Several current researches have proven that kids and youth stay media-saturated lives: a percent starting from 83 to 97% have a domestic console for VG with which have to interact for numerous hours in line with the day. Video gaming isn't always confined to the youngest: it's been said that greater than 1/2 of U.S. adults are inquisitive about gambling of VGs and its miles believed that such possibilities will moderately boom over the years[7].

In 2018, U.S. Surgeon General hypothesized that VGs had been one of the main motives for medical immunity. In the following years, the controversy moved and persevered inside the medical network displaying regularly contrasting factors of view stating video gaming leads to several ill medical conditions in kids and youths[8].

Human beings that play to traditional VGs tend to reveal sizeable behavioural effects such as misguided ingesting habits, BMI boom, and an elevated threat of weight problems in each male, women, and independently through age at the contrary[9].

Folks who play exergames tend to reveal a few fitness blessings because of the development of bodily fitness, significant weight loss, and improved enjoyment[10]. In general, it'd be considered that all those observations are applicable caveats while a scientific evaluation of literature is achieved with recognition of psychological, behavioral, and physiological ill effects of videogaming[11].

Indians preferred to use mobile games than the computer or console games. In 2016, India had about 201 million users of mobile games across the country. This was projected to reach nearly 370 million users by the year 2022. An increase in mobile use for gaming is associated with multiple negative outcomes including decreased sleep time and increased tiredness, and very little information is available on the neural changes in addition to bad cognitive changes due to mobile gaming[12].

Carson, V et al report that video gaming brings delayed cognition in young children[13]. Tripathi, M et al found that a positive association was found between screen-time usage and adiposity in young children and adolescents[14]. Chaput, J. P et al expressed in the study that gaming before bedtime increases calories thus leading to obesity, and obesity-related issues[15].

As per World Health Organization (WHO), the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), and the International Classification of Diseases (ICD-11) videogames were considered an addiction disorder[16, 17]. Khodakovskaia, O et al report that 72% of the youths were considering gaming as a threat than alcohol[18].

Wang, H. R et al explains that gaming leads to aggression, depression, and anxiety thus bringing poor personality characteristics such as less interest in social network, poor physical and mental well-being, maladaptive coping, loneliness, and lowest self-esteem[19, 20]. Raouf, S. Y. A et al reported that there is a significant correlation found between gaming disorder and BMI[21].

These researches have additionally been currently deeply reviewed and mentioned in a theoretical framework of mind plasticity and at the possibility to apply this generation of kids and youths leading to both physical and mental ill health bringing several hospitalizations and even suicide.

Hence, this study was planned and conducted among volunteered medical students who are playing video games and can bring awareness among the medical students and also all the kids, and youths who play video games for longer hours and spoil their physical and mental strength.

Ethical clearance
This study was approved by the Institutional Ethical Committee and provided with a clearance certificate to conduct the study.

Conflicts-None
Funding-None
Inclusion criteria
- Volunteered Smartphone users playing games
- Both male and female volunteers aged 19 to 23 years
- Students with normal vision (6/6), and normal colour vision.

Exclusion criteria
- Visual abnormality including refractive errors (VEP testing needs normal vision)
- Any organic brain disease is likely to reduce cognition.
- History of cardiac abnormality.
- History of autonomic dysfunction.
- Using other gaming gadgets like consoles, X-box, etc.,
- History of prolonged hospitalization likely to reduce the attention span.
- Students are not willing to give consent.

MATERIALS AND METHODS
Methodology:
Study Subjects and Data Collection
Medical students studying at **Sri Venkateshwaraa Medical College Hospital and Research centre, Ariyur, Puducherry** in the year from 2018 to 2021, who are playing video games, volunteered for this observational study conducted from January 2021-December-2021.

The study subjects were interviewed individually, and anthropometric parameters, and the subjective sensations and electrocardiogram were recorded. The basal cardiovascular parameters such as Heart Rate (HR) [22], Blood Pressure (BP) [23], and Body Mass Index (BMI)[24] were also recorded. Students were tested and the data for Heart rate variability (HRV) [25], Visual Evoked Potential (VEP) [26], and Cognition test using Mini-mental status examination (MMSE) [27] were done and data were collected and recorded.

Heart Rate Variability (HRV)
HRV was done using PHYSIOPAC SYSTEM, MEDICAID SYSTEMS, Chandigarh in which, in 5 minutes time domain (RR interval, the standard deviation of all normal RR intervals (SDNN)[28], root mean square of differences between adjacent normal RR intervals (RMSSD)[29] and the percentage of adjacent RR intervals with a difference of duration greater than 50 msec (PNN50)[30] and frequency domain (Total power (TP)[31], low frequency normalized unit (LFnu), high frequency normalized unit (HFnu), and Ratio of low frequency-high frequency (LF/HF ratio)[32] parameters of HRV were assessed by the frequency analysis of sequential R wave to R wave intervals of according to Electrocardiogram International Guidelines[33] the RR time interval series were extracted from ECG records using Kubios HRV analysis software[34] and recorded for all the study population.

Visual Evoked Potential (VEP)
Visual acuity was assessed using Snellen's chart[35] and the

Visual Evoked Potential test using waveforms of N75, P100, N145, and N75-P100 amplitude in both the eyes were done using the PHYSIOPAC-PP4, MEDICAIDSYSTEM[36]-Chandigarh-India. Prior to the VEP distance of 1 meter from the pattern generator screen in dark air-conditioned room and was asked to look at the central spot on the screen with one eye, with the other eye patched. The VEPs was picked up (10-20 International System of Electrode placement)[37] as the difference between the active electrode and the reference electrode. The ground electrode was fixed at the wrist. The shift pattern test stimulus on the TV monitor is white & black checks (15x15 mm size). The electrode impedance was kept below 5kilo ohms, with automatic artifact rejection. The readings were recorded.

The students were also issued a validated questionnaire for Mini-Mental Status Examination (MMSE) for Cognition.

Mini-mental status examination (MMSE) for Cognitive Functions

To assess the Cognitive functions- A mini mental status examination (MMSE) was done using a validated form of 25 questions for a total score of 50 marks. The students write the answer as fast as possible within 30 seconds. The student writes the correct answer within 30 seconds, the response is recorded as an immediate response, and the mark is allotted, if the student writes beyond 30 seconds, the response is recorded as delayed, and marks were not allotted. Marks scored>35 marks show no cognitive impairment, 18-34 show mild cognitive impairment and 0-17 show severe cognitive impairment.

For Orientation to time the questionnaire has questions on months, dates, years, seasons, days, weeks, and the allowed time is 30 seconds and the responses were recorded. For Orientation to place the questionnaire has questions on, buildings, floors, campuses, cities, states and the allowed time were 30 seconds and the responses were recorded. Attention and calculation were done by Letter digit substitution test (LDST) [38] to assess the neuropsychology activity of the brain in which the student has to write the corresponding letter under each digit within 30 seconds, and the responses were recorded.

For Recall, Wechsler memory scale – revised (WMS-R)[39] is done, in which a page with the designs was placed in the grid for 10 seconds and was asked to remember and reproduce the correct designs and place them in the puzzle grid within 30 seconds and the responses were recorded. For language, different Indian languages were given and the students were asked to identify the languages as many within 30 seconds, and the responses were recorded.

