Research Paper

Relationship between game addiction and psychological, physical health and ocular surface states: a questionnaire based cohort study

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ABSTRACT

Objective: The purpose of this study was to explore the relationship between the psychological and physical conditions, ocular surface condition, and addiction to online games among different populations in China. We evaluated the impact of different game times on various health outcomes, as well as the influence of factors such as gender, age, and regional differences on their outcomes.

Methods: A cross-sectional questionnaire based cohort study was conducted among 530 participants aged between 18 and 40, who were randomly selected from the initial 1130 participants for varying degrees of game participation. Data were collected using validated scales, including the Hospital Anxiety and Depression Scale (HADS), the Van Dream Anxiety Scale (VDAS), the 36-item Short-Form (SF-36) Health Survey, the Ocular Surface Disease Index (OSDI), the Internet Addiction Test (IAT), and the Internet Gaming Disorder Scale-20 (IGD-20) . Linear regression analysis, Pearson correlation analysis, and multiple unpaired t-tests were used to investigate the association between the severity of game addiction and various psychological and physical health indicators. The data collection period lasted from July 2023 to January 2024, and the subsequent data analysis lasted from March 2024 to June 2024.

Results: The results showed that there was a significant correlation between excessive play and mental and physical health deterioration. There were significant differences in the scores of the game group and the non-game group ($P < 0.0001$), and there was a weak correlation between the HAS and HDS scores of the game group ($r = 0.502, P < 0.0001$). There was a strong correlation between HAS and HDS scores in the non-game group ($r = 0.934, P < 0.0001$), and a weak correlation between PCS and MCS scores in the game group (r = 0.3573, P <

0.0001), while the non-game group did not show correlation. The scores of HADS, VDAS, IAT and IGD-20 reported by male gamers were significantly higher than those of females ($P < 0.0001$), and the SF-36 score was significantly lower than that of females ($t = 7.131$, $P < 0.0001$). Male gamers have significantly more dry eyes than females ($t=5.416$, $P<0.0001$), which may be mainly due to the significantly longer gaming time of male gamers compared to females ($t = 6.344$, $P < 0.0001$). In this study, regional differences did not show an impact on each score. The correlation between IGD-20 score and Mental Component Summary (MCS) was stronger in people who played online games 5-6 hours a day ($r = -0.477$, $P < 0.05$) and more than 6 hours a day ($r = -0.545$, $P < 0.05$). In addition, the IGD-20 scores of gamers aged 18-20 and 21-25 were more correlated with the rest of the scores.

Conclusions: These findings emphasize the significant impact of online gaming on mental, physical health, and ocular surface conditions. Male and young gamers show higher susceptibility to mental and ocular surface problems. The observed significant differences in the scores of the game and non-game groups emphasized the necessity of implementing intervention measures, including cognitive and behavioral correction, preventive eye care and mental health support for high-risk groups.

INTRODUCTION

With the rapid development of online games, many people have become game players. Rational use of online games can relax and improve social skills[1], but excessive use may cause physical and mental damage. Internet and video game addiction has become a result of a steady development in modern life. Behavioral and process addiction, especially addiction to Internet and video games, requires specialized treatment programs and techniques[2]. Once addicted to the online world and face the computer for a long time, the rules of daily life are completely broken, unable to eat normally, lack of sleep, circadian rhythm disorders, physical and psychological problems, severe cases can even lead to death[3].

The most comprehensive definition of addiction is the definition issued by the American Society of Addiction Medicine, which captures the neurobiological and behavioral causes of the interruption of the reward circuit at the edge of the brain and the effects of addictive behavior : addiction is mainly a brain reward, motivation, memory and brain circuit-related chronic disease[4]. Addiction affects neural transmission and interactions within the reward structure of the brain (including the basal forebrain, nucleus accumbens, amygdala, and anterior cingulate cortex)[5], thereby altering motivation and behavior, including alcohol, drugs, and related behaviors. In addition, addiction also affects neural transmission and the interaction between cortical and hippocampal circuits and the reward structure of the brain. Memory previously exposed to reward experiences (such as food, alcohol, drugs and sex) triggers biological and behavioral responses to external factors, leading to craving and participation in addictive behavior[6]. The neurobiology of addiction not only involves the neurochemistry of rewards, but also the potential white matter connections between the cerebral cortex and frontal lobe. Reward, motivation, and memory circuits are the basis for changes in impulse control and judgment[7]. Accumulated adverse consequences due to drug use and other addictive behaviours lead to a dysfunctional pursuit of reward when addicted, i.e. infected people often crave a ' normal ' experience. In addition, the time of exposure to addictive substances[8], heredity[9], environment[10], culture[11] etc.are all critical factors in the development of addiction.

It is reported that the extensive use of the Internet is also associated with emotional disorders, impulsivity[12], poor sleep quality[13], low self-esteem[14], suicide [15], low levels of physical activity[16] and health problems[17]. When humans are exposed to artificial light at night, the blue part of the visible spectrum strongly affects circadian rhythms and sleep through retinal ganglion cells containing melanopsin[18]. Therefore, due to long-term exposure to blue light, game addicts have chaotic sleep rhythms and lack of sleep, which in turn leads to a series of psychological problems[19]. In addition, prolonged contact with the screen[20] and lack of sleep [21] can also lead to deterioration of ocular surface status, causing the occurrence of dry eye. In addition, game addicts can also cause a series of physical health issues[20] and even death due to sedentary and lack of sleep[22].

