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Association Between Problematic Internet Use, Digital Game Addiction, and Digital Eye Strain Among Adolescents: A Cross-Sectional Clinical Study

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ABSTRACT

Objective: This study aimed to investigate the prevalence of digital eye strain (DES) among adolescents in a child psychiatry clinic and examine its association with problematic Internet use and digital game addiction (DGA).

Methods: A cross-sectional study was conducted on 244 adolescents aged 11-18 years attending a child psychiatry outpatient clinic. Participants completed the Computer Vision Syndrome Questionnaire, Problematic Internet Use Scale-Adolescent (PIUS-A), and Digital Gaming Addiction Scale (DGAS-7). A digital habits questionnaire was also administered. Logistic regression analysis was performed to identify risk factors for DES.

Results: The prevalence of DES was 53.3% among the study sample. Digital eye strain showed a moderate positive correlation with PIUS-A scores ($r = 0.426$, $P < .001$) and a weak but significant positive correlation with DGAS-7 scores ($r = 0.168$, $P < .009$). Logistic regression analysis revealed that higher PIUS-A scores (OR = 1.045, 95% CI 1.032-1.069), DGA (OR = 2.364, 95% CI 1.071-5.236), increased digital device use after the pandemic (OR = 2.932, 95% CI 1.589-5.411), and not taking breaks (OR = 2.151, 95% CI 1.033-4.478) were significant risk factors for DES.

Conclusion: Digital eye strain is highly prevalent among adolescents in child psychiatry clinics and is significantly associated with problematic Internet use and DGA. These findings highlight the need for psychoeducation and interventions to promote healthier digital habits and increase awareness of ocular health implications in this population.

Keywords: Digital eye strain, problematic Internet use, internet addiction, digital gaming, gaming disorder, adolescent

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INTRODUCTION

Digital devices, including computers, laptops, smartphones, and tablets, have become integral to adolescents' lives, fulfilling their entertainment, socialization, and educational needs.[1] Recent studies have documented a significant increase in adolescent engagement with digital devices, driven by various factors such as the ongoing evolution of digital technology and, notably, the coronavirus 2019 (COVID-19) pandemic.[2] The widespread availability and use of digital devices have also impacted adolescents' health and well-being, raising concerns about issues such as digital addiction and physical and mental health.[3]

Adolescents' extensive use of digital devices for online socialization and gaming can lead to problematic internet use (PIU) and digital game addiction (DGA).[4] Problematic internet use, also known as Internet addiction disorder or pathological Internet use, is characterized by impaired regulation of online behavior, affecting personal, social, and academic domains. Closely related to PIU, DGA has emerged as a distinct concern, defined as compulsive video game play that significantly interferes with daily functioning. These issues are not uncommon among young people, as evidenced by a study of Spanish adolescents that reported a PIU prevalence of 33%, while problematic gaming affected 3.1% of participants, utilizing a DSM-5 inspired assessment framework.[5] The impact of these conditions extends beyond behavioral concerns, as both PIU and DGA are associated with psychological issues like mood dysregulation and social isolation. Furthermore, these digital-related problems can also lead to physical health complications, including musculoskeletal discomfort and visual impairments.[4,6]

Digital Eye Syndrome (DES), also known as Computer Vision Syndrome, has emerged as a significant concern associated with prolonged screen use. The American Optometric Association categorizes DES symptoms into 3 primary groups: (1) visual symptoms, including reduced visual acuity, blurred vision, and general discomfort; (2) ocular symptoms, affecting the eye's anterior segment, such as dry eyes and irritation; and (3) extraocular symptoms, involving areas beyond the eye, including headaches and neck and shoulder pain. The prevalence of DES is alarmingly high among both adolescents and the general population. A recent meta-analysis revealed a pooled prevalence of 66% (95% CI: 59-74) across various population groups.[7] This high prevalence is particularly concerning for adolescents, as the high-energy waves emitted by digital screens can potentially cause retinal damage and contribute to the long-term development of myopia.[7,8]

