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Digital Eye Strain (DES) among children attending online classes during COVID-19 pandemic in Al-Madinah region, Saudi Arabia

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ABSTRACT

Background: Digital eye strain is a group of eye disorders caused by usage of digital devices. Online learning has replaced the traditional methods during the COVID-19 pandemic. *Objectives:* To determine the prevalence, symptoms, frequency, and associated risk factors of Digital eye strain and the pattern of digital device usage among children attending online classes during the COVID-19 pandemic. *Methods:* A cross-sectional study was conducted using an online questionnaire distributed among parents of children. *Results:* Out of 443 participants, the majority were females (51.5%). Tablets (47.6%) and smart phones (40.6%) were the most commonly used for online classes. The commonest Digital eye strain symptoms were headache (27.5%), excessive blinking (25.6%), redness (25.3%) and itching (24.8%). Severe eye strain was reported among (14%) of children. Children's preference for smart phones and tablets and an increase in hours spent on digital devices were some of the risk factors of Digital eye strain in our study. *Conclusions:* A high prevalence of Digital eye strain has been reported among children who attended online classes during the COVID-19 pandemic.

Keywords: digital eye strain, children, COVID-19 pandemic, online classes

1. INTRODUCTION

Corona virus disease (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2 virus) that started at the end of 2019 in China and rapidly spread throughout the world. In March 2020, the COVID-19 outbreak was declared as a pandemic by the World Health Organization (Dinis-Oliveira, 2020). In order to reduce virus transmission, the Saudi Arabian government adopted a national lockdown on

8 March, restricted national and international travel, closed schools and prohibited non-emergency hospital visits (Meo, 2020). Learning, living and staying connected during the COVID-19 pandemic have become increasingly dependent on technology. As a result of social distancing and isolation, children benefited from technology and were able to maintain their wellbeing (Goldschmidt, 2020). In order to preserve young children's learning at home, online learning has become widely promoted as a substitute for traditional face-to-face learning (Dong et al., 2020).

The COVID-19 pandemic has negatively impacted our lives. While the world is suffering from the worldwide impact of COVID-19, governments are making adjustments to allow daily life to carry on, such as closing schools and educating our school children through online platforms. In this aspect, digital technology has been quite helpful in minimizing disruptions to school education, but it is critical to be aware of the consequences of our increased reliance on digital technology. This indicates that this new e-learning system will require longer time device usage (Wong et al., 2021). Long periods of time spent in front of these devices can cause a variety of eye problems in children and has been correlated to increased symptoms of digital eye strain in various studies (Kim et al., 2016).

A series of eye and vision illnesses called digital eye strain (DES), as well referred to as computer vision syndrome, are brought on by prolonged usage of a computer, tablet, smart phone, or e-reader. Eyestrain, headache, blurred vision, dry eyes and neck and shoulder pain are the most common digital eye strain symptoms (American Optometic Association, 2022). Several studies conducted among different countries have reported that DES can occur between 25% and 93% of the population (Hagan & Lory, 1998; Portello et al., 2012; Reddy et al., 2013). However, in a study conducted in Saudi Arabia, the incidence of DES was 78% during the COVID-19 lockdown (Alabdulkader, 2021). COVID-19 pandemic has made this burden worse by forcing schools to use e-learning platforms. As a result, DES in children has become increasingly harmful and is now regarded as a public health concern in the United Kingdom (UK), where prevalence ranges from 22.3% to 39.8% (Sheppard & Wolffsohn, 2018).

There are many practices that have been approved by different studies to minimize the likelihood of DES during screen use, including the following: 1) the 20-20-20 rule (looking at an object for 20 feet, every 20 minutes, for 20 seconds), 2) environmental and behavioral adjustments while using digital devices, such as a how far away should you be from the screen (ideally, 18 to 24 inches), appropriate lighting, good posture and frequent breaks and 3) increasing the blinking rate when watching a screen (Alabdulkader, 2021; Mohan et al., 2021).