Our hypothesis is that game addiction can have adverse impacts on physical and psychological health as well as eye surface conditions. Therefore, this study focuses on the effects of game addiction on psychology, physical health and ocular surface status, as well as whether gender, age, region and other factors have an impact on the results.

MATERIALS AND METHODS

Participant and inclusion procedure

The data collection period of this study lasted from July 2023 to January 2024, and the subsequent data analysis lasted from March 2024 to June 2024. This study was carried out according to the Declaration of Helsinki[23], and was approved by the ethics committee of the First Affiliated Hospital of Nanchang University, the ethical code for this study is 2023029. This study used an online questionnaire survey, which was spread through the Internet, including 6 rating scales and other related issues. The aim of this study was to assess the daily game and sleep duration, mental and physical health status, ocular surface status, and the severity of online game disorders in the general population. The main objective is to clarify the relationship between game participation behavior and various health outcomes. This study used a cross-sectional design to collect and summarize samples within one year. Respondents participated in the Massively Multiplayer Online Role-Playing Game called "Three Kingdoms Dominance". This study used random sampling to select a subset of samples that matched the quantity for subsequent analysis. The selection process aimed to exclude extreme and abnormal data, ensure data representativeness, and particularly emphasized balancing key demographic variables (Figure 1). Inclusion criteria for the game group : (1) IAT score greater than or equal to 20 points[24]; (2) Age range: 18-40. Inclusion criteria for the non-game group : (1) IAT score less than 20 points; (2) Age range: 18-40. The data of this study have undergone a rigorous review process, and any submissions that do not meet the specified game type and age range, unreasonable or incomplete completion time are excluded from the analysis.

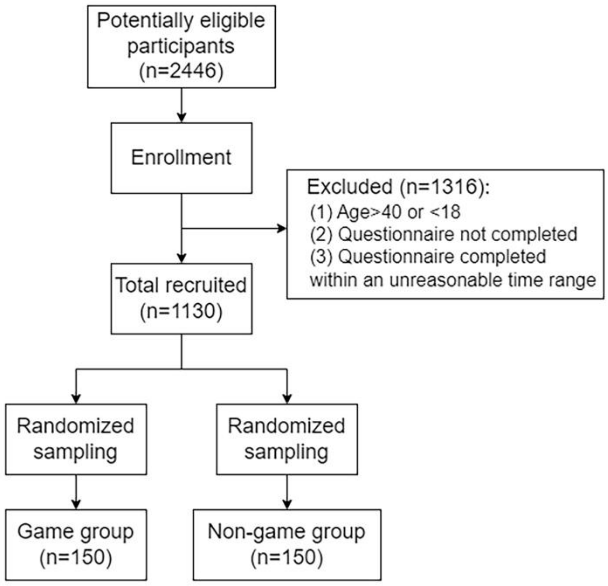

Figure 1. Inclusion procedure.

Measures

Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS) is mainly used to screen anxiety and depression in patients in comprehensive hospitals. HADS consists of fourteen items, with seven items assessing depression (HDS) and seven items assessing anxiety (HAS). Among them, there are six items for reverse questioning, five items for depression scale, and one item for anxiety scale. Each item was scored by a four-level score of 0-3 points, and 0 points indicated no symptoms. A score of one indicates that the patient is aware of mild symptoms, which has no or mild effect on the subject. A score of two indicates that the patient is aware of the symptom, which has a particular impact on the subject. Three points suggested that the symptoms were conscious, and the frequency and intensity were very serious, which had a severe effect on the subjects. The scores for anxiety and depression scales are as follows: 0-7 points for asymptomatic, 8-10 points for suspected anxiety or depression, and 11-21 points for definite anxiety or depression [25].

Van Dream Anxiety Scale (VDAS)

The Van Dream Anxiety Scale (VDAS) consists of 17 items, with items 7 to 10 aimed at collecting clinical information and not included in the final VDAS score. The remaining 12 items were scored using a five-point Likert scale, ranging from zero (never) to four (usually). These items assess various dimensions such as nightmare frequency, sleep disturbances due to the anticipation of nightmares, difficulty returning to sleep after experiencing nightmares, dream recall frequency, occupational and social disturbances, and cognitive issues, etc. Each scored from 0 to 4. The summed score for these symptoms ranges from 0 to 4, based on specific thresholds: 0-10 yields a score of 0, 11-20 scores 1, 21-30 scores 2, 31-40 scores 3, and 41-48 scores 4. Summarizing all 13 items, the final VDAS score is between 0 and 52[26].

The Short-From-36 Health Survey (SF-36)

The Short-From-36 Health Survey(SF-36) is used to evaluate health-related quality of life across eight distinct domains, including physical functioning, bodily pain , role physical, role emotional, vitality, general health, social functioning and mental health. These eight domains can be grouped into two parts: the Mental Component Summary (MCS) and the Physical Component Summary (PCS). SF-36 is currently one of the most commonly used standardized measurement tools for quality of life internationally. It can be self-assessed, he-assessed or by telephone. The evaluation usually takes 5 ~ 10 minutes. The scoring method is to calculate the sum of the integrals of each item in the subscale according to the different weights of each item, obtain the rough integral of the subscale, and convert the rough integral into a standard score of 0 to 100. The higher the score on the scale, the better the quality of life[27].