Studies have shown that there are preventable or modifiable factors in the development of DES. Extended use of digital devices is the most significant risk factor for DES. Other identified risk factors include poor ergonomics, environmental factors such as inadequate lighting, close use of digital screens, and the lack of regular breaks. Maintaining regular blinking is also critical, as increasing the effective blinking rate is one of the most important factors in preventing DES.[7]

The COVID-19 pandemic has exacerbated concerns surrounding adolescents' digital device usage, significantly altering their screen time patterns. This global health crisis has not only intensified the risks associated with PIU and DGA but has also potentially increased the prevalence of DES among young people. Recent studies have documented a substantial increase in screen time during lockdowns and periods of remote learning.[2,9,10] For instance, Mohan et al[10] (2021) reported that 36.9% of children were spending more than 5 hours daily on digital devices during the pandemic, a significant increase compared to the pre-pandemic period. Moreover, Demirayak et al[9] (2022) reported that the mean daily screen time for children was 7.02 ± 4.5 hours in a study conducted during the later stages of the pandemic. This dramatic increase in screen time has raised concerns about potential health implications, particularly regarding ocular health and the prevalence of DES. Indeed, Mohan et al[10] observed that 50.23% of adolescents in their study experienced DES. The pandemic-induced shift towards increased digital engagement underscores the critical need to examine the relationship between heightened screen time and DES prevalence in adolescents, as it may have long-lasting impacts on their ocular health and overall well-being.

PIU and DGA have emerged as significant factors contributing to increased referrals to child psychiatry outpatient clinics, often presenting comorbidly with other psychiatric disorders. While the psychological impacts of these issues are well-documented, their physical effects are frequently overlooked by clinicians and underreported by children compared to adults.[4,11] To date, a limited number of studies have reported an increased prevalence of DES in adolescents with Internet gaming disorder in non-clinical samples.[6,12,13] Therefore, we aimed to determine the prevalence of DES, explore its relationship with PIU and DGA in adolescents admitted to a child psychiatry outpatient clinic, and examine how the COVID-19 pandemic related digital device usage habits may have influenced these factors.

MATERIAL AND METHODS

Participants

A cross-sectional, single-center study was conducted using a convenience sample of adolescents attending the Trakya University Child and Adolescent Psychiatry Outpatient unit. The sample size calculation was based on the prevalence of PIU and DGA in the clinical population, with DGA chosen as the primary factor due to its lower prevalence.[14] Using a reference clinical prevalence of 17.5% for digital gaming addiction,[11] a sample size of 222 was determined to be necessary to achieve a 95% confidence level with a margin of error of $d = 0.05$. To account for potential attrition, the target sample size was increased by 10% to 244 participants.

The study, conducted between November 1, 2022, and February 1, 2023, comprised adolescents aged 11-18 years. Exclusion criteria included the presence of intellectual disability, autism spectrum disorder, or inadequate reading and writing skills to complete the study scales.

Written and verbal informed consent was obtained from participants and their parents who participated in this study. Ethics committee approval was received for this study from the ethics committee of Trakya University (Approval no: 2022/354, Date: October 10, 2022).

Measurements

Digital Habits Questionnaire The questionnaire for digital habits, developed by researchers, examined demographic characteristics such as age and gender, along with variables potentially contributing to the onset of DES symptoms. These variables included the preferred digital device (computers, tablets, or smartphones), daily duration of digital device use (categorized as less than 2 hours, 2-4 hours, and 4

hours or more), break-taking behaviors during digital media use (yes/no), break duration (less or more than 20 minutes), break frequency (every 30 minutes/1 hour/2 hours), and preferred time for digital device usage (day/night). An additional factor considered was whether digital device usage had increased compared to pre-pandemic levels (yes/no). The categorical thresholds were established based on significant findings from previous research.[15] Participants were asked to respond to these questions reflecting on their usage patterns over the preceding month.

