Investigating the Severity and Risk Factors of Digital Eye Syndrome (DES) in Individuals Aged 4 to 18 Years

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Abstract

Introduction: Digital eye syndrome (DES) encompasses a range of vision-related complications arising from prolonged exposure to digital screens. This study aimed to investigate the severity and risk factors of digital eye syndrome among individuals aged 4 to 18 years who come to clinic for eye exam. Materials and Methods: This research is based on a cross-sectional descriptive design. A questionnaire was utilized to assess the presence and severity of digital eye syndrome based on clinical symptoms. Nine clinical symptoms associated with digital screen use were included in the questionnaire. Each symptom was assigned a score: (1) for presence and (0) for absence and the severity of DES is classified according to total score (1-3 mild,4-6 moderate,6-9 sever DES) Simultaneously the role of expected risk factors on the severity of DES were evaluated. Results: Among the participants, the highest prevalence was observed among 15-year-olds, with 55.5% male and 44.5% female respondents. Significant associations were found between the severity of digital eye syndrome with factors such as use of multiple electronic devices, duration of electronic screen usage, duration of digital screen usage in dark rooms, continuous/intermittent screen usage, presence of refractive errors, and years of digital screen usage (p < 0.05). However, no confirmed associations were found between gender, screen brightness, timing of digital screen use (day/night), and previous diagnosed dry eye disease with the severity of digital eye syndrome. Conclusion: The study findings demonstrate a higher prevalence of DES among the 4 to 18 years old population with direct correlation between the severity of digital eye syndrome and expected risk factors.

Keywords: *Digital eye syndrome, digital screen, severity of digital eye syndrome.*

Introduction

Digital eye syndrome, also known as computer vision syndrome or digital eye strain, is a condition that arises from the prolonged use of digital devices. According to the American Optometric Association, digital eye syndrome encompasses a range of vision and eye complications resulting from extended periods of viewing digital screens (1). Symptoms associated with this syndrome include eye fatigue, blurred vision, dry eyes, headaches, neck pain, and shoulder pain. Additionally, it may lead to eye irritation, redness, or a burning sensation (2). With the widespread use of electronic devices such as computers, laptops, smartphones, tablets, and e-books, digital eye syndrome has emerged as a significant public health concern across all age groups (3). Utilizing a computer or any other digital device for more than three hours daily presents an increased risk for developing digital eye syndrome. Global estimates reveal that approximately 60 million individuals have been diagnosed with

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digital eye syndrome, with one million new cases arising annually (4).

Experiencing eye pain directly corresponds to the duration of time spent viewing digital screens. Given the substantial rise in digital gadget usage in recent years, millions of individuals of all ages face susceptibility to digital eye syndrome. Though symptoms are typically temporary, this condition may result in severe and enduring discomfort for affected individuals, with attendant health and financial implications (5). Experts suggest that prolonged exposure to blue light emitted by electronic devices can result in severe repercussions. Such exposure can lead to photochemical damage to the eyes, potentially causing the degeneration of retinal cells and increasing susceptibility to age-related macular degeneration (6).

Children represent the most vulnerable age group in terms of digital eye syndrome (7). The American Vision Association's report shows that over 25% of children spend more than three hours per day engaged with some form of digital device, (8). Extended screen watching time, especially among children whose eyes and visual systems are still developing, imposes significant strain on the eyes. This arises from the unfamiliarity of our eyes with the pixelated images produced and displayed on screens, leading to eye fatigue after prolonged exposure (9). Furthermore, unlike adults, children may lack the self-control necessary to limit their time spent using electronic devices or to recognize when they are experiencing eye strain or other symptoms of digital eye syndrome, which can deteriorate the condition and exacerbate the symptoms of digital eye syndrome in children (10, 11).

While several studies have examined the relationship between digital device usage and vision problems in adults, research on digital eye syndrome in children remains relatively scarce. Thus, the aim of this study is to assess the severity and risk factors of digital eye syndrome among individuals aged 4 to 18 years.