Ocular Surface Disease Index (OSDI)

The Ocular Surface Disease Index (OSDI) is a tool for assessing the symptoms and quality of life of patients with ocular surface diseases. It was developed by the International Conference on Dry Eye to evaluate and monitor ocular surface diseases, especially dry eye. The OSDI Ocular Surface Disease Questionnaire contains 12 questions about eye health and comfort, covering the patient 's symptoms, limitation of movement, and degree of distress to the eye condition. Each question has a specific answer option, and the patient needs to choose an option that matches his or her condition. The total score range of the questionnaire is 0-100 points, and the higher the score, the more severe the impact on symptoms and quality of life. 0-12 points indicate normal eye health, 13-22 points indicate mild dry eye, 23-32 points indicate moderate dry eye, and 33-100 points indicate severe dry eye[28].

Internet Addiction Test (IAT)

The Internet Addiction Test (IAT) is used to assess the severity of internet addiction[29]. This scale consists of twenty items, each scored on a scale of one to five based on their level of conformity. One points means never occurs, two points means rarely occurs, three points means occasionally occurs, four points means often occurs, five points means often occurs. The scale score ranges from 20 to 100 points.Those with a total score of less than 50 points were normal Internet users. The higher the total score, the more serious the Internet addiction. Those with a total score of 80 points or more were severe Internet addicts[30].

Internet Gaming Disorder Scale-20 (IGD-20)

The Internet Gaming Disorder Scale-20 (IGD-20) evaluates the symptoms of online gaming disorder through six subscales (significance, emotion regulation, tolerance, withdrawal symptoms, relapse, and conflict). All scales include three items, but there are five conflicting items. Using the Likert scale, answer from one (strongly disagree) to five (strongly agree). The final minimum score is 20 points and the maximum score is 100 points. Participants with a score of 71 or above are classified as IGD[31].

Statistical analysis

IBM SPSS Statistics (Version 27.0) and GraphPad Prism (Version 10.1.2) were used for data collection and analysis. SPSS was used for independent sample t-test to evaluate the mean of continuous variables between two different groups. For categorical variables, a chi-square test was performed to assess the difference in the proportion between different demographic categories. Respondents were classified according to their game duration, age and region, and Prism was used for linear regression model.

Pearson correlation analysis was performed on each variable to investigate the correlation between game addiction and a series of psychological anxiety indexes and health-related variables. Statistical significance was determined using a p-value threshold < 0.05, and the effect size was calculated to evaluate the observed association strength. The r value of 0.8-1.0 was considered to be highly correlated, 0.6-0.8 was considered to be strongly correlated, 0.4-0.6 was considered to be moderately correlated, 0.2-0.4 was considered to be weakly correlated, and 0.0-0.2 was considered to be uncorrelated[32].

RESULTS

A total of 1130 eligible participants completed the questionnaire survey. After random sampling, 530 respondents were selected for analysis, ranging in age from 18 to 40 years old, most of whom were between 18 and 20 years old (67 % in the non-game group and 62 % in the game group). Males (73 % in the non-game group and 71 % in the game group) and southern Chinese (60 % in both groups) accounted for a large proportion (Figure 2). There was no significant difference in gender, age and region between the two groups. The sleep time of the game group was significantly shortened (t = 2.282, P = 0.023). The mean ± standard deviation of the baseline characteristics of the study subjects are shown in Table 1.

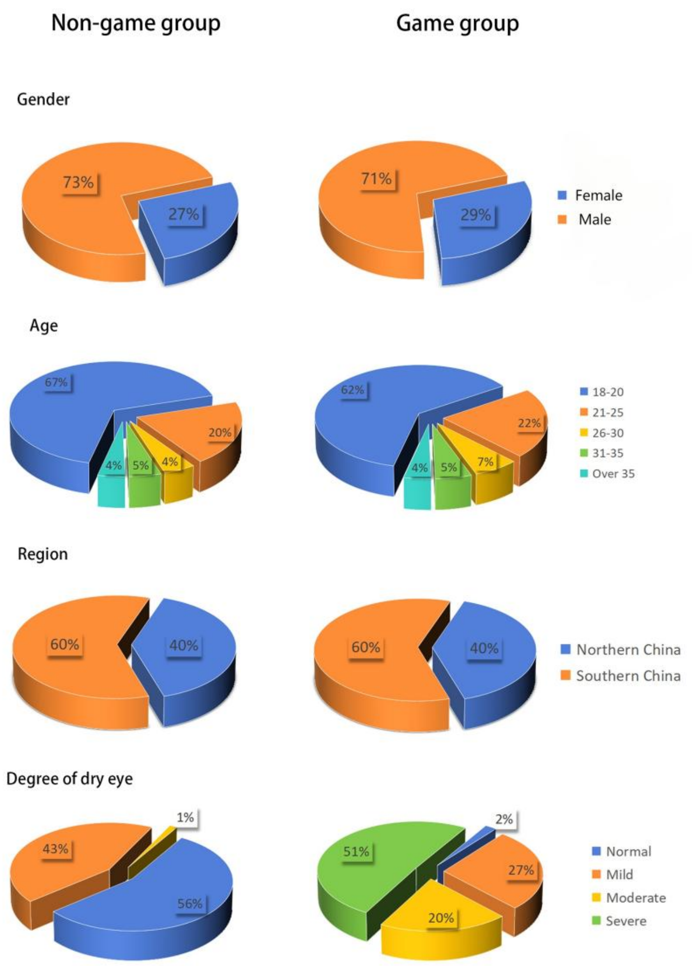

Figure 2. The population proportion of enrolled participants. The population composition of participants by gender, region, age and degree of dry eye.