Despite the fact that virtual classes were used more frequently during the COVID-19 pandemic, ocular complications of using digital devices among young adults and adolescents have been extensively reported and studied in previous literature, but not many studies have addressed DES amongst children. Therefore, this study aimed to determine the prevalence, clinical manifestations, frequency and factors that are associated with DES among children attending online classes at the time of COVID-19 pandemic in the Al-Madinah region of Saudi Arabia.

Objectives

To determine the prevalence, clinical manifestations, frequency and factors that are associated with DES among children attending online classes during the COVID-19 pandemic in the Al-Madinah region of Saudi Arabia.

To evaluate the pattern of digital device usage among children during the COVID-19 pandemic.

To assess the parental awareness of DES symptoms and the impact of digital devices on their children’s eyes and the practices used to prevent it.

2. METHODS

This research project is a cross-sectional observational study. The study was performed in Al-Madinah, Saudi Arabia, from February to June 2022, utilizing an online questionnaire distributed through social media applications among parents of children aged 5 to 13 who are enrolled in e-learning online classes during the COVID-19 pandemic. The study excluded children with ocular illnesses, such as cataracts, glaucoma, congenital eye problems and refractive abnormalities. Consent and confidentiality, personal information, child's pattern of digital device use, symptoms of DES, practices to reduce the symptoms of DES and parents' awareness about DES were the six sections of a predesigned questionnaire adapted from two studies conducted in India. The participants were informed about the study's objectives including its length and anonymity prior to being recruited. The parents were also notified that their information would be utilized for research purposes, but the participants' identities would remain anonymous. The Scientific Research Ethics Committee of Taibah University's College of Medicine ethically approved the study on 30 January 2022 (study ID: TU-21-015-IRB00010413).

The children or their parents were instructed to estimate the average spending time on each of the listed activities during the COVID-19 era: Computer/tablet use, smart phone use, online classes, TV viewing and playing video games, as well as the total device usage time before and after the COVID-19 era with documentation of the frequency and intensity of DES symptoms. The DES symptoms and their severity were assessed using the Computer Vision Syndrome Questionnaire (CVS-Q) (Seguí et al., 2015). The CVS-Q evaluated the frequency and intensity of 16 eye strain-related symptoms. The total score was calculated using the formula as follows: "Score Σ I =1 16 (frequency of symptom occurrence) I x (intensity of symptom) I". DES was considered to be diagnosed if the total score was ≥6. Further classification was done as follows: Mild (DES score = 6–12), moderate (DES score = 13–18) and severe (DES score = 19–32) (Mohan et al., 2021).

Data entry and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) software, version 26. Frequency and percentage were applied to describe categorical variables while arithmetic mean, range and standard deviation (SD) were used to describe continuous variables. A chi-square test was adopted to test for the association between eye strain severity and related factors and a p-value less than 0.05 was considered statistically significant.

3. RESULTS

Personal and socio-demographic characteristics

The study included the parents of 443 children. Participants' age ranged between 5 and 13 years with an arithmetic mean of 8.8 years and a SD of 2.3 years. Females represented 51.5% of the children and the majority of them (91%) live in Al-Madinah. All of them attended online classes. Previous history of any eye diseases or previous eye operations was observed among 7.9% of the children, while a history of wearing eyeglasses or contact lenses was observed among 14.2% of them.

Child's use of digital devices

As demonstrated in Table 1, tablets (47.6%) and smart phones (40.6%) were the most commonly used devices for online classes, followed by laptops (32.1%). The average distance of the device from the eyes during online classes was less than arm's length away for 51% of children and approximately at arm's length for 42% of them. Upright with a bent back was the most commonly used posture while using a digital device (56%). The duration the child spent in a day before the COVID-19 pandemic using electronic devices, ranged between 1 to 3 hours for 46% of the children, while during the pandemic, it exceeded 5 hours for 37.3% of the students. The total number of hours the child spent watching TV or playing video games in a day were ≤2 among 75.4% and 69.1% of children, respectively. Most of the children (76.6%) attended online classes for more than two hours daily. Regarding the activity that the child spends the maximum time on his/her digital devices, playing games ranked first (68.8%), followed by studying (38.1%) and watching movies (28.4%).