Computer Vision Syndrome Questionnaire

The severity of DES symptoms was assessed using the validated Computer Vision Syndrome Questionnaire (CVS-Q) developed by Seguí et al.[16] The CVS-Q evaluates 16 eye strain-related symptoms, including burning, itching, tearing, excessive blinking, redness, pain, heavy eyelids, dryness, blurred vision, double vision, difficulty focusing on near objects, light sensitivity, colored halos, deteriorating vision, and headache. The frequency and intensity of these symptoms were used to quantify DES.

Symptom frequency was categorized as follows: never (0 points), occasionally (1 point; once a week or irregular episodes), and frequently (2 points; more than 2-3 times a week). Symptom intensity was scored as either moderate (1 point) or intense (2 points). The final score for each symptom was calculated by multiplying frequency and intensity, then transforming the resulting score (0=0 points, 1 or 2=1 point, and 4=2 points). A total CVS-Q score of 6 or above indicated the presence of DES. In our study, the CVS-Q demonstrated good internal consistency, as measured by a Cronbach's alpha of 0.863.

Problematic Internet Use Scale-Adolescent

The Problematic Internet Use Scale-Adolescent (PIUS-A), developed by Ceyhan and Ceyhan (2014), is a 27-item instrument that uses a 5-point Likert scale.[17] It comprises 3 subscales: negative consequences of Internet use, overuse, and social benefit/social comfort. Scores range from 27 to 135, with higher scores indicating more PIU among adolescents. Elevated scores may suggest a tendency towards Internet addiction or the presence of PIU behaviors. In our study, the PIUS-A demonstrated excellent internal consistency, as measured by a Cronbach's alpha of 0.925.

Digital Gaming Addiction Scale-7

The Digital Gaming Addiction Scale (DGAS-7), developed by Lemmens et al,[18] is designed to assess problematic digital gaming behaviors among adolescents aged 12-18. This 7-item, 5-point Likert-type scale (1=never; 5=all the time) is a short form of the original DGAD-21 scale. Adolescents who score 3 points (sometimes) or higher on all 7 items are considered to have monothetic addiction, while those who score 3 or higher on at least 4 items are considered to have polythetic addiction. The Turkish adaptation of the scale was conducted by Irmak and Erdoğan.[19] In our study, the DGAS-7 demonstrated good internal consistency, as measured by a Cronbach's alpha of 0.885.

Statistical Analysis

Descriptive statistics, including means, SDs, and 95% CIs, were calculated for continuous variables. Prevalence was reported as a percentage. The Kolmogorov-Smirnov test was used to assess the normality of continuous variables' distributions. For non-normally distributed continuous variables, Spearman's rank correlation coefficient was employed to analyze relationships. Logistic regression analysis was conducted to evaluate potential risk factors for DES in the entire sample. Statistical significance was set at $P < .05$. All statistical analyses were performed using SPSS version 20 for Windows (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY, USA: IBM Corp.).

RESULTS

Digital Device Usage Habits and Descriptive Values of Digital Eye Strain, Digital Game Addiction, and Problematic Internet Use

The study cohort comprised 244 adolescents with a mean age of 14.59 years, of which 59% were female. Smartphones were the preferred digital device for the majority of participants (73.4%). Regarding daily digital device usage, 48.4% reported 2-4 hours of use, while 41.8% exceeded 4 hours per day. Although most adolescents reported taking breaks from device use, 23.4% did not. Among those who took breaks, the majority did so every 30-60 minutes, while 15.5% took breaks after 2 hours. Notably, 62% of adolescents reported break durations of less than 20 minutes. Furthermore, 67.6% of participants indicated an increase in digital device usage compared to pre-pandemic levels (Table 1).

Digital eye strainwas found in 53.3% of the study sample, and the mean DES score was 6.99 ± 5.03 (95% CI 6.36-7.63). The mean DGAS-7 score was 13.60 ± 6.58 (95% CI 12.77-14.43) and according to the polytetic addiction cutoff, 25.8% of adolescents were found to have DGA. The mean PIUS-A score was 66.18 ± 22.70 (95% CI 63.32-69.04).