Table 1. Demographic characteristic of participants

	Non-gaming (SD) n=150	Gaming (SD) n=150	t	P value
Age	20.9±(3.06)	21.5±(5.41)	1.546	0.075
Gender				
Male	110	106	N/A	N/A
Female	40	44	N/A	N/A
Region				
Northern China	61	60	N/A	N/A
Southern China	89	90	N/A	N/A
Sleeping Duration (Hours)	7.41±(0.93)	7.16±(1.00)	2.282	0.023*

*: P<0.05

Under all six evaluation indicators, the mental and physical health status and ocular surface status of the game group showed a worse trend than the non-game group (P < 0.0001) (Figure 3). Table 2 reports the mean ± standard deviation of the study variables and their respective subscales.

Table 2. Multifaceted health status and online gaming disorder scores of enrolled participants

	Non-gaming (SD) n=150	Gaming (SD) n=150	t	P value
Health Status				
HAS	1.67±(1.26)	4.45±(1.49)	17.53	<0.0001****
HDS	1.68±(1.19)	4.20±(1.16)	18.55	<0.0001****
HADS	3.35±(2.41)	8.69±(2.32)	19.56	<0.0001****
VDAS	5.53±(2.98)	20.11±(6.80)	24.05	<0.0001****
SF-36 (PCS)	66.61±(2.90)	65.01±(3.12)	4.60	<0.0001****
SF-36 (MCS)	64.12±(2.87)	38.42±(7.17)	40.75	<0.0001****
SF-36	522.91±(17.57)	413.71±(35.12)	34.05	<0.0001****
Ocular Status				
OSDI	10.37±(6.30)	33.41±(12.82)	19.75	<0.0001****
Internet Engagement				
IAT	17.68±(2.21)	42.87±(20.38)	12.76	<0.0001****
IGD-20	30.52±(11.47)	67.31±(9.88)	29.76	<0.0001****

****: P<0.0001

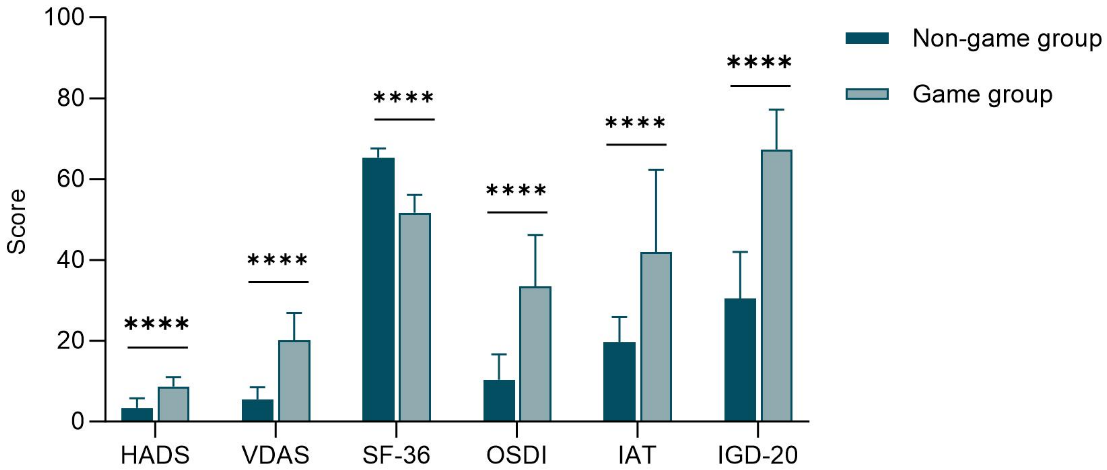

Figure 3. Comparative analysis of differences in multiple health indicators between groups. This figure presents a comprehensive comparison of health indicators between the two groups, including Hospital Anxiety and Depression Scale (HADS), Van Dream Anxiety Scale (VDAS), 36-item Short-Form Health Survey (SF-36), Ocular Surface Disease Index (OSDI), Internet Addiction Test (IAT) and Internet Gaming Disorder Scale-20 (IGD-20). Significant mean differences between groups are symbolized by asterisks. ****: P<0.0001.

The HAS and HDS scores of the game group (r = 0.5018, P < 0.0001) and the non-game group (r = 0.9342, P < 0.0001) were strongly correlated (Figure 4 A, B). The MCS and PCS of the game group showed a correlation (r = 0.3573, P < 0.0001) (Figure 4 C), and the non-game group did not show any correlation (Figure 4 D).