Table 1 Pattern of children's use of digital devices

	Frequency	Percentage
Device child is using for online classes*		
Smartphone	180	40.6
Tablet	211	47.6
Laptop	142	32.1
Desktop computer	39	8.8
Television	22	5.0
Average distance of the device from eyes during online classes		
Less than arm's length away	226	51.0
At arm's length	186	42.0
More than arm's length away	31	7.0
Most commonly used posture by the child while using a digital device		
Upright with a bent back	248	56.0
Upright with a straight back	98	22.1
Lying down in a supine position	41	9.3
Lying down in prone position	56	12.6
Total hours the child spent in a day using digital devices before		

the COVID-19 pandemic		
Less than 1 hour	65	14.7
1–2 hours	106	23.9
2–3 hours	98	22.1
3–4 hours	77	17.4
4–5 hours	46	10.4
>5 hours	51	11.5
Total hours the child spent in a day using digital devices during the COVID-19 pandemic		
Less than 1 hour	25	5.6
1–2 hours	50	11.3
2–3 hours	52	11.7
3–4 hours	57	12.9
4–5 hours	94	21.2
>5 hours	165	37.3
Number of hours a child spends each day watching TV		
<1 hour	176	39.7
1–2 hours	158	35.7
>2 hours	109	24.6
Number of hours a child plays video games in a day		
<1 hour	164	37.0
1–2 hours	142	32.1
>2 hours	137	30.9
Number of hours a child attends online classes in a day		
<1 hour	33	7.4
1–2 hours	71	16.0
>2 hours	339	76.6
Activity the child spent the maximum time on his/her digital devices*		
Watching movies	126	28.4
Studying	169	38.1
Recreational reading	38	8.6
Social media	110	24.8
Playing games	305	68.8

*Not mutually exclusive

Digital eye strain symptoms

The most commonly reported eye strain symptoms encountered by children (either of severe or moderate intensity) were headache (27.5%), excessive blinking (25.6%), eye redness (25.3%) and eye itching (24.8%) (Table 2). Overall, eye strain was observed among almost two-thirds (64.8%) of the school children as illustrated in Figure 1. Moderate and severe eye strain was reported among 31.2% and 14% of the children, respectively (Figure 2).

Table 2 Frequency and intensity of symptoms of eye strain during or immediately after using any digital device among children compared with before the COVID-19 pandemic

	Always of severe intensity	Always of moderate intensity	Occasionally of severe intensity	Occasionally of moderate intensity	Never
Dryness	29 (6.5)	78 (17.6)	76 (17.2)	72 (16.3)	188 (42.4)
Difficulty focusing	33 (7.4)	76 (17.2)	90 (20.3)	80 (18.1)	164 (37.0)
Itchiness	33 (7.4)	77 (17.4)	73 (16.5)	91 (20.5)	169 (38.2)

Excessive blinking	37 (8.4)	76 (17.2)	85 (19.2)	82 (18.5)	163 (36.7)
Burning sensation	34 (7.7)	60 (13.5)	87 (19.6)	82 (18.5)	180 (40.7)
Blurred vision	27 (6.1)	55 (12.4)	80 (18.1)	54 (12.2)	227 (51.2)
Heavy eyelids	15 (3.4)	58 (13.1)	87 (19.6)	50 (11.3)	233 (52.6)
Sensitivity to bright light	35 (7.9)	66 (14.9)	91 (20.5)	78 (17.6)	173 (39.1)
Eye pain	28 (6.3)	70 (15.8)	82 (18.5)	69 (15.6)	194 (43.8)
Eye redness	37 (8.4)	75 (16.9)	78 (17.6)	88 (19.9)	165 (37.2)
Tearing	29 (6.5)	67 (15.1)	91 (20.5)	90 (20.3)	166 (37.6)
Foreign body sensation	25 (5.6)	55 (12.4)	89 (20.1)	59 (13.3)	215 (48.6)
Halos around objects	30 (6.8)	65 (14.7)	73 (16.5)	57 (12.9)	218 (49.1)
Worsening of eyesight	25 (5.6)	56 (12.6)	81 (18.3)	61 (13.8)	220 (49.7)
Change in glasses prescription	32 (7.2)	49 (11.1)	77 (17.4)	46 (10.4)	239 (53.9)
Headache	47 (10.6)	75 (16.9)	83 (18.7)	90 (20.3)	148 (33.4)