Analysis

The volunteered students were grouped into 3 groups based on their hours of gameplay based on an American guideline[40], and the guidelines clearly show gaming time-line 1-2 hours/day was considered as (unhealthy) excess of playing game time, and < 1-2 hours/day was considered as 0 tie-line of games played in 24 hours. The 1st group was students who played video games for ≤ 3 hours, the second group was students who played games for 4-6 hours, and the 3rd group was students who played games for >6 hours intermittently in 24 hours.

These groups were analyzed for age categories, gadgets in which the games were played, BMI, heart rate, blood pressure, Standard deviation of sequential 5-minute N-N interval (SDNN), The root mean square of successive differences between normal heartbeats (RMSSD), Proportion of adjacent R-R intervals (PNN-50), Total Power Heart Rate Variability (TP-PHRV), Ratio of High and Low-Frequency Powers of Heart Rate Variability (RHLFP-HRV), N75, N145, P100, N75-P100 amplitude (Right eye), N75-P100 amplitude (Left eye), Mini-Mental Status Examination (MMSE) for cognition, and results were recorded.

Statistical analysis of data:

Statistical analysis was done using the statistical package SPSS version 21. The data were expressed as mean ± SD for distributive variables, and frequency/percentage for descriptive variables. The association of hours of game played and clinical variables, HRV variables, and VEP variables were analyzed by Chi-square tests and the P value of <0.05 was considered statistically significant.

RESULTS

A total of 400 young medical students in the Tertiary Teaching Institute were questioned regarding the gaming nature and the effect of gaming on Heart Rate Variability, Visual Evoked Potential, Cognition, circadian rhythm autonomic functions, and its characteristics were outlined in **Table 1.** Out of 400 students, males 183 (45.8%) and females were 270 (54.2%). The 400 students ages were categorized into 2 groups, in which 19-20 years were 168 (42.0%) students, and 21-22 years were 232 (58.0%) students with a mean ± SD value of **20.605±0.9702.**

Students were asked how many hours they play the games intermittently in 24 hours, and 223 (55.7%) students were playing the games ≤ 3 hours intermittently in 24 hours, 123 (30.8%) students were playing the games 4-6 hours intermittently in 24 hours, and 54 (13.5%) students were playing the games > 6 hours intermittently in 24 hours. Students were asked which gadgets were used to play games, and 311 (77.7%) played on mobiles, whereas 89 (22.3%) of students played their games using laptops **(Table 1).**

Students' clinical markers concerning gaming were recorded. Student's Body Mass Index (BMI) was noted and students with ≥ 25 BMI were 142 (35.5%) whereas < 25 were 258 (65.5%). The cardiovascular parameter such as Heart Rate (HR) was observed, and a normal heart rate was found in 353 (88.2%) students, a slow heart rate (Bradycardia) was found in 33 (8.3%) students, and a high heart rate (Tachycardia) was found in 14 (3.5%) of students. The student's other clinical markers such as Blood Pressure (BP) were also observed and recorded. Normal blood pressure was recorded in 128 (32.0%), whereas low blood pressure was found in 193 (48.3%), and high blood pressure was found in 79 (19.7%) of students playing games **(Table 1).**

The Electrocardiogram (ECG) was done for the students based on international guidelines to evaluate the Heart Rate Variability (HRV) of the students playing games and the readings of the ECG were tested and recorded. The 5 minutes of short-term variation of the heart with time and frequency domain were analyzed to check the functioning of the autonomic nervous system of students playing games. The standard deviation of sequential 5-minute N-N interval (SDNN) was analyzed and found < 50 milliseconds SDNN was found in 37 (9.3%) of students, 50-100 milliseconds of SDNN values of time domain were found in 156 (39%) of students, and > 100 milliseconds of SDNN were found in 207 students (51.7%) with mean ± SD value of 107.511±61.773 **(Table 1).**

The root means square of successive differences between normal heartbeats (RMSSD) were analyzed and healthy males were found in 45 (11.2%) of students, healthy females were found in 125 (31.3%), whereas unhealthy males were found in 138 (34.5%), and unhealthy females were 92 (23.0%) with mean ± SD value of 67.566±35.3752, as per the standards-based time domain. The proportion of adjacent R-R intervals (PNN-50) was analyzed and found < 50 milliseconds PNN-50 was found in 58 (14.5%) of students, 50-100 milliseconds of PNN-50 values were found in 192 (48%) of students, and > 100 milliseconds of PNN-50 were found in 150 students (37.5%) with mean ± SD value of 94.678±46.3322 **(Table 1).**

The other marker of the heart rate variability Total Power (TP) was also analyzed and ≤ 0.4 milliseconds squared of the total power of frequency domain was found in 227 (56.8%) students, and > 0.4 milliseconds squared of total power was found in 173 (43.2%) students with mean ± SD value of 0.3631±0.147. The ratio of High and Low-Frequency Powers of Heart Rate Variability (RHLFP-HRV) was analyzed and ≤ 0.4 milliseconds squared of RHLFP-HRV was found in 257 (64.3%) students, and > 0.4 milliseconds squared of RHLFP-HRV of frequency domain was found in 143 (35.7%) students with mean ± SD value of 0.3927±0.189 **(Table 1).**

We also conducted tests to analyze and evaluate the Visual Evoked Potential (VEP) capacity of the students who are playing games. One of the markers of VEP is N75 latency, which was calculated as acceptable latency as ≤100 which was found in 266 (66.5%) of students, whereas unhealthy (unacceptable) N75 latency of >100 was found in 134 (33.5%) of students with mean ± SD value of 84.7487±18.1148. The other marker N145 latency was also calculated and found ≤100 in 259 (64.8%) of students which was considered to be an acceptable latency, whereas unhealthy (unacceptable) N145 latency >100 was found in 141 (35.2%) of students with mean ± SD value of 78.8344±28.0098 playing games **(Table 1).**

The other marker P100 latency was also calculated and found ≤100 in 279 (69.8%) of students which was considered to be an acceptable latency, whereas unhealthy (unacceptable) P100 latency >100 was found in 121 (30.2%) of students with mean ± SD value of 80.5497±24.0108 playing games. N75-P100 amplitude was also calculated for the students in both right and left eye playing games and was found in 115 (28.8%) which was considered as healthy males as per standard, whereas unhealthy males were 68 (17%) in the N75-P100 amplitude test.