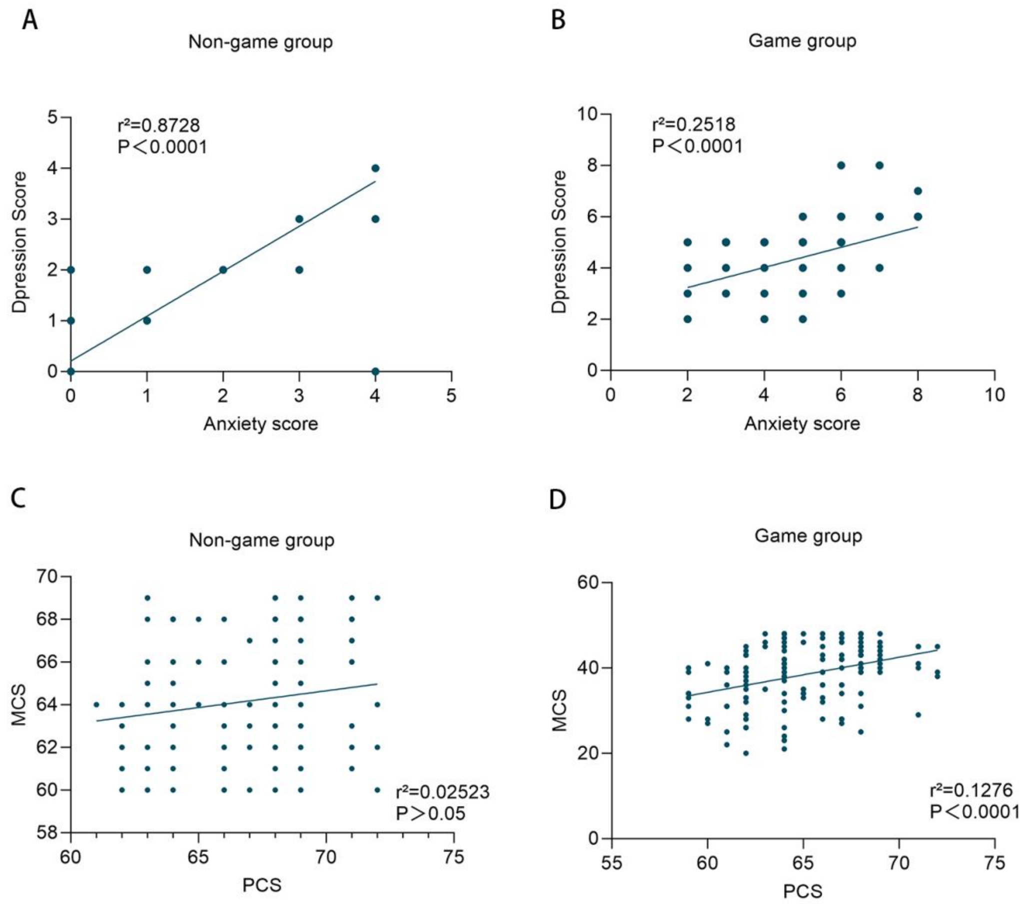

Figure 4. Linear regression analysis assessing the association of HAS and HDS, PCS and MCS between groups. This figure presents the results of linear regression analyses investigating the relationships between the Hospital Anxiety Scale (HAS) and the Hospital Depression Scale (HDS), the Mental Component Summary (MCS) and the Physical Component Summary (PCS) between groups. The analyses were conducted separately for (A),(C) non-game group and (B),(D) game group.

The study found that game duration was strongly correlated with OSDI (r = 0.80) and IAT (r = 0.83). There was a strong correlation between game duration and VADS (r = 0.69), SF-36 (r = -0.67), HADS (r = 0.65) and IGD-20 (r = 0.65). In addition, OSDI was strongly correlated with IAT (r = 0.79) and SF-36 (r = -0.63). SF-36 was strongly correlated with IAT (r = -0.69). IAT was strongly correlated with HADS (r = 0.66) and IGD-20 (r = 0.64). All the above P values were less than 0.001 (Figure 5).

Our analysis also shows the statistical differences in the scores of respondents with different demographic characteristics. Table 3 lists the comparative P values of these health assessment indicators in different demographic groups. In addition to the significant differences between the game group and the non-game group, the table also shows the significant differences in the scores between male and female in the game group.