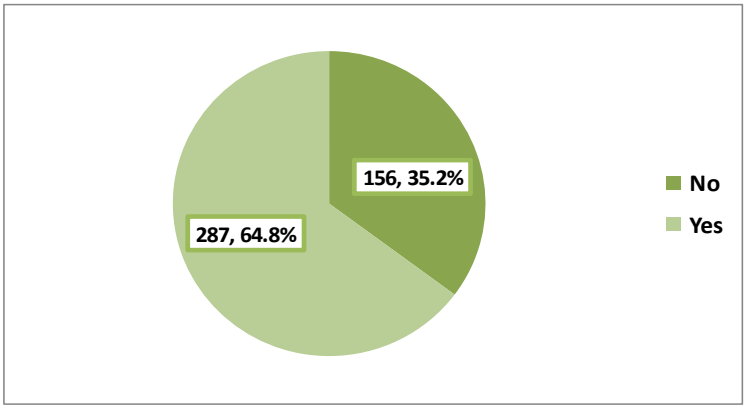

Figure 1 Prevalence of digital eye strain (DES) among the participants.

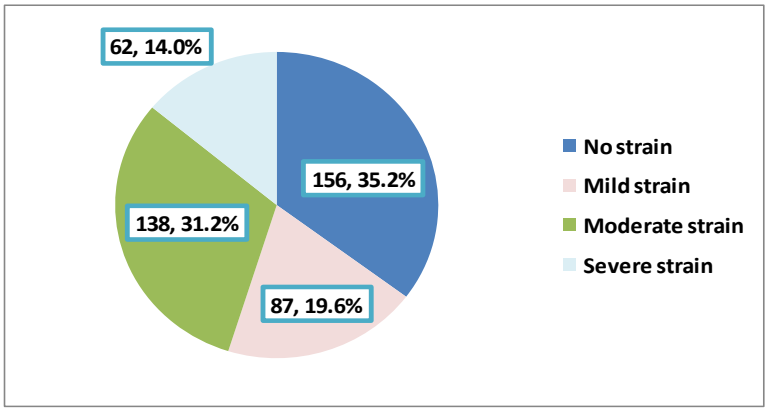

Figure 2 Severity of DES among the participants.

Significant correlations were found between total hours the child spent in a day before the COVID-19 pandemic using digital devices and the severity of eye strain, as the highest rate of severe eye strain was observed among children who spent more than 5 hours (23.5%; p = 0.001) using digital devices. During the pandemic, 18.2% of children who spent more than 5 hours in a day using electronic devices, had severe eye strain compared to those who spent less than 1 hour using digital device (p = 0.001). A quarter of children who used devices for watching movies expressed severe eye strain compared to those who used them for recreational reading (p = 0.048) (Table 3).

Table 3 Association between device used during online class and severity of eye strain among school children