The Relationships Between Digital Eye Strain, Problematic Internet Use, and Digital Game Addiction Scale

The DES showed a moderate positive correlation with the PIUS-A ($r=0.426$, $P < .001$) and a weak but significant positive correlation with the DGAS-7 ($r=0.168$, $P < .009$). Notably, the strongest correlation was observed between PIUS-A and DGAS-7 ($r=0.540$, $P < .001$), suggesting a substantial overlap between PIU and DGA in adolescents (Table 2).

Table 1. Digital Device Usage Habits of the Study Sample

			% (n)/Mean ± SD
Age			14.59 ± 1.90
Sex	Boy		41% (100)
	Girl		59% (144)
Preferred digital device	Tablets		6.6% (16)
	Computers		20.1% (49)
	Smartphones		73.4% (179)
Daily digital device use	<2 hours		9.8% (24)
	2-4 hours		48.4% (118)
	>4 hours		41.8% (102)
Taking breaks during digital device usage	Yes		76.6% (187)
	No		23.4% (57)
	Break frequency	After 30 minutes	35.8% (67)
		After 1 hour	48.7% (91)
		After 2 hours	15.5% (29)
	Break duration	<20 minutes	62% (116)
		≥20 minutes	38% (71)
Increase in digital device usage compared to pre-pandemic levels	Yes		67.6% (165)
	No		32.4% (79)

Table 2. The Correlations Between Digital Eye Strain, Problematic Internet Use, and Digital Game Addiction Scale Scores

		DES	PIUS-A
PIUS-A	*r*	0.426	N/A
	P	<0.001	N/A
DGAS-7	*r*	0.168	0.540
	P	<0.009	<0.001

Note: Spearman correlation analysis was used for statistical analysis. DES, digital eye strain; DGAS-7, Digital Gaming Addiction Scale-7 item; N/A, not applicable; PIUS-A, The Problematic Internet Use Scale-Adolescent.

Risk Factors of Digital Eye Strain

To identify risk factors for DES, we conducted a backward logistic regression analysis. The model included the following variables: age, sex, PIUS-A score, DGAS-7 polythetic addiction, digital device type, daily digital device use duration, taking breaks, and increased digital device use after the pandemic. Our analysis revealed that higher PIUS-A scores (OR = 1.045, 95% CI 1.032-1.069), DGA (OR = 2.364, 95% CI 1.071-5.236), increased digital device use after the pandemic (OR = 2.932, 95% CI 1.589-5.411), and not taking breaks (OR = 2.151, 95% CI 1.033-4.478) were associated with an increased risk of DES (Table 3). The logistic regression model was statistically significant ($X^2(6)=56.920$ and $P < .001$) and well-fitted to the data, as indicated by the Hosmer–Lemeshow goodness-of-fit test ($X^2(8)=4.364$, $P = .823$). The model explained 28% of the variance (Nagelkerke R^2) in DES risk.

DISCUSSION

To our knowledge, this is the first study to examine the prevalence of DES in a child psychiatry clinic and investigate the association between DES and both PIU and DGA. We found that DES was prevalent in 53.3% of this population. Statistically significant positive correlations were observed between DES and both PIUS-A and DGAS-7 scores. Furthermore, elevated scores on PIUS-A and DGA were identified as significant risk factors for DES.

The prevalence of DES among children has risen dramatically over the past decade. Studies indicate an increase from 19.7% in 2015 to approximately 50% in recent years.[8,20] The COVID-19 pandemic further exacerbated this issue, with studies reporting a surge in DES prevalence to 50-60% during this period.[9,10] Our study aligns with these post-COVID findings, revealing a DES prevalence of 53.3% in our sample. Importantly, we identified increased digital device usage following the onset of the COVID-19 pandemic as a risk factor for DES. This finding not only corroborates the significant increase in DES cases among children but also extends the existing literature by confirming the high prevalence of DES in a specific clinical population. Our results suggest that adolescents in psychiatric care may be particularly vulnerable to this condition, highlighting the need for psychiatrists to consider DES as a potential comorbidity in young patients with mental health concerns.