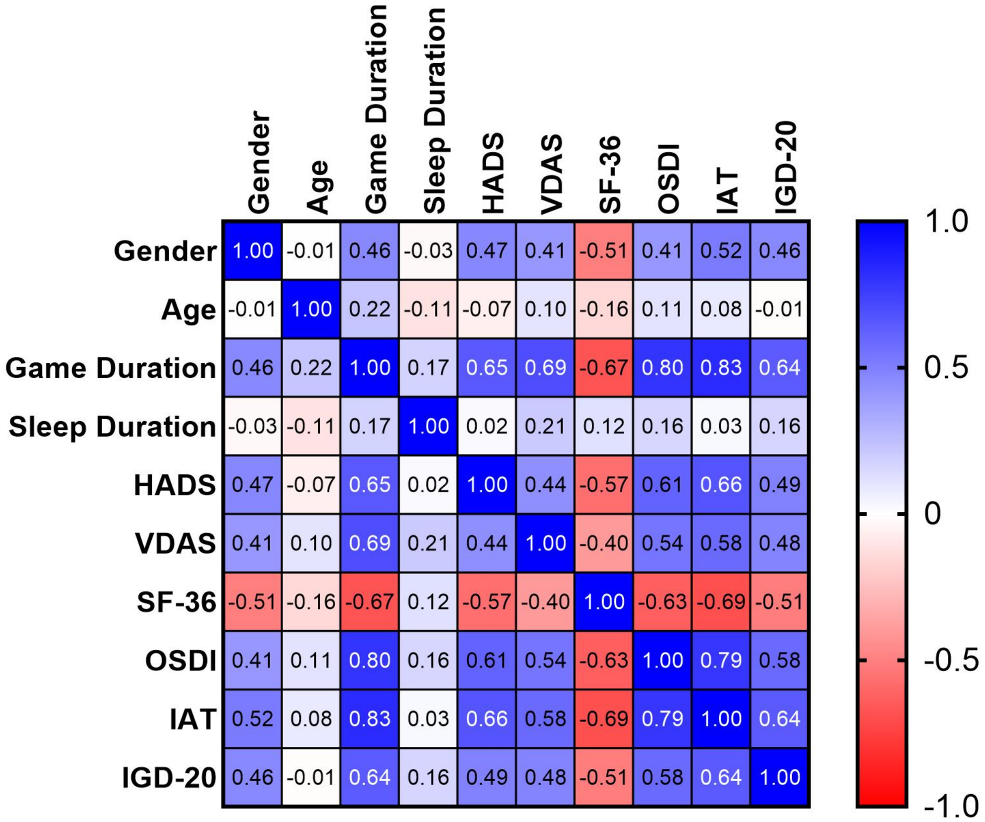

Figure 5. Pearson correlation coefficient matrix of various indicators in the game group. This figure shows the results of Pearson correlation analysis between various indicators in the game group, investigating the relationship between gender, age, game duration, sleep duration, Hospital Anxiety and Depression Scale (HADS), Van Dream Anxiety Scale (VDAS), 36-item Short-Form Health Survey (SF-36), Ocular Surface Disease Index (OSDI), Internet Addiction Test (IAT) and Internet Gaming Disorder Scale-20 (IGD-20).

Table 3. The comparison of the multifaceted health and game addiction across demographic characteristic

Indicators / Characteristic	HAS	HDS	HADS	VDAS	PCS	MCS	SF-36	OSDI	IAT	IGD-20
Gender										
Non-gaming male vs. Gaming male	**<0.0001 **** (t=18.21)**	**<0.0001 **** (t=17.94)**	**<0.0001 **** (t=19.64)**	**<0.0001 **** (t=23.03)**	**<0.0001 **** (t=5.66)**	**<0.0001 **** (t=37.57)**	**<0.0001 **** (t=33.12)**	**<0.0001 **** (t=19.68)**	**<0.0001 **** (t=14.79)**	**<0.0001 **** (t=32.89)**
Non-gaming female vs. Gaming female	**<0.0001 **** (t=5.79)**	**<0.0001 **** (t=7.27)**	**<0.0001 **** (t=7.36)**	**<0.0001 **** (t=12.07)**	0.754 (t=0.32)	**<0.0001 **** (t=27.97)**	**<0.0001 **** (t=19.82)**	**<0.0001 **** (t=8.26)**	**0.016* (t=2.45)**	**<0.0001 **** (t=9.74)**
Gaming male vs. Gaming female	**<0.0001 **** (t=6.033)**	**<0.0001 **** (t=4.557)**	**<0.0001 **** (t=6.465)**	**<0.0001 **** (t=5.396)**	**<0.0001 **** (t=5.225)**	**<0.0001 **** (t=6.091)**	**<0.0001 **** (t=7.131)**	**<0.0001 **** (t=5.416)**	**<0.0001* *** (t=9.388)**	**<0.0001 **** (t=6.943)**
Region										
Gaming northerner vs. Gaming southerner	0.806 (t=0.25)	0.946 (t=0.07)	0.819 (t=0.23)	0.891 (t=0.14)	0.232 (t=1.20)	0.850 (t=0.19)	0.563 (t=0.58)	0.599 (t=0.53)	0.555 (t=0.59)	0.400 (t=0.84)

*: P<0.05; ****: P<0.0001

In this regard, we further analyzed the game group. The game duration, HADS, VDAS, OSDI, IAT and IGD-20 of male gamers were significantly higher than those of female (P < 0.0001), and the SF-36 of male gamers was significantly lower than that of female (P < 0.0001) (Figure 6, A), while there was no difference in scores between different regions (Figure 6, B). We speculate that this is due to the fact that male gamers ' game time is significantly longer than that of female gamers, which further confirms the significant impact of game addiction on each score.