The healthy females were found 181 (45.2%), whereas unhealthy females were found to be 36 (9%) with a mean ± SD value of 6.7648±2.5121 in the right eye. 140 (35.0%) which was considered as healthy males as per standard, whereas unhealthy males were 43 (10.7%) in the N75-P100 amplitude test. The healthy females were found 176 (44.0%), whereas unhealthy females were found 41 (10.3%) with a mean ± SD value of 6.5964±2.3962 in the left eye **(Table 1).**

We have done Mini-Mental Status Examination (MMSE) for the cognition capacity of students playing games, and we have done 5 parameters to identify the process of cognitions and the responses were recorded as immediate and delayed responses. Among the 5 parameters fundamental process of cognitions was identified by orientation to time, and we found that immediate responses to the questions were given by 302 (75.5%) students, and delayed responses were given by 98 (24.5) students **(Table 1).**

For orientation to place, immediate responses to the questions were given by 292 (73.0%) students, and delayed responses were given by 108 (27.0%) students. For attention and calculation, immediate responses to the questions were given by 282 (70.5%) students, and delayed responses were given by 118 (29.5%) students **(Table 1).**

For recall, immediate responses to the questions were given by 306 (76.5%) students, and delayed responses were given by 94 (23.5%) students. For language, immediate responses to the questions were given by 285 (71.3%) students, and delayed responses were given by 115 (28.7%) students **(Table 1).**

Table 1 Basic Outline of Mobile Gaming on Cognition Study Population

Variables	No (%)
Gender (n=400)	
Males	183 (45.8)
Females	217 (54.2)
Age Categories (in years) 20.605±0.9702	
19-20 years	168 (42.0)
21-22 years	232 (58.0)
Hours of games played (Hours)	
≤3	223 (55.7)
4-6 hours	123 (30.8)
>6	54 (13.5)
Gadgets in which the games played	
Mobile	311 (77.7)
Laptop	89 (22.3)
BMI	
≥25	142 (35.5)
<25	258 (64.5)
Heart Rate (beats/minutes-bpm)	
Normal Range	353 (88.2)
Bradycardia	33 (8.3)
Tachycardia	14 (3.5)
Blood Pressure (mmHg)	
Normal Blood Pressure	128 (32.0)
Low Blood Pressure	193 (48.3)
High Blood Pressure	79 (19.7)
Standard deviation of sequential 5-minute N-N interval (SDNN) (ms) 107.511±61.773	
< 50	37 (9.3)
50-100	156 (39.0)
>100	207 (51.7)
The root mean square of successive differences between normal heartbeats (RMSSD) (ms) 67.566±35.3752	
53.5–82 ms — Healthy Males	45 (11.2)
Unhealthy Males	138 (34.5)
22–79 ms — Healthy Females	125 (31.3)
Unhealthy Females	92 (23.0)
Proportion of adjacent R-R intervals (PNN-50) (ms) 94.678±46.3322	
< 50	58 (14.5)
50-100	192 (48.0)
>100	150(37.5)
Total Power Heart Rate Variability (TP-PHRV) (ms2) 0.3631±0.147	
≤0.4	227 (56.8)
>0.4	173 (43.2)
Ratio of High and Low Frequency Powers of Heart Rate Variability (RHLFP-HRV) (ms2) 0.3927±0.189	
≤0.4	257 (64.3)
>0.4	143 (35.7)
N75 (ms) 84.7487±18.1148	
≤100	266 (66.5)
>100	134 (33.5)
N145 (ms) 78.8344±28.0098	
≤100	259 (64.8)
>100	141 (35.2)
P100 (ms) 80.5497±24.0108	
≤100	279 (69.8)
>100	121 (30.2)
N75-P100 amplitude (μV) Right Eye 6.7648±2.5121	
8–3 ms — Healthy Males	115 (28.8)
Unhealthy Males	68 (17.0)
8-3 ms — Healthy Females	181 (45.2)

Unhealthy Females	36 (9.0)
N75-P100 amplitude (µV) Left Eye 6.5964±2.3962	
8–3 ms — Healthy Males	140 (35.0)
Unhealthy Males	43 (10.7)
8-3 ms — Healthy Females	176 (44.0)
Unhealthy Females	41 (10.3)
Mini-Mental Status Examination (MMSE) for Cognition	
Orientation to time	
Immediate	302 (75.5)
Delayed	98 (24.5)
Orientation to place	
Immediate	292 (73.0)
Delayed	108 (27.0)
Attention and calculation	
Immediate	282 (70.5)
Delayed	118 (29.5)
Recall	
Immediate	306 (76.5)
Delayed	94 (23.5)
Language	
Immediate	285 (71.3)
Delayed	115 (28.7)

We further categorized the young medical students into 3 categories based on their hours of games played intermittently in 24 hours.

The 1st category was students played games ≤3 hours which was counted as 223 students, the 2nd category was 4-6 hours which was counted as 123 students, the 3rd category was >6 hours which was counted as 54 students, and the basic details such as gender, age categories, and the gadgets used to play the games were described in **Table 2.**

In **Table 2,** we explained that out of 183 young male medical students, 108 (48.4%) males who played games for <3 hours, 52 (42.3%) males played games for 4-6 hours, and 23 (42.6%) males played games for >6 hours, whereas out of 217 young females medical students, 115 (51.6%) females who played games for ≤3 hours, 71 (57.7%) females played games for 4-6 hours, and 31 (57.4%) females played games for >6 hours.

We categorized the young medical students based on age also, and 19-20 years of age was found in 168 students, in whom 104 students played games for ≤3 hours, 43 students played games for 4-6 hours, and 21 students played games for >6 hours. 21-22 years of age was found in 232 students, in whom 119 students played games for ≤3 hours, 80 students played games for 4-6 hours, and 33 students played games for >6 hours **(Table 2).**

Table 2 also expresses the details in regards to the gadgets in which the young students played the games based on the hours they played, and it was found 311 students played games using mobile, among them 188 (84.3%) played games for ≤3 hours, 92 (74.8%) students played games for 4-6 hours, and 31 (57.4%) students played games for >6 hours, whereas 89 students played games using laptops, among them 35 (15.7%) played games for ≤3 hours, 31 (25.2%) students played games for 4-6 hours, and 23 (42.6%) students played games for >6 hours with a statistical significance of **0.00007 (Chi-square-19.0763).**

Table 2 Basic Attributions of Students Playing Games Based on the Hours of Games Played

Variables	Categories	Hours of games played (Hours)			Chi square	p value
		≤3 hours (n=223)	4-6 hours (n=123)	>6 hours (n=54)		
Genders	Males	108 (48.4)	52 (42.3)	23 (42.6)	1.4604	0.4818
	Females	115 (51.6)	71 (57.7)	31 (57.4)		
Age Categories (in years)	19-20 years	104 (46.6)	43 (35.0)	21 (38.9)	4.6857	0.0961
	21-22 years	119 (53.4)	80 (65.0)	33 (61.1)		
Gadgets in which the games played	Mobile	188 (84.3)	92 (74.8)	31 (57.4)	19.0763	0.00007*
	Laptop	35 (15.7)	31 (25.2)	23 (42.6)		

***Statistical Significant**

In **Table 3** we explained the clinical profile of the young medical students playing games based on the hours of games played, and the students with ≥25 Body Mass Index (BMI) was found 145 students, among them 73 (32.7%) played games for ≤3 hours, 51 (41.5%) students played games for 4-6 hours, and 21 (38.9%) students played games for >6 hours, whereas out of 255 students whose BMI was <25, among them 150 (67.3%) played games for ≤3 hours, 72 (58.5%) students played games for 4-6 hours, and 33 (61.1%) students played games for >6 hours.