Our findings demonstrate that DGA and PIU are significant risk factors for DES in adolescents. Studies have shown that PIU correlates with increased dry eye symptoms,[21] while mobile gaming for more than an hour daily is a significant DES risk factor in children.[10] Longitudinal research has revealed worsening dry eye symptoms over time in adolescents with Internet gaming disorder,[22] and a positive correlation between gaming disorder symptoms and DES has been observed in high school graduates.[12] In particular, the term 'video game vision syndrome' has been proposed to describe the increased asthenopia symptoms, absence of fine stereopsis, and refractive errors observed in 7-year-olds who played digital games for 30 minutes or more daily.[13] These findings collectively underscore the potential ocular health risks associated with excessive digital engagement among young people.

Notably, our findings revealed a nuanced relationship between DES and digital engagement patterns. While both PIUS-A and DGAS-7 scores correlated positively with DES, the association was stronger for PIU than for DGA. This distinction suggests that PIU may have a more pronounced link to DES than DGA in our sample. Several factors could account for this difference, including the broader range of activities involved in PIU, which may lead to more prolonged and varied screen exposure, as well as increased task-switching and multitasking.[23] Problematic Internet use users tend to be more heavily engaged with their smartphones to pursue these diverse activities, further intensifying their screen time and potentially exacerbating the effects.[24] This highlights the complex interplay between digital technology use and ocular health, suggesting that different forms of digital engagement may impact DES to varying degrees. Further research is needed to explore the underlying mechanisms of these differences.

Excessive digital screen use (2-4 hours daily) has been linked to an increased risk of DES in adolescents.[25,26] To reduce this risk, current research suggests limiting daily screen time—including smartphone, tablet, computer, and television use—to 2 hours or less. This reduction

Table 3. Regression Analysis of Digital Eye Strain Risk Factors

							95% C.I. for EXP(*B*)	
	B	S.E.	Wald	*df*	Sig.	Exp(*B*)	Lower	Upper
PIUS-A score	0.049	0.009	30.174	1	<0.001	1.050	1.032	1.069
DGAS-7 game politetic addiction (yes)	0.861	0.405	4.528	1	0.033	2.364	0.191	0.934
Taking break (no)	0.766	0.374	4.188	1	0.041	2.151	1.033	4.478
Increase digital device use after pandemic (yes)	1.076	0.313	11.842	1	0.001	2.932	1.589	5.411
Sex (girl)	-0.493	0.298	2.731	1	0.098	0.611	0.340	1.096
Constant	-3.953	0.739	28.621	1	<0.001	0.019		

Note: Backward LR logistic regression is used for statistical analysis. Variables entered in step 1: age, sex, PIUS-A score, DGAS-7 polythetic addiction, digital device type, daily digital device use duration, taking breaks, and increased digital device use after the pandemic. DGAS-7, Digital Gaming Addiction Scale-7 item; PIUS-A, Problematic Internet Use Scale-Adolescent

may also decrease the risk of refractive error development and progression.[27] However, a longitudinal study of school-aged children found that 70% of children spend more than 2 hours a day on smartphones, and daily smartphone use of 4 hours or more was associated with an increased incidence of DES, an effect that persisted after 1 year of follow-up.[28] Alarmingly, our study revealed that a significant majority of adolescents (91.2%) exceeded 2 hours of daily screen time.