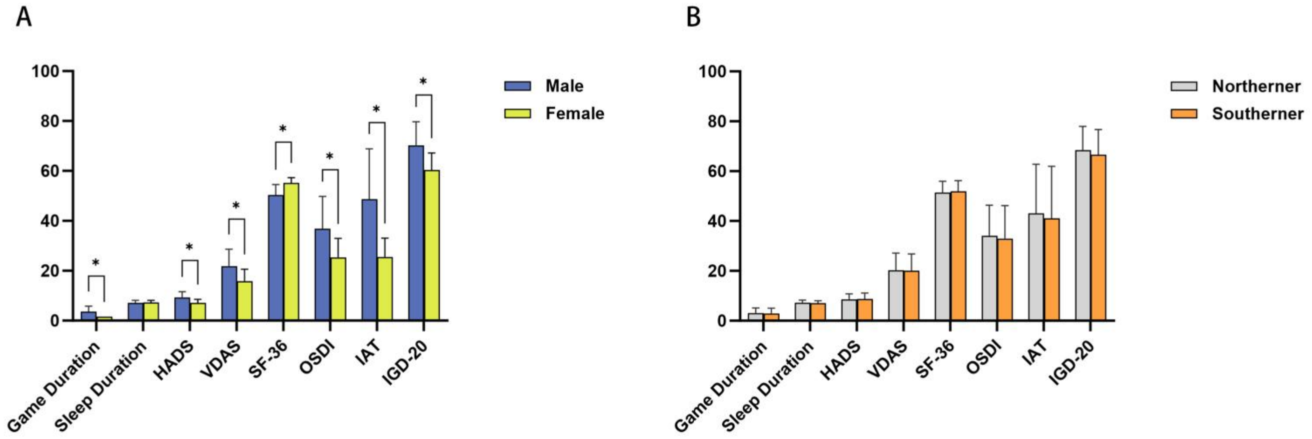

Figure 6. Comparative Analysis of Demographic Variations in Multifaceted Indicators. This figure presents a comprehensive comparison of indicators across different demographic groups, focusing on gender and regional characteristics. The analyses assess the impact of demographic variations on game duration, sleep duration, Hospital Anxiety and Depression Scale (HADS), Van Dream Anxiety Scale (VDAS), 36-item Short-Form Health Survey (SF-36), Ocular Surface Disease Index (OSDI), Internet Addiction Test (IAT) and Internet Gaming Disorder Scale-20 (IGD-20). (A) Comparative analysis of gender variations in multifaceted indicators. (B) Comparative analysis of region variations in multifaceted indicators. Significant mean differences between groups are symbolized by asterisks. *: P<0.0001.

In addition, IGD-20 and SF-36 (MCS) of the game group showed a correlation among respondents who played more than 5 hours of online games per day compared with the non-game group, with the strongest correlation among respondents who played more than 6 hours of online games per day (Table 4).

Table 4. Correlation coefficient of IGD-20 with psychological and physical health scores, grouped by game duration

Gaming Duration (Hours)	0	1-2	3-4	5-6	>6
Mental Status					
HAS	0.118	-0.141	0.2047	0.217	0.232
HDS	0.066	0.099	0.1939	0.297	0.392
HADS	0.094	-0.037	0.2748	0.308	0.256
VDAS	0.030	0.081	-0.02833	0.000	0.490
SF-36 (PCS)	0.157	-0.093	0.1112	-0.086	-0.233
SF-36 (MCS)	-0.043	0.091	0.1734	**-0.477***	**-0.545***
SF-36	0.076	0.028	0.2226	**-0.456***	**-0.529***
Ocular Status					
OSDI	0.064	0.034	0.04576	0.010	-0.110

*: P<0.05

In the study of the game group, it was found that IGD-20 of the game group in the 18-20 and 21-25 age groups was significantly correlated with the other scores, including HAS, HDS, HADS, VDAS, PCS, MCS, SF-36 and OSDI. Among them, the 18-20 age group is more significant (Table 5). It is speculated that Internet addiction has more significant impact on the physical and psychological health of adolescents.

reported that, as suggested by evolutionary psychologists, men are more inclined than women to make impulsive decisions regarding health control. Zheng et al. [33] reported that patients with internet gaming disorder exhibit more impulsive decision-making, which is regulated by the middle frontal gyrus. Women exhibit higher temporal discount rates than men, with higher activation rates in the striatum and insula, and lower activation rates in the

Table 5. Correlation coefficient of IGD-20 with psychological and physical health scores in game group, grouped by age

Age (Years)	18-20	21-25	26-30	31-35	>35
Mental Status					
HAS	**0.415********	**0.585******	0.082	0.449	0.748
HDS	**0.301****	**0.443****	-0.116	0.604	0.179
HADS	**0.423********	**0.596******	0.041	0.641	0.758
VDAS	**0.402********	**0.590******	0.132	**0.869****	0.717
PCS	**-0.348******	**-0.548******	**-0.742***	-0.166	0.028
MCS	**-0.459********	**-0.685********	-0.538	0.010	-0.084
SF-36	**-0.512********	**-0.712********	**-0.667***	-0.044	-0.071
Ocular Status					
OSDI	**0.558********	**0.569******	0.628	**0.898****	0.247

*: P<0.05; **: P<0.01; ***: P<0.001; ****: P<0.0001

DISCUSSION

Our study aims to illustrate the relationship between play addiction, psychological anxiety and ocular surface health, thus highlighting the multifaceted effects of excessive play in different populations.

Our results showed that the game duration, HADS, VDAS, OSDI, IAT and IGD-20 of male gamers were significantly higher than those of female gamers ($P < 0.0001$), and the SF-36 of male gamers was significantly lower than that of female gamers ($P < 0.0001$). It has been reported that male game addicts show impaired intertemporal decision-making related to neurological dysfunction. The influencing factors of impulsive decision-making in online game barriers are different between men (time sensitivity) and women (discount rate)[33]. Rungnirundorn et al. [34] reported that women are biologically protected and relatively less likely to engage in addictive behavior. In addition, Mei et al. [35] dorsolateral prefrontal cortex. In females, the severity of addiction was related to discount rates and activation of the left inferior frontal gyrus; In males, the severity of addiction was related to time sensitivity and activation of the right dorsolateral prefrontal cortex. These findings indicate that there are differences in the neural mechanisms underlying online gaming addiction between males and females. Chen et al. [36] reported that men are more addicted to online games than women in the gaming population, specifically in terms of game duration and negative health effects. In isolated incidents, this also leads to death. These reports are consistent with our findings.