We observed the Heart Rate (HR) of the medical students who played games and plotted based on the hours of games played. Out of 400 students, 353 medical students showed a normal range of HR, whereas 47 student's HR was abnormal and among them, 33 showed Bradycardia, in 33 students with bradycardia, 5 (2.3%) played games ≤ 3 hours, 16 (13.0%) played games 4-6 hours, and 12 (22.2%) played games >6 hours, whereas 14 students showed Tachycardia, among them 3 (1.3%) played game for ≤ 3 hours, 04 (3.3%) played games 4-6 hours, and 7 (13.0%) played games >6 hours, with the statistical significance of **<0.00001 (Chi-square-48.0334) (Table 3).**

We examined the Blood Pressure (BP) in our young medical students during the study, and found out of 400 students 128 students found normal BP, out of these 128 students, 215 students played the games ≤ 3 hours, 103 (83.7%) played games 4-6 hours, and 35 (64.8%) played games >6 hours, whereas 193 students showed Low BP (LBP), among them 120 (53.8%) played game for ≤ 3 hours, 54 (43.9%) played games 4-6 hours, and 19 (35.2%) played games >6 hours, 79 students showed High Blood Pressure (HBP), in the 42 (18.8%) played games ≤ 3 hours, 21 (17.1%) played games 4-6 hours, and 16 (29.6%) played games >6 hours with the statistical significance of **0.0314 (Chi-square-10.6033) (Table 3).**

Table 3 Clinical profile of Students Playing Games Based on the Hours of Games Played

Variables	Categories	Hours of games played (Hours)			Chi square	p value
		≤3 hours (n=223)	4-6 hours (n=123)	>6 hours (n=54)		
BMI	≥25	73 (32.7)	51 (41.5)	21 (38.9)	2.8013	0.2464
	<25	150 (67.3)	72 (58.5)	33 (61.1)		
Heart Rate (beats/minutes-bpm)	Normal Range	215 (96.4)	103 (83.7)	35 (64.8)	48.0334	<0.00001*
	Bradycardia	5(2.3)	16 (13.0)	12 (22.2)		
	Tachycardia	3 (1.3)	4 (3.3)	7 (13.0)		
Blood Pressure (BP) (mmHg)	Normal BP	61 (27.4)	48 (39.0)	19 (35.2)	10.6033	0.0314*
	Low BP	120 (53.8)	54 (43.9)	19 (35.2)		
	High BP	42 (18.8)	21 (17.1)	16 (29.6)		

***Statistical Significant**

As we wanted to know the effects caused due to the stress on the Heart/Autonomic Nervous System (ANS) in regards to playing games, hence we collected the data on Heart Rate Variability (HRV) of students playing games based on the hours of games played and reported in **Table 4.** Among the heart rate variability, the Standard deviation of sequential 5-minute N-N interval (SDNN) was recorded and found <50 milliseconds (unhealthy value) of SDNN were noted in 44 students, among them 7 (3.1%) students played for ≤ 3 hours, 10 (8.1%) played games 4-6 hours, and 27 (50.0%) played games >6 hours. 50-100 milliseconds of SDNN were noted in 151 students, among them, 44 (19.7%) students played for ≤ 3 hours, 85 (69.1%) played games for 4-6 hours, and 22 (40.7%) played games >6 hours. >100 milliseconds of SDNN were noted in 205 students, among them, 172 (77.2%) students played for ≤ 3 hours, 28 (22.8%) played games for 4-6 hours, and 5 (9.3%) played games >6 hours. with the statistical significance of **<0.00001 (Chi-square-206.655).**

In **Table 4,** the other marker of HRV, the root mean square of successive differences between normal heartbeats (RMSSD) was explained for the study population who played the games. Based on the standards of RMSSD the medical students were classified as healthy and unhealthy. The students whose RMSSD was 53.5-82 milliseconds were considered healthy males (n=124), among them 77 (34.5%) played games of RMSSD was ≤ 3 hours, 32 (26.0%) played games 4-6 hours, and 15 (27.8%) played games >6 hours, and students whose RMSSD was below and above the normal range were considered as unhealthy males (n=59), among them 31 (13.9%) played games of RMSSD was ≤ 3 hours, 20 (16.3%) played games 4-6 hours, and 8 (14.8%) played games >6 hours. The students whose RMSSD was 22-79 milliseconds were considered healthy females (n=164), among them, 77 (34.5%) played games of RMSSD was ≤ 3 hours, 60 (48.8%) played games 4-6 hours, and 27 (50.0%) played games >6 hours, and students whose RMSSD was below and above the normal range were considered as unhealthy females (n=53), among them 38 (17.1%) played games of RMSSD was ≤ 3 hours, 11 (8.9%) played games 4-6 hours, and 4 (7.4%) played games >6 hours with the statistical significance of **0.0422 (Chi-square-13.053).**

The proportion of adjacent R-R intervals (PNN-50) was one of the other markers we recorded for the study population to evaluate the heart rate variability and found <50 milliseconds (unhealthy value) of PNN-50 was recorded in 58 students, among them 17 (7.6%) students played for ≤ 3 hours, 14 (11.4%) played games 4-6 hours, and 27 (50.0%) played games >6 hours.

50-100 milliseconds of PNN-50 was observed in 192 students, among them, 79 (35.4%) students played for ≤ 3 hours, 87 (70.7%) played games for 4-6 hours, and 26 (48.1%) played games >6 hours. >100 milliseconds of PNN-50 was recorded in 150 students, among them, 127 (57.0%) students played for ≤ 3 hours, 22 (17.9%) played games for 4-6 hours, and 1 (1.9%) played games >6 hours. with a statistical significance of **<0.00001 (Chi-square-129.0331) (Table 4).**

We conducted certain tests to evaluate the effects of playing games on the Sympathetic and Parasympathetic systems. Total Power (TP) is one of the salient factors to check the sympathetic and para-sympathetic systems, and the spectral density of ≤0.4 milliseconds squared was considered a healthy outcome. 285 students were found healthy based on TP and among them, 170 (76.2%) students played for ≤ 3 hours, 80 (65.0%) played games for 4-6 hours, and 35 (64.8%) played games >6 hours. The spectral density of >0.4 milliseconds squared was considered an unhealthy outcome. 115 students were found unhealthy, among them, 53 (23.8%) students played for ≤ 3 hours, 43 (35.0%) played games for 4-6 hours, and 19 (35.2%) played games for>6 hours with a statistically significance of 0.0471 (Chi-square-6.1101) (Table 4).

Low-frequency (LF) and High-frequency bands were measured and the ratio was calculated as the Ratio of High and Low-Frequency Powers of Heart Rate Variability (RHLFP-HRV). For the RHLFP-HRV, the spectral density of ≤0.4 milliseconds squared was considered a healthy outcome. 263 students were found healthy, among them, 160 (71.7%) students played for ≤ 3 hours, 72 (58.5%) played games for 4-6 hours, and 31 (57.4%) played games for>6 hours.

The spectral density of >0.4 milliseconds squared was considered an unhealthy outcome. 137 students were found unhealthy, among them, 63 (28.3%) students played for ≤ 3 hours, 51 (41.5%) played games for 4-6 hours, and 23 (42.6%) played games for>6 hours with the statistical significance of 0.0176 (Chi-square-8.0746) (Table 4).