	Eye strain				p-value*
	No N = 156 N (%)	Mild N = 87 N (%)	Moderate N = 138 N (%)	Severe N = 62 N (%)	
Device child is using for online classes*					
Smartphone (n = 94)	27 (28.7)	19 (20.2)	36 (38.3)	12 (12.8)	
Tablet (n = 134)	47 (35.1)	23 (17.2)	46 (34.3)	18 (13.4)	
Laptop (n = 68)	30 (44.1)	19 (27.9)	11 (16.2)	8 (11.8)	
Desktop computer (n = 23)	6 (26.1)	4 (17.4)	7 (30.4)	6 (26.1)	
Television (n = 2)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0.252
More than one device (n = 122)	45 (36.9)	21 (17.2)	38 (31.1)	18 (14.8)	
The average distance between the device and the eyes during online classes					
Less than arm's length away (n = 226)	66 (29.2)	48 (21.2)	76 (33.6)	36 (15.9)	
About an arm's length away (n = 186)	75 (40.3)	34 (18.3)	56 (30.1)	21 (11.3)	
More than arm's length away (n = 31)	15 (48.4)	5 (16.4)	6 (19.4)	5 (16.1)	0.149
Most commonly used posture by the child while using a digital device					
Upright with a bent back (n = 248)	83 (33.5)	48 (19.4)	79 (31.9)	38 (15.3)	
Upright with a straight back (n = 98)	44 (44.9)	15 (15.3)	27 (27.6)	12 (12.2)	
Lying down in a supine position (n = 41)	11 (26.8)	9 (22.0)	14 (34.1)	7 (17.1)	
Lying down in prone position (n = 56)	18 (32.1)	15 (26.8)	18 (32.1)	5 (8.9)	0.463
Total hours the child spent in a day using digital devices before the COVID-19 pandemic					
Less than 1 hour (n = 65)	28 (43.1)	11 (16.9)	18 (27.7)	8 (12.3)	
1–2 hours (n = 106)	43 (40.6)	20 (18.9)	30 (28.3)	13 (12.3)	
2–3 hours (n = 98)	39 (39.8)	21 (21.4)	22 (22.4)	16 (16.3)	
3–4 hours (n = 77)	26 (33.8)	15 (19.5)	27 (35.1)	9 (11.7)	0.001
4–5 hours (n = 46)	11 (23.9)	10 (21.7)	21 (45.7)	4 (8.7)	
>5 hours (n = 51)	9 (17.6)	10 (19.6)	20 (39.2)	12 (23.5)	
Total hours the child spent in a day using digital devices during the COVID-19 pandemic					
Less than 1 hour (n = 25)	16 (64.0)	3 (12.0)	6 (24.0)	0 (0.0)	
1–2 hours (n = 50)	19 (38.0)	4 (8.0)	19 (38.0)	8 (16.0)	
2–3 hours (n = 52)	21 (40.4)	10 (19.2)	15 (28.8)	6 (11.5)	
3–4 hours (n = 57)	26 (45.6)	17 (29.8)	10 (17.5)	4 (7.0)	0.001
4–5 hours (n = 94)	34 (36.2)	15 (16.0)	31 (33.0)	14 (14.9)	
>5 hours (n = 165)	40 (24.2)	38 (23.0)	57 (34.5)	30 (18.2)	
Number of hours a child spends each day watching TV					
<1 hour (n = 175)	62 (35.2)	32 (18.2)	56 (31.8)	26 (14.8)	
1–2 hours (n = 158)	63 (39.9)	24 (15.2)	49 (31.0)	22 (13.9)	0.191
>2 hours (n = 109)	31 (28.4)	31 (28.4)	33 (30.3)	14 (12.8)	
Number of hours a child plays video games in a day					
<1 hour (n = 164)	69 (42.1)	23 (14.0)	53 (32.3)	19 (11.6)	0.093
1–2 hours (n = 142)	48 (33.8)	29 (20.4)	45 (31.7)	20 (14.1)	

>2 hours (n = 137)	39 (28.5)	35 (25.5)	40 (29.2)	23 (16.8)	
Number of hours a child attends online classes in a day					
<1 hour (n = 33)	10 (30.3)	6 (18.2)	11 (33.3)	6 (18.2)	
1–2 hours (n = 71)	31 (43.7)	13 (18.3)	20 (28.2)	7 (9.9)	0.736
>2 hours (n = 339)	115 (33.9)	68 (20.1)	107 (31.6)	49 (14.5)	
Activity the child spent the maximum time on his/her digital devices*					
Watching movies (n = 32)	12 (37.5)	5 (15.6)	7 (21.9)	8 (25.0)	
Studying (n = 37)	13 (35.1)	5 (13.5)	12 (32.4)	7 (18.9)	
Recreational reading (n = 8)	6 (75.0)	0 (0.0)	2 (25.0)	0 (0.0)	
Social media (n = 34)	12 (35.3)	9 (26.5)	9 (26.5)	4 (11.8)	0.048
Playing games (n = 131)	45 (34.4)	37 (28.2)	39 (29.8)	10 (7.6)	
More than one activity (n = 201)	68 (33.8)	31 (15.4)	69 (34.3)	33 (16.4)	