Materials and Methods

Study Design: This descriptive cross-sectional study was conducted at the Eye Clinic of Imam Rezai Hospital in Ardabil during the period of 2022-2023. The study focused on children aged 4 to 18 years. In order to participate in the study, parental consent was obtained. All individuals outside the specified age range or those with any other eye disorders except refractive error were excluded.

Sample Size: The sample size was determined using Cohen's table (12), based on an effect size of 0.5, a test power of 0.8, and a significance level of 0.05. The minimum sample size for the univariate hypothesis was calculated to be 110 individuals.

Procedure: Data collection for this research was carried out using a digital eye syndrome questionnaire. This questionnaire assessed digital eye syndrome based on clinical symptoms. Specifically, it evaluated 9 clinical symptoms that may arise after prolonged digital screen usage, including 1. Headache 2. blurred vision 3.neck, shoulder, or back pain 4.fatigue 5.eye strain 6.eye redness 7.dry eyes sensation 8.double vision and 9.difficulty on focusing. Participants were instructed to indicate the presence or absence of each symptom by assigning a score of 1 or 0, respectively. In this study, individuals with one or more of these clinical symptoms (score of 1 or higher) were classified as having digital eye syndrome, while those without any clinical symptoms (score of 0) were considered healthy. Severity assessment was conducted by assigning scores as follows: a total score of clinical symptoms between 1 and 3 indicated mild digital eye syndrome, a score between 4 and 6 indicated moderate digital eye syndrome, and a

score between 7 and 9 indicated severe digital eye syndrome. Additionally, the questionnaire assessed various risk factors that may influence the severity of digital eye syndrome, including the number of electronic devices used, duration and manner of digital screen usage, screen brightness, and years of usage.

Data Analysis: Following sample collection and data entry, statistical analysis was performed using SPSS version 25 software. Independent t-tests, Spearman and Chi-square correlation coefficients, and a 95% confidence level were applied to analyze the results.

Ethical Considerations: All participants were ensured that their involvement in the study was purely for research purposes, and their identities would remain confidential. Informed consent was obtained from all participants, who willingly and satisfactorily answered the research questions. This study received ethical approval under the code IR.IAU.ARDABIL.REC.1402.059 from the Ethics Committee of Islamic Azad University, Ardabil branch.

Results

The present study encompassed a cohort of 110 participants, comprising 61 (55.5%) males and 49 (44.5%) females. Concerning the distribution of age, there were 5 individuals (4.5%) at 4 years old, 6 individuals (5.5%) at 5 years old, 4 individuals (3.6%) at 6 years old, 4 individuals (6.6%) at 7 years old, 4 individuals (3.6%) at 8 years old, 11 individuals (10%) at 9 years old, 6 individuals (5.5%) at 10 years old, 10 individuals (9.1%) at 11 years old, 7 individuals (6.4%) at 12 years old, 5 individuals (4.5%) at 13 years old, 11 individuals (10%) at 14 years old, 12 individuals (10.9%) at 15 years old, 9 individuals (8.2%) at 16 years old, 7 individuals (6.4%) at 17 years old, and 9 individuals (8.2%) at 18 years old. Remarkably, the highest frequency was observed in the age group of 15 years old, while the lowest frequency was noted among individuals aged 6 to 8 years.

The frequency distribution of clinical symptoms among the participants showed that headache was reported by 49(44.5%) individuals, blurred vision by 32(29%) individuals, neck, back, and shoulder pain by 22(20%) individuals, fatigue by 19(17.2%) individuals, eye strain by 46(41.8%) individuals, eye redness by 59(53.6%) individuals, dry eyes sensation by 54(49%) individuals, double vision by 22(20%) individuals, and difficulty on focusing by 9(8.1%) individuals.So the eye redness seems to be the most common sign of DES among the people who were visited followed by dry eye sensation and headache respectively.