Table 4 Heart Rate Variability (HRV) of Students Playing Games Based on the Hours of Games Played

Variables	Categories	Hours of games played (Hours)			Chi square	P value
		≤3 hours (n=223)	4-6 hours (n=123)	>6 hours (n=54)		
Standard deviation of sequential 5-minute N-N interval (SDNN) (ms)	< 50	7 (3.1)	10(8.1)	27 (50.0)	206.655	<0.00001*
	50-100	44 (19.7)	85 (69.1)	22 (40.7)		
	>100	172 (77.2)	28 (22.8)	5 (9.3)		
The root mean square of successive differences between normal heartbeats (RMSSD) (ms)	Healthy Males	77 (34.5)	32(26.0)	15(27.8)	13.053	0.0422*
	Unhealthy Males	31(13.9)	20(16.3)	8(14.8)		
	Healthy Females	77 (34.5)	60(48.8)	27(50.0)		
	Unhealthy Females	38 (17.1)	11(8.9)	4(7.4)		
Proportion of adjacent R-R intervals (PNN-50) (ms)	< 50	17 (7.6)	14 (11.4)	27 (50.0)	129.0331	<0.00001*
	50-100	79 (35.4)	87 (70.7)	26 (48.1)		
	>100	127 (57.0)	22 (17.9)	1 (1.9)		
Total Power Heart Rate Variability (TP-PHRV) (ms2)	≤0.4	170 (76.2)	80(65.0)	35 (64.8)	6.1101	0.0471*
	>0.4	53 (23.8)	43 (35.0)	19 (35.2)		

Ratio of High and Low Frequency Powers of Heart Rate Variability (RHLFP-HRV) (ms2)	≤0.4	160 (71.7)	72 (58.5)	31 (57.4)	8.0746	0.0176*
	>0.4	63 (28.3)	51 (41.5)	23 (42.6)		

***Statistical Significant**

We have conducted a few tests to understand the visual stimulus, visual pathway, and the effects caused to the eyes such as refractive errors due to playing games hence Visual Evoke Potential (VEP) tests were conducted and were expressed in **Table 5.** N75 latency was done and ≤100 milliseconds was considered as healthy (normal) eyes found in 282 young medical students, among them 164 (73.5%) were found in students playing the games ≤ 3 hours, 86 (69.9%) was in students playing 4-6 hours, and 32 (59.3%) was found in students playing > 6 hours, whereas N75 latency >100 milliseconds was considered as unhealthy (abnormal) eyes found in 118 students, among them 59 (26.5%) was found in students playing the games ≤ 3 hours, 37 (30.1%) was in students playing 4-6 hours, and 22 (40.7%) was found in students playing > 6 hours.

N145 latency was also done to evaluate VEP, and ≤100 milliseconds was considered as healthy (normal) eyes found in 276 students, among them 174 (78.0%) were found in students playing the games ≤ 3 hours, 73 (59.3%) was in students playing 4-6 hours, and 29 (53.7%) was found in students playing > 6 hours, whereas N145 latency >100 milliseconds was considered as unhealthy (abnormal) eyes found in 124 students, among them 49 (22.0%) was found in students playing the games ≤ 3 hours, 50 (40.7%) was in students playing 4-6 hours, and 25 (46.3%) was found in students playing > 6 hours with the statistical significance of **0.00005 (Chi-square-19.7573) (Table 5).**

In Table 5 we also have reported the other important marker of VEP, P100 latency, and ≤100 milliseconds was considered as healthy (normal) eyes found in 292 students, among them 184 (82.5%) were found in students playing the games ≤ 3 hours, 77 (62.6%) was in students playing 4-6 hours, and 31 (57.4%) was found in students playing > 6 hours, whereas P100 latency >100 milliseconds was considered as unhealthy (abnormal) eyes found in 108 students, among them 39 (22.0%) was found in students playing the games ≤ 3 hours, 46 (37.4%) was in students playing 4-6 hours, and 23 (42.6%) was found in students playing > 6 hours with the statistical significance of **<0.00001 (Chi-square-23.6437).**

In **Table 5,** one of the prime markers of VEP is N75-P100 amplitude which was tested in both the eyes (right eye and left eye) study subjects. Based on the standards, the N75-P100 amplitudes were classified as healthy and unhealthy. The students whose N75-P100 amplitude was 3.9-8.3 microVolt (□V) for the right eye were considered as healthy males (n=135), among them 98 (43.9%) played games of N75-P100 amplitude was ≤ 3 hours, 33 (26.8%) played games 4-6 hours, and 4 (7.4%) played games >6 hours, and students whose N75-P100 amplitude was below and above the normal range were considered as unhealthy males (n=48), among them 10 (4.5%) played games of N75-P100 amplitudes was ≤ 3 hours, 19 (15.4%) played games 4-6 hours, and 19 (35.2%) played games >6 hours. The students whose N75-P100 amplitude was 5.9-12.3 microVolt (□V) for the right eye were considered as healthy females (n=168), among them 107 (48.0%) played games of N75-P100 amplitude was ≤ 3 hours, 53 (43.1%) played games 4-6 hours, and 8 (14.8%) played games >6 hours, and students whose N75-P100 amplitude was below and above the normal range were considered as unhealthy females (n=49), among them 8 (3.6%) played games of N75-P100 amplitudes was ≤ 3 hours, 18 (14.7%) played games 4-6 hours, and 23 (42.6%) played games >6 hours with the statistical significance of **<0.00001 (Chi-square-121.8749).**

The students whose N75-P100 amplitude was 3.6-8 microVolt (μV) for the left eye, were considered to be healthy males (n=149), among them 103 (46.2%) played games of N75-P100 amplitude was ≤ 3 hours, 37 (30.1%) played games 4-6 hours, and 9 (16.7%) played games >6 hours, and students whose N75-P100 amplitude was below and above the normal range were considered as unhealthy males (n=34), among them 5 (2.2%) played games of N75-P100 amplitudes was ≤ 3 hours, 15 (12.2%) played games 4-6 hours, and 14 (25.9%) played games >6 hours. The students whose N75-P100 amplitude was 5.1-11.5 microVolt (μV) for the left eye, were considered healthy females (n=173), among them 105 (47.1%) played games of N75-P100 amplitude was ≤ 3 hours, 57 (46.3%) played games 4-6 hours, and 11 (20.4%) played games >6 hours, and students whose N75-P100 amplitude was below and above the normal range were considered as unhealthy females (n=44), among them 10 (4.5%) played games of N75-P100 amplitudes was ≤ 3 hours, 14 (11.4%) played games 4-6 hours, and 20 (37.0%) played games >6 hours with the statistical significance of <0.00001 (Chi-square-93.632) (Table 5).