Interestingly, our regression analysis revealed that PIU and DGA are significant risk factors for DES, whereas daily digital device use duration was not a significant predictor in the final model. This finding suggests that the nature and quality of digital engagement may be more predictive of DES than the total time spent on devices. Problematic usage patterns may involve intense, uninterrupted periods of screen exposure or be associated with specific behaviors that exacerbate eye strain, such as closer viewing distances or decreased blinking rates.[29] These results underscore the complexity of the relationship between digital technology use and ocular health, indicating that interventions aimed at reducing DES in adolescents should focus more on addressing problematic usage patterns and potential addiction rather than solely reducing overall screen time. Future research should aim to elucidate the specific aspects of problematic use and addiction that contribute most significantly to DES to inform more targeted prevention and intervention strategies.

Our study corroborates and expands upon existing literature[25,26] by identifying inadequate break-taking as a significant risk factor for DES among adolescents. While previous research has established the importance of breaks during screen use, our findings quantify the extent of non-adherence to recommended practices. Notably, 64.2% of adolescents in our study reported taking breaks only after 1 hour of screen use, which starkly contrasts with the American Academy of Pediatrics' recommendation[30] of taking breaks every 20 minutes. This discrepancy between guidelines and actual behavior highlights a critical gap in the implementation of healthy screen use habits. Our results not only reinforce the importance of regular breaks but also provide a more nuanced understanding of adolescent screen use patterns, underscoring the need for targeted psychoeducation to address this gap.

Psychoeducation can play a crucial role in preventing and treating PIU and DGA by promoting behavioral changes.[6,11] Similarly, DES can be addressed quickly through simple behavioral modifications, such as reducing screen time[31] and increasing awareness.[25] However, children may overlook visual symptoms from digital devices to avoid restrictions on their activities and often do not report symptoms like dry eye unless they experience significant vision loss.[26] Therefore, psychiatrists should assess adolescents with problematic internet and gaming use for DES and provide psychoeducation to enhance their well-being.

The primary strength of our study is the large sample size of adolescents admitted to the clinic, which enhances the statistical power and generalizability of our findings. However, there are several limitations to consider when evaluating our findings. Firstly, the use of questionnaires to assess digital habits and reliance on self-reported scales limits the objectivity of our data. Additionally, the lack of comprehensive eye examinations beyond symptom screening for diagnosing DES, and the inability to assess other eye diseases or issues among participants, reduces the diagnostic accuracy.

Furthermore, it's important to consider potential confounding factors that may influence the relationship between digital device use and DES. Pre-existing eye conditions, such as allergic conjunctivitis, may predispose individuals to DES symptoms.[32] Environmental factors, including suboptimal lighting conditions or inappropriate viewing distances, may exacerbate eye strain independently of usage time.[25,29] To address these limitations, future studies should aim to control for these confounding factors to better define the relationship between digital device use and DES. This could involve incorporating objective measures of digital device use, conducting comprehensive eye examinations, and accounting for environmental and pre-existing ocular conditions. Despite these potential confounders and methodological limitations, the strong associations found in our study provide a valuable foundation for further research in this critical area of adolescent health.

In conclusion, this study highlights the significant prevalence of DES among adolescents in a child psychiatry clinic, with a notable association between DES and both PIU and DGA. These findings have substantial implications for child psychiatric practice, suggesting that routine screening for DES, alongside assessments of PIU and DGA, should be considered part of standard care for adolescents in psychiatric settings. The results underscore the urgent need for psychoeducation to reduce these risks by promoting healthier digital habits and increasing awareness of the ocular health implications of prolonged screen time.

By addressing these interconnected issues, child psychiatrists can play a crucial role in promoting both mental and ocular health in this vulnerable population. Further research should aim to incorporate comprehensive eye examinations to enhance diagnostic accuracy and explore the long-term effects of digital engagement on ocular health in this at-risk group. Ultimately, by fostering a balanced approach to technology use and integrating ocular health considerations into psychiatric care, we can better safeguard the overall well-being of young people in an increasingly digital world.

Availability of Data and Materials: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Trakya University (Approval no: 2022/354, Date: October 10, 2022).

Informed Consent: Written and verbal informed consent was obtained from participants and their parents who participated in this study.

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