Regarding the frequency of electronic device usage, 31 individuals (28.2%) reported utilizing a computer, 21 individuals (19.1%) reported employing a laptop, 55 individuals (50%) reported using a tablet, and 76 individuals (69.1%) reported engaging with a mobile phone. Among the participants, 49 individuals (44.5%) relied on a single device, while 61 individuals (55.5%) utilized multiple devices.

The data revealed that 19 individuals (17.3%) reported using electronic screens for less than 1 hour, 28 individuals (25.5%) reported using screens for 1 to 2 hours, 27 individuals (24.5%) reported using screens for 2 to 3 hours, 16 individuals (14.5%) reported using screens for 3 to 4 hours, 15 individuals (13.6%) reported using screens for 4 to 5 hours, and 5 individuals (4.5%) reported using screens for over 6 hours. The average duration of electronic screen usage was 2.954 hours, with a standard deviation of 1.436.

Regarding the frequency of using digital screens in dark rooms, 63.6% reported less than 1

hour, 30.9% reported 1 to 2 hours, and 5.5% reported more than 2 hours usage in dark room. Furthermore, 23.6% reported using digital screens continuously, while 62.7% reported using them intermittently.

The brightness of the digital screens used by the participants was categorized as follows: less than 10% brightness for 2 individuals (1.8%), between 11% and 25% brightness for 24 individuals (21.8%), between 26% and 50% brightness for 42 individuals (38.2%), between 51% and 75% brightness for 28 individuals (25.5%), and between 76% and 100% brightness for 10 individuals (9.1%). The majority of participants (73.6%) reported using digital screens during the day, while 25.5% reported using them at night.

Regarding previous dry eye disease, 15 individuals (13.6%) were diagnosed with dry eye disease, while 95 individuals (86.4%) had no history of previous dry eye disease.

Additionally, 38 individuals (34.5%) reported having refractive errors, while 71 individuals (64.5%) were normal.

In terms of the number of years of digital screen usage, 49 individuals (44.5%) reported using screens for approximately 1 year, 49 individuals (44.5%) reported using screens for approximately 2 years, 8 individuals (7.3%) reported using screens for approximately 3 years, 3 individuals (2.7%) reported using screens for approximately 4 years, and 1 individual (0.9%) reported using screens for over 5 years in the same way.

Regarding the severity of digital eye syndrome, 79 individuals (71.8%) were classified as having the mild type (score 1 to 3 for clinical symptoms), 29 individuals (26.4%) were classified as having the moderate type (score 4 to 6 for clinical symptoms), and 2 individuals (1.8%) were classified as having the severe type (score 7 to 9 for clinical symptoms). So fortunately the mild form of the diseases seems to be more frequent than other types yet.

The correlation coefficient between age and the severity of digital eye syndrome was found to be 0.499, (Table 1) which was statistically significant at a significance level below 5% (P<0.05). This indicates a positive and significant relationship between age and the severity of digital eye syndrome in children aged 4 to 18 years. In other words, as age increases, the severity of digital eye syndrome also tends to increase.

Table 1: Relationship between Age Range and Severity of Digital Eye Syndrome.

		Age	**Severity Of Digital Syndrome**
Age	The correlation coefficient	1	0.499
	Significance level	-	0.000
	Sample size	110	110
Severity of digital syndrome	The correlation coefficient	0.499	1
	Significance level	0.000	-
	Sample size	110	110

According to our research findings, there is a significant positive correlation (r = 0.353, p < 0.05) between the duration of digital screens usage and the severity of digital eye syndrome among children aged 4 to 18 years. This indicates that the longer the duration of using digital screens, the greater the severity of digital eye syndrome.

An analysis of gender differences using a t-test revealed no significant variation (t = -0.379, p > 0.05) in the severity of digital eye syndrome between boys and girls (Table 2). Therefore, gender cannot be considered a predictive factor for the severity of digital eye syndrome.

Table 2: the relationship between gender and severity of digital eye syndrome.