Our results showed that there were significant positive correlation between game duration ($r = 0.80$, $P < 0.001$), ITA ($r = 0.83$, $P < 0.001$) and OSDI. This suggests that excessive screen time and digital engagement have largely contributed to ocular surface damage. Mehra et al. [20]

showed that prolonged exposure to digital screens leads to decreased blink frequency, increased tear film instability, and increased tear evaporation, which are the main factors in the development of DED. Symptoms often include eye fatigue, dry eyes, burning sensation, blurred vision, and irritation. In addition, long-term exposure to blue light on the screen is associated with oxidative stress and inflammation on the ocular surface[37], which aggravates dry eye symptoms. This prolonged digital exposure not only increases the risk of digital eye fatigue, but also leads to insufficient blinks and reduced tear secretion, which eventually leads to tear film instability and meibomian gland dysfunction[38]. In addition, IGD-20 and SF-36 (MCS) observed the most significant correlation among gamers who played online games for more than 5 hours per day, emphasizing the dose-dependent relationship between game duration and psychological distress. Especially in gamers who play more than 6 hours a day, it is associated with adverse physical health outcomes, including disrupted sleep and eye fatigue.

In addition, we found a significant positive correlation between GD-VDAS scores ($r = 0.69$, $P < 0.001$), which clarified the association between game addiction and increased dream-related anxiety. The immersive and intense nature of games, especially in competitive or high-stress environments, may overactivate cognitive and emotional processing during sleep, leading to disruption of dream quality and the emergence of anxiety-related sleep disorders. Long-term exposure to a tense gaming environment and lack of sleep may lead to activation of the HPA axis, resulting in elevated cortisol levels[39]. Elevated cortisol levels are related to increased anxiety and sleep pattern disorders[40], leading to sleep fragmentation and rapid eye movement sleep disruption, both of which are essential for emotional regulation, thereby exacerbating IGD-related anxiety. In addition, sleep deprivation can damage the function of the prefrontal cortex[41], thereby weakening impulse control, increasing the vulnerability of addictive behavior, and forming a vicious circle.

Our results show that the IGD-20 of the game group in the 18-20 and 21-25 age groups has a significant correlation with the rest of the scores, which is more significant in the 18-20 age group, while the IGD-20 of game gamers in other age groups does not show a correlation with the rest of the scores. It is speculated that young gamers are more likely to develop game addiction. The frontal lobe is essential for inhibiting impulses and helping individuals to appropriately delay gratification[42]. The brain develops rapidly during adolescence, during which cognitive control and decision-making abilities are improved, while impulse control is also enhanced. These behaviors are partly attributed to the maturation of the frontal lobe. Gamma aminobutyric acid (GABA) is an essential inhibitory neurotransmitter system that also matures during puberty. GABA receptors in the frontal lobe reach adult level in the late puberty[43]. During adolescence and a short period of adulthood, the frontal lobe is still in the process of maturation, and its morphology and function are not yet fully developed[44]. Therefore, early exposure to online games is an important factor leading to internet addiction.

In addition, genetic factors have a significant influence on the development of individual addiction, accounting for almost half of it[45]. Moreover, the interaction between environment and genes affects the degree to which genetic factors play a role[46]. A person's upbringing or later life experiences can affect the degree to which genetic factors lead to behaviors such as addiction[47]. Cultural factors also have a certain impact on the process of addiction[48].

The present study is subject to several limitations. Cross-sectional design makes it impossible to make causal inferences between online games and established physical and psychological health and ocular status results. In addition, the answers to the online questionnaire are more subjective, which may affect the accuracy of reporting behaviors and symptoms. Nevertheless, the advantages of this study include a comprehensive assessment of various health indicators of different population groups, and the use of validated psychological measurement tools to improve the reliability of the results. Future research should adopt longitudinal design, diversified population, and integrate objective clinical evaluation to improve the effectiveness and universality of research results.

CONCLUSIONS

This study reveals that there is a significant association between game addiction and a range of adverse physical and mental health and eye health outcomes, especially in men and young people. Too long playing time will have significant negative impacts on psychological, physical health and ocular surface status. The scoring results of male gamers are significantly worse than those of female gamers, which may be due to the generally longer game time of male gamers, which highlights the necessity of intervention measures for different gender groups. Young gamers are more susceptible to anxiety, depression and ocular surface diseases. There is a significant dose-response relationship between game duration and symptom severity, which highlights the necessity of interventions for people of different ages.In addition, the increase in Internet gaming disorder level is always related to the aggravation of dream-related anxiety of all gamers, which in turn affects the sleep time of gamers. Overall, our research findings emphasize the necessity of targeted interventions to mitigate the negative health impacts associated with excessive gaming. These interventions should include promoting good play habits, raising awareness of eye care, and providing early mental health support, with particular emphasis on high-risk groups such as men and young gamers. Future research should investigate the longitudinal effects of games on physical and psychological health, and the effectiveness of behavioral and cognitive interventions in reducing complications associated with online games.

AUTHOR CONTRIBUTIONS

XW, JH, and QG analyzed the data and draft the manuscript, CC, SX, QL, and YZ assisted with data interpretation and figure composing, WY, HW, JZ and LH collected the data, YS and YL conceived, designed and directed the study, and final revised and approved the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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