Table 5 Visual Evoked Potential (VEP) of Students Playing Games Based on the Hours of Games Played

Variables	Categories	Hours of games played (Hours)			Chi square	P value
		≤3 hours (n=223)	4-6 hours (n=123)	>6 hours (n=54)		
N75 (ms)	≤100	164 (73.5)	86 (69.9)	32 (59.3)	4.2934	0.1169
	>100	59 (26.5)	37 (30.1)	22(40.7)		
N145 (ms)	≤100	174 (78.0)	73 (59.3)	29 (53.7)	19.7573	0.00005*
	>100	49 (22.0)	50 (40.7)	25 (46.3)		
P100 (ms)	≤100	184 (82.5)	77 (62.6)	31 (57.4)	23.6437	<0.00001*
	>100	39 (17.5)	46 (37.4)	23 (42.6)		
N75-P100 amplitude (μV) (Right eye)	Healthy Males	98 (43.9)	33 (26.8)	4 (7.4)	121.8749	<0.00001*
	Unhealthy Males	10 (4.5)	19 (15.4)	19 (35.2)		
	Healthy Females	107 (48.0)	53 (43.1)	8 (14.8)		
	Unhealthy Females	8 (3.6)	18 (14.7)	23 (42.6)		
N75-P100 amplitude (μV) (Left eye)	Healthy Males	103 (46.2)	37 (30.1)	9 (16.7)	93.632	<0.00001*
	Unhealthy Males	5 (2.2)	15 (12.2)	14 (25.9)		
	Healthy Females	105 (47.1)	57 (46.3)	11 (20.4)		
	Unhealthy Females	10 (4.5)	14 (11.4)	20(37.0)		

***Statistical Significant**

We have conducted Mini-Mental Status Examination (MMSE) for the Cognition of Students Playing Games Based on the Hours of Games Played and plotted in Figure 1. We have done 5 parameters to identify the process of cognitions and the responses were recorded as immediate and delayed responses. Among the 5 parameters fundamental process of cognitions was identified by orientation to time, and we found that immediate responses to the questions were given by students who played games ≤ 3 hours (89.2%), whereas delayed responses were found higher in students who played games > 6 hours (81.5%).

The other MMSE variable was an orientation to the place which identifies the involvement mind in response to 3 dimensions such as person, place, and time. Immediate responses were higher in students who played games ≤ 3 hours (85.6%), whereas delayed responses were found higher in students who played games > 6 hours (75.9%), and for the 3rd MMSE variable, attention and calculation, immediate responses (85.2% in ≤ 3 hours), and delayed responses (85.2% in > 6 hours) **(Figure 1).**

The 4th and 5th MMSE variables were recall (amnestic impairment) and visuospatial (images and perception). Immediate responses for recall were (90.6%) in ≤ 3 hours, and delayed responses were (72.2%) in students who played games > 6 hours. The immediate responses to the 5th MMSE variable visuospatial for language were found higher (84.3% in ≤ 3 hours), and delayed responses (79.6% in > 6 hours) **(Figure 1).**

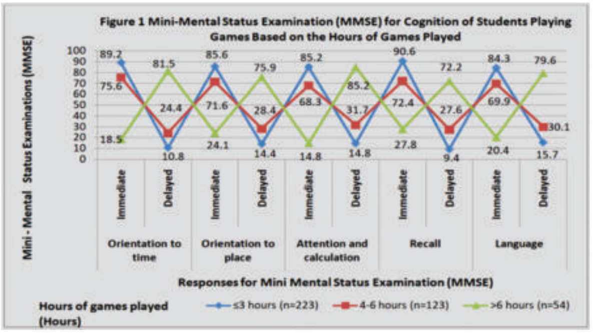

Figure 1 Mini-Mental Status Examination (MMSE) for Cognition of Students Playing Games Based on the Hours of Games Played

DISCUSSION

Gaming is bringing a negative impact on physical and mental health making human life inappropriate for a better quality of life. Among the game-playing categories, young children are more vulnerable to worsening their circadian rhythm, visual effects, cognition, and autonomic functions.

As reported by Shakir, R. N et al, gaming is associated with body fat, and we in our study reported that ≥25 BMI was found in 35.5% of our medical students[41].

Data on boxing games and heart rate by Cavalcante-Neto, J. L and esports gaming and heart rate by Onishi, T et al reported in their studies, that the heart rate increased in 94.7% of the boxers, and after the esports, the heart rate increased, whereas, in our present study of video gaming also, we found that Tachycardia (increased heart) found in 3.5% of the students who played video games, we also found the statistical significance in game duration and heart rate[42,43].

Research published by Krarup, K. B et al reported that in their study done in 9 gamers, no-dip were found in both blood pressure and heart rate, and not reported based on game duration, but our present study showed that normal BP was found in32.0%, but low BP was found in 48.3%, and high BP was found in 19.7%, and also reported the BP variations changes as per game duration[44]. A study by Hou, C. J et al shows that the ratio of high and low-frequency powers was 0.697 during rest, but it increased to 1.325 during gaming, our study also found that the interquartile range was 0.3927±0.189[45].

Onishi, T et al described in their study, that VEP tests were done as routine ophthalmic tests, and they categorized the patients as mild, moderate, and severe based on mean deviation, and the results were N75 was 64.60±2.95 in the mild category, 75.93±4.67 in the moderate category, and in the severe category, the N75 was 85.39±4.89, in our present study as the study was on video gaming, we categorized our students into 3 categories based on hours of game played, and we found N75 mean ± SD was 84.7487±18.1148[46].

Xie, X et al reported one of the important markers of VEP in patients with routine ophthalmic check-ups and they found N75-P100 amplitude at 1 of spatial frequency was 8.43 (6.74, 9.64), and 0.25 spatial frequency was 8.09 (5.27, 9.40), and in our study, we have done for students who played video games, we found in the right eye was 6.7648±2.5121, and in the left eye was 6.5964±2.3962 (μV)[47].

Hamdan, F. B et al published research on VEP in Autism children in their study, they found that the P100 latency (119.2 ± 7.06)was significantly prolonged in children with Autism in both eyes, whereas we also found that mean ±SD was 80.5497±24.0108, and students who played video games > 6 hours/day was higher with 42.6%, compared to who played ≤3 hours, and 4-6 hours with 22.0%, and 37.4% with the statistical significance of <0.00001 (Chi-square-23.6437) indicating that playing video games longer will bring adverts effects on the eyes which are indicated by P100 latency the VEP marker[48].

Sayorwan, W et al explained that a negative association was found between (N145) latency and Vineland Adaptive Behavior Scales, but we found in our study that there is a significant correlation between the N145 and the hours of video game played, and we found the longer the games played the higher the percentage of unhealthiness increased being the students who played >6 hours with 46.3%, 4-6 hours was 40.7%, and ≤3 hours was 22.0%[49].

Significant changes such as a Sharpe decline were found for RMSSD, and not for SDNN in a study published by Kim, D et al who have done research in the autonomic nervous system and reactivity of the cardio-vascular system, but in our present study, we found, that RMSSD was 67.566±35.3752, and our study also found that a significant change in between males and females based on hours of games played with statistical significance of 0.0422 (Chi-square-13.053)[50].

Hu, S et al reported SDNN (24.14) showed a significant decrease in Borrmann I-II tumors, whereas our study showed that a higher percentage of students were deceased SDNN found in the category playing video games >6 hours indicating the weakened Autonomic Nervous System (ANS) with statistical significance of <0.00001 (Chi-square-206.655)[51].