T Test Statistic				
Standard error difference	mean difference	P value	Degrees of freedom	t statistic
0.293	-0.111	0.706	108	-0.379

However, when evaluating the relationship between the presence of refractive errors and the severity of digital eye syndrome, a significant difference was identified (t = 2.953, p < 0.05). This suggests that the presence of refractive errors can serve as a predictive factor for the severity of digital eye syndrome. Individuals with refractive problems are more likely to experience a more severe form of digital eye syndrome.

Additionally, the analysis using chi-square test demonstrated a confirmed association between the number of electronic devices used and the severity of digital eye syndrome ($\chi^2 = 6.712$, p < 0.05). This implies that multi device users are at risk of more severe forms of digital eye syndrome (Table 3).

Table 3: The Relationship between the Number of Electronic Devices Used and the Severity of Digital Eye Syndrome.

Variable	Floors	Group			Chi-Square Measure	P Value
		Mild	Moderate	Severe		
Electronic tools used	A device	41	8	0	6.712	0.035
	More than one device	38	21	2		

In contrast, there was no significant negative correlation found between the brightness of the digital screen used and the severity of digital syndrome in children aged 4 to 18 years (r = -0.008, p > 0.05). Therefore, the brightness of the digital screen does not have a significant impact on the severity of digital eye syndrome.

Furthermore, the analysis revealed a significant positive correlation between the duration of using the electronic screen and the severity of digital syndrome among children aged 4 to 18 years (r = 0.678, p < 0.05, Table 4). This indicates that there is a direct relationship between the duration of screen usage and the severity of digital eye syndrome. As the duration of screen usage increases, the severity of this syndrome also tends to increase.

Table 4: The Relationship between the Duration of Using the Electronic Screen and the Severity of Digital Eye Syndrome.

			Severity of digital eye syndrome	Duration of use
Spearman	Severity of digital eye syndrome	The correlation coefficient	1	0.678
		Significance level		0.000
		Sample size	110	110

Duration of use	The correlation coefficient	0.678	1
	Significance level	0.000	
	Sample size	110	110

Analyzing by t-test, indicates a significant difference in the severity of digital eye syndrome between continuous digital device users and intermittent users (P < 0.05). Therefore, the manner in which the digital screen is utilized serves as a predictive factor for the severity of digital eye syndrome. Specifically, prolonged and continuous use of the digital screen correlates with an increased intensity of the syndrome, whereas intermittent use is associated with lower levels of severity.

According to the data presented in Table 5, a positive and significant relationship exists between the duration of using a digital screen in a dark room and the severity of digital syndrome in children aged 4 to 18 years.

Table 5: The Relationship between the Duration of Using a Digital Screen in a Dark Room and the Severity of Digital eye Syndrome.

			Severity of digital eye syndrome	Duration of use in a dark room
Spearman	Severity of digital eye syndrome	The correlation coefficient	1	0.464
		Significance level		0.000
		Sample size	110	110
	Duration of use in a dark room	The correlation coefficient	0.464	1
		Significance level	0.000	
		Sample size	110	110

Conversely, after confirming the homogeneity of variance, the t-test statistic yielded a value of -1.326, with the significance level exceeding P > 0.05. Then no significant difference was found in the severity of digital eye syndrome between the two groups when using the digital screen during the day or night.

Furthermore, the t-test statistic yielded a value of 1.930, with the significance level exceeding 5 percent (P> 0.05), indicating no significant difference in the severity of digital eye syndrome between the two groups with our without previous history of dry eye disease. Consequently, the presence or absence of diagnosed dry eye disease seems not to serve as a predictive factor for the severity of digital eye syndrome.

Discussion

Digital eye syndrome refers to a collection of symptoms and complications that arise from prolonged and excessive use of electronic devices, such as TVs, computers, mobile phones, and tablets. It is particularly prevalent among children aged 10 to 15, primarily due to two factors. Firstly, children in this age group tend to use electronic devices extensively and spend prolonged periods using them. Secondly, their eye muscles are still developing, making it more challenging for them to focus on electronic screens, resulting in fatigue and eye muscle tension

(13).

According to this study most of affected people still are in mild category (71.8%) which may progress to advanced stages during next years.

Research indicates a positive and significant correlation between age and the severity of digital eye syndrome in children between the ages of 4 and 18. These findings align with the studies conducted by Noreen (2016) (14) and Sheppard & Wolffsohn (2018) (4), affirming the relationship between age and the severity of digital eye syndrome. This finding suggests a close link between age and the severity of digital eye syndrome in children.

Additionally, the research findings indicate no notable difference in the severity of digital eye syndrome between boys and girls. Therefore, gender is not a predictive factor for the severity of digital eye syndrome. These results support the studies conducted by Tesfaye (2022) (15) and Blehm (2005) (16), which indicated a weak relationship between gender and the severity of digital eye syndrome. Essentially, the nature, causes, and symptoms of the condition render gender irrelevant in determining its severity.

Furthermore, the research findings highlight a significant difference between the groups that use a single electronic device versus those that use multiple devices. These results align with the research conducted by Sitaula (2018) (17). Therefore, using multiple electronic devices acts as a predictive factor for the prevalence of moderate and severe forms of digital eye syndrome. This finding suggests that the severity of digital eye syndrome in children is associated with the number of electronic devices utilized and their continuous use. Continuous digital device usage reduces opportunities for blinking and eye rest and deteriorates DES signs. This can lead to complications such as dry eyes, fatigue, and headaches. Moreover, reduced eye movement during device usage can increase muscle tension and eye strain in children. Considering that children typically use these devices more than adults, the potential negative impact on their eyes can be substantial. Additionally, children experience more fatigue and eye strain due to their inability to adjust eye contrast with the brightness intensity of electronic screens.

The duration of screen usage in a dark room has been found to have a positive and significant relationship with the severity of the syndrome, consistent with the findings of Shantakumari (2014) (18). When using a digital screen in a dark environment, the decrease in ambient brightness intensifies the background light on the screen, putting additional strain on the eyes and leading to increased fatigue.

Beside that this study indicates no significant relationship between the brightness of the digital screen used and the severity of digital eye syndrome in children. These findings align with the studies conducted by Arumugam et al (2014) (13) and Rosenfield (2011) (1). Thus, the intensity of screen light does not appear to impact the severity of digital eye syndrome. Additionally, there was no significant difference in the severity of the syndrome between groups that used digital screens during the day versus those that used them at night.

However, it is important to note that in this study there was not a significant relationship between the previous diagnosed dry eye disease and the severity of digital eye syndrome. While this may be attributed to the small sample size, it is worth considering the potential exacerbating effect of dry eye on digital eye syndrome. It is well-documented that using eye drops can alleviate the symptoms of digital eye syndrome. Therefore, the presence of dry eye may indeed contribute to the severity of the syndrome, but further investigation with larger sample sizes is necessary to establish a conclusive relationship.

The findings reveal a significant association between refractive errors and the severity of digital eye syndrome. Thus, it can be inferred that refractive error indices are predictive factors for the severity of this syndrome. An explanation for this finding lies in the challenges faced by individuals with refractive errors in accurately focusing images on their retinas and establishing the correct distance between their eyes and digital screens.

Additionally, the blue light emitted by digital screens can adversely affect ocular health.Researches suggest that blue light easily penetrates the retina, causing oxidative damage and impairing photoreceptor cells. Consequently, complications such as dry eyes and an elevated risk of eye diseases like cataracts may arise. Thus, excessive digital screen usage and inadequate eye hygiene amplify the severity of digital eye syndrome in children (19).

Conclusion

Regarding to this study children and teenagers' uncontrolled usage of digital devices caused an increased prevalence of DES which seem to be increasing, so public education along with early determination and management of risk factors can be of great value in prevention and treatment of this new rising eye health treat.

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