Zhao, C et al research showed that blood pressure was increased as the weeks of excises increased, our present is compatible with their study as the hours of video games playing increased higher percentage of high blood pressure was found with a statistical significance of 0.0314 (Chi-square-10.6033)[52].

Grzęda-Hałon, M et al found that PNN-50 showed a reduction during night time sleep in sleep apnea patients, in our present study, we found there is an increased percentage of students with the deceased value of PNN-50 indicating the students who played longer than 6 hours have unhealthy HRV with statistical significance of <0.00001 (Chi-square-129.0331)[53].
In conclusion, this our present study describes clearly, that

students who play longer hours > 4 hours per day weaken their heart rate, increase body weight and thus leading to high-fat diseases, decreased visual signals which were proven by visually evoked potential tests, and end up in lesser cognitive capacities, completely weakened physical and mental strength (abnormal autonomic system) due to the long hours of video gaming in the young ages, thus spoiling their complete life, and losing the hope of the parents, the hope of the teachers, hope of the stakes, the hope of the government, hope in themselves leading to suicide, for just for the games.

Hence this study will bring a positive impact on the medical student (study population), psychiatrists, child counselors counseling kids, and youths who would have attempted suicide due to failure in video games, and other health care workers, thus bringing the best impact on kids and youths who can uplift their education, physical capabilities, and strong mental health leading to the best quality of life, good scores in education, highly paid jobs, thus supporting the stakes and the country.

REFERENCES

1. Parekh, P., Patel, S., Patel, N., & Shah, M. (2020). Systematic review and meta-analysis of augmented reality in medicine, retail, and games. Visual computing for industry, biomedicine, and art, 3(1), 1-20.
2. Sánchez-Iglesias, I., Bernaldo-de-Quirós, M., Estupiñá, F. J., Fernández-Arias, I., Labrador, M., Vallejo-Achón, M., & Labrador, F. J. (2022). Maladaptive Cognitions in Adolescents and Young Adults When They Play: The Dysfunctional Cognitions in Gaming Scale (DCG). Sustainability, 14(23), 16109.
3. Khan, N., Muhammad, K., Hussain, T., Nasir, M., Munsif, M., Imran, A. S., & Sajjad, M. (2021). An adaptive game-based learning strategy for children road safety education and practice in virtual space. Sensors, 21(11), 3661.
4. Karhulahti, V. M., Nerg, H., Laitinen, T., Päivinen, A., & Chen, Y. (2022). Eight Hypotheses on Technology Use and Psychosocial Wellbeing: A Bicultural Phenomenological Study of Gaming during the COVID-19 Pandemic. Current Psychology, 1-19.
5. Peracchia, S., & Curcio, G. (2018). Exposure to video games: effects on sleep and on post-sleep cognitive abilities. A systematic review of experimental evidences. Sleep Science, 11(4), 302.
6. Rone, V. E., Aksoy, C., &Pozderac-Chenevey, S. (Eds.). (2022). Nostalgia and Videogame Music: A Primer of Case Studies, Theories, and Analyses for the Player-Academic. Intellect Books.
7. Donati, M. A., Guido, C. A., De Meo, G., Spalice, A., Sanson, F., Beccari, C., &Primi, C. (2021). Gaming among children and adolescents during the COVID-19 lockdown: The role of parents in time spent on video games and gaming disorder symptoms. International Journal of Environmental Research and Public Health, 18(12), 6642.
8. Mohan, D., Fischhoff, B., Angus, D. C., Rosengart, M. R., Wallace, D. J., Yealy, D. M., & Barnato, A. E. (2018). Serious games may improve physician heuristics in trauma triage. Proceedings of the National Academy of Sciences, 115(37), 9204-9209.
9. Vaghetti, C. A. O., Monteiro-Junior, R. S., Finco, M. D., Reategui, E., & da Costa Botelho, S. S. (2018). Exergames experience in physical education: A review. Physical Culture and Sport. Studies and Research, 78(1), 23-32.
10. Kojic, T., Sirotina, U., Möller, S., & Voigt-Antons, J. N. (2019, June). Influence of ui complexity and positioning on user experience during vr exergames. In 2019 Eleventh International Conference on Quality of Multimedia Experience (QoMEX) (pp. 1-6). IEEE.
11. Barr, M. (2018). Student attitudes to games-based skills development: Learning from video games in higher education. Computers in human behavior, 80, 283-294.
12. Sharma, A. (2020). Persuasive/Serious Games: Agents of Change in Individual Beliefs (Doctoral dissertation, Dissertation]. Breda: Breda University. https://doi. org/10.13140/RG. 2.2. 10443.21281).
13. Carson, V., Lee, E. Y., Hesketh, K. D., Hunter, S., Kuzik, N., Predy, M., & Hinkley, T. (2019). Physical activity and sedentary behavior across three time-points and associations with social skills in early childhood. BMC public health, 19(1), 1-8.
14. Tripathi, M., & Mishra, S. K. (2020). Screen time and adiposity among children and adolescents: a systematic review. Journal of Public Health, 28(3), 227-244.
15. Chaput, J. P., Tremblay, M. S., Katzmarzyk, P. T., Fogelholm, M., Hu, G., Maher, C., & ISCOLE Research Group. (2018). Sleep patterns and sugar-sweetened beverage consumption among children from around the world. Public health nutrition, 21(13), 2385-2393.
16. World Health Organization . ICD-11 beta draft: gaming disorder; p. C2018.
17. World Health Organization Gaming disorder (6C51) p. C2019.
18. Khodakovskaia, O., Bogdsnovskaya, I., Koroleva, N., Alekhin, A., & Mokhnatkin, I. (2019, June). Implicit concepts of the psychological effects of video games among young adult students. In International Conference on Digital Transformation and Global Society (pp. 648-660). Springer, Cham.
19. Wang, H. R., Cho, H., & Kim, D. J. (2018). Prevalence and correlates of comorbid depression in a nonclinical online sample with DSM-5 internet gaming disorder. Journal of affective disorders, 226, 1-5.
20. Milani, L., La Torre, G., Fiore, M., Grumi, S., Gentile, D. A., Ferrante, M., & Di Blasio, P. (2018). Internet gaming addiction in adolescence: Risk factors and maladjustment correlates. International Journal of Mental Health and Addiction, 16(4), 888-904.
21. Raouf, S. Y. A., Gabr, H. M., Al-Wutayd, O., & Al-Batanony, M. A. (2022). Video game disorder and mental wellbeing among university students: a cross-sectional study. The Pan African Medical Journal, 41.
22. Achten, J., & Jeukendrup, A. E. (2003). Heart rate monitoring. Sports medicine, 33(7), 517-538.
23. Stamler, J. (1991). Blood pressure and high blood pressure. Aspects of risk. Hypertension, 18(3_supplement), I95.
24. Obese, H. (1998). Body mass index (BMI). Obes Res, 6(2), 51S-209S.
25. Stein, PhD, P. K., & Kleiger, MD, R. E. (1999). Insights from the study of heart rate variability. Annual review of medicine, 50(1), 249-261.
26. Aminoff, M. J., & Goodin, D. S. (1994). Visual evoked potentials. Journal of Clinical Neurophysiology, 11(5), 493-499.
27. Folstein, M. F., Robins, L. N., & Helzer, J. E. (1983). The mini-mental state examination. Archives of general psychiatry, 40(7), 812-812.
28. Hejjel, L., & Roth, E. (2004). What is the adequate sampling interval of the ECG signal for heart rate variability analysis in the time domain?. Physiological measurement, 25(6), 1405.
29. Thong, T., Li, K., McNames, J., Aboy, M., & Goldstein, B. (2003, September). Accuracy of ultra-short heart rate variability measures. In Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE Cat. No. 03CH37439) (Vol. 3, pp. 2424-2427). IEEE.
30. Khaykin, Y., Dorian, P., Baker, B., Shapiro, C., Sandor, P., Mironov, D., & Newman, D. (1998). Autonomie correlates of antidepressant treatment using heart-rate variability analysis. The Canadian Journal of Psychiatry, 43(2), 183186.
31. Stein, P. K., Bosner, M. S., Kleiger, R. E., & Conger, B. M. (1994). Heart rate variability: a measure of cardiac autonomic tone. American heart journal, 127(5), 1376-1381.
32. Biswas, A. K., & Sommerauer, J. F. (2003). Low-frequency/high-frequency ratio and functional outcome. Critical care medicine, 31(1), 335.
33. Crawford, M. H., Bernstein, S. J., Deedwania, P. C., DiMarco, J. P., Ferrick, K. J., Garson, A., & Smith, S. C. (1999). ACC/AHA guidelines for ambulatory electrocardiography: a report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines (Committee to Revise the Guidelines for Ambulatory Electrocardiography) developed in collaboration with the North American Society for Pacing and Electrophysiology. Journal of the American College of Cardiology, 34(3), 912948.
34. Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV–heart rate variability analysis software. Computer methods and programs in biomedicine, 113(1), 210-220.
35. McGraw, P., Winn, B., & Whitaker, D. (1995). Reliability of the Snellen chart. Bmj, 310(6993), 1481-1482.
36. Mohan, P., Udayakumar, K. P., & Hiramath, P. B. (2020). Does the frequency domain parameters among pregnant women with gestational hypertension associated with levels of serum zinc, magnesium, and copper? A cross-sectional study. National Journal of Physiology, Pharmacy and Pharmacology, 10(9), 744-744.
37. Towle, V. L., Bolaños, J., Suarez, D., Tan, K., Grzeszczuk, R., Levin, D. N., & Spire, J. P. (1993). The spatial location of EEG electrodes: locating the best-fitting sphere relative to cortical anatomy. Electroencephalography and clinical neurophysiology, 86(1), 1-6.
38. Van der Elst, W., van Boxtel, M. P., van Breukelen, G. J., & Jolles, J. (2006). The Letter Digit Substitution Test: normative data for 1,858 healthy participants aged 24–81 from the Maastricht Aging Study (MAAS): influence of age, education, and sex. Journal of clinical and experimental neuropsychology, 28(6), 998-1009.
39. Elwood, R. W. (1991). The Wechsler Memory Scale-Revised: psychometric characteristics and clinical application. Neuropsychology review, 2(2), 179-201.
40. Gentile, D. A., Oberg, C., Sherwood, N. E., Story, M., Walsh, D. A., & Hogan, M. (2004). Well-child visits in the video age: pediatricians and the American Academy of Pediatrics' guidelines for children's media use. Pediatrics, 114(5), 1235-1241.
41. Shakir, R. N., Coates, A. M., Olds, T., Rowlands, A., & Tsiros, M. D. (2018). Not all sedentary behaviour is equal: Children's adiposity and sedentary behaviour volumes, patterns and types. Obesity research & clinical practice, 12(6), 506-512.
42. Cavalcante-Neto, J. L., Jelsma, D., Draghi, T. T. G., Tudella, E., & Smits-Engelsman, B. (2022). Active Video Games Performance and Heart Rate on the Wii or Kinect in Children with and without Developmental Coordination Disorder. Children, 9(12), 1823.
43. Onishi, T., Yamasaki, M., Hara, T., Hirotomi, T., & Miyazaki, R. (2022). Esports for Seniors: Acute Effects of Esports Gaming in the Community on the Emotional State and Heart Rate among Japanese Older Adults. International Journal of Environmental Research and Public Health, 19(18), 11683.
44. Krarup, K. B., Rantanen, J. M., Mørk, M., Pedersen, I. S., Christensen, J. H., Kristensen, S. R., & Krarup, H. B. (2022). The Physiological and Cardiologic Effects of Long Video Gaming Sessions in Adult Males. Sports medicine international open, 6(01), E39-E46.
45. Hou, C. J., Chen, Y. T., Capilayan, M. A., Huang, M. W., & Huang, J. J. (2022). Analysis of Heart Rate Variability and Game Performance in Normal and Cognitively Impaired Elderly Subjects Using Serious Games. Applied Sciences, 12(9), 4164.
46. Onishi, T., Yamasaki, M., Hara, T., Hirotomi, T., & Miyazaki, R. (2022). Esports for Seniors: Acute Effects of Esports Gaming in the Community on the Emotional State and Heart Rate among Japanese Older Adults. International Journal of Environmental Research and Public Health, 19(18), 11683.
47. Xie, X., Feng, K., Wang, J., Zhang, M., Hong, J., & Zhang, H. (2022). Comprehensive visual electrophysiological measurements discover crucial changes caused by alcohol addiction in humans: Clinical values in early prevention of alcoholic vision decline. Frontiers in Neural Circuits, 73.
48. Hamdan, F. B., Shareef, H. R., & Jasim, H. S. (2022). Visual evoked potential findings and correlation between visual evoked potential and clinical severity in children with autism spectrum disorder. pathways, 17, 18.
49. Sayorwan, W., Phianchana, N., Permpoonputtana, K., & Siripornpanich, V. (2018). A study of the correlation between VEP and clinical severity in children

with autism spectrum disorder. Autism research and treatment, 2018.
50. Kim, D., Lee, Y., Jeong, J., & Kim, S. (2022). Stimulation method and individual health index study for real-time cardiovascular and autonomic nervous system reactivity analysis using PPG signal. Biomedical Signal Processing and Control, 76, 103714.
51. Hu, S., Lou, J., Zhang, Y., & Chen, P. (2018). Low heart rate variability relates to the progression of gastric cancer. World journal of surgical oncology, 16(1),15.
52. Zhao, C., Zhao, C., Li, Y., Zhao, M., Wang, L., Guo, J., & Zhu, W. (2022). The Effects of Active Video Game Exercise Based on Self-Determination Theory on Physical Fitness and Cognitive Function in Older Adults. Journal of Clinical Medicine, 11(14), 3984.
53. Grzęda-Hałon, M., Poręba, M., Gut, G., Czerwińska, K., Gać, P., Martynowicz, H., & Poręba, R. (2022). The effect of CPAP therapy on heart rate variability in patients with obstructive sleep apnea. Sleep and Biological Rhythms, 1-12.