*Chi-square test

Parental practices to reduce the symptoms of DES

Most of the parents (75.2%) claimed that they asked their children to take breaks during electronic device use. Among 34.2% of them, the break duration exceeded 60 minutes. Only 12.6% of parents reported using a blue light-filtering product for their children. The level of screen brightness of the child's electronic device was bright in almost half of cases (49.9%), whereas it was faint in 17.8% of them. Slightly more than half of the parents (51.9%) reported regular cleaning of child's screen.

Children who take breaks during electronic device use were more likely to have no eye strain compared to those who did not take break (39.3% vs. 20.9%). Additionally, they were less likely to suffer from severe eye strain than their counterparts (11.7% vs. 20.9%; p = 0.001). The highest proportion of children with no eye strain reported a pale level of screen brightness (45.2%), whereas the lowest proportion was observed among those who reported a bright level of screen brightness (30.8%). On the other hand, 36.8% of children whose level of screen brightness was very bright had severe eye strain, compared to only 11.3% of those whose level of screen brightness of electronic device was pale (p = 0.020). Duration of break, using a blue light-filtering product and regular cleaning of the child's screen were not significantly associated with severity of eye strain.

Parents' awareness about DES

About one-third of parents had heard about DES (31.8%) and knew about the effects caused by the blue light generated from digital devices (31.6%), while only 26% have awareness of the symptoms of DES. The 20-20-20 rule was recognized by 15.6% of parents, while more than a third of parents knew the optimum working distances for each digital device (38.1%) and utilized applications to control the Luminance of the screen or used night mode (35%).

Children whose parents were aware of DES symptoms were less likely to have eye strain or to have moderate eye strain in contrast to those whose parents were not aware of DES symptoms (40% vs. 33.5% and 25.2% vs. 33.2%, respectively; p = 0.014). Other parameters of parents' awareness about DES (hearing about it, knowing about the effects caused by blue light generated from digital devices, hearing about the 20-20-20 rule, knowing the optimum working distances for each digital device and using applications to adjust the display screen's brightness or using night mode) were not significantly associated with eye strain among children.

4. DISCUSSION

At the time of COVID-19 pandemic, Saudi Arabia's Ministry of Education adopted digital learning material.[16] Therefore, this resulted in increased digital device usage in children. In this study, the total amount of time spent per day on electronic devices prior to the COVID-19 pandemic ranged from 1 to 3 hours for 46% of children and exceeded 5 hours for 11.5%, while during a pandemic, it exceeded 5 hours for 37.3%. Comparatively, only 1.8% of students utilized digital devices for >5 hours in the pre-COVID-19 era, according to Indian research, whereas 36.9% of participants did during pandemic (Mohan et al., 2021). In an American survey, the average time spent was 3 hours (Wartella et al., 2014). Another study in Abu Dhabi showed time spent was 5.2 hours (Badri et al., 2017). Moreover, a Turkish study showed >3.5 hours (Konca et al., 2022). Duration using devices for online classes and other indoor activities were higher than before the pandemic. This can be linked to the lockdown period, during which

children attending online classes, doing homework online and using devices for leisure purposes (Kim et al., 2016; Mohan et al., 2021; Simon & Paul, 2021; Ganne et al., 2021; Moon et al., 2014; Agarwal et al., 2013).

In our study, there was a strong relation between the total hours spent using digital devices per day before the pandemic and the severity of eye strain. The highest rate of severe eye strain was observed among children who spent > 5 hours on digital devices. A direct proportion was observed between the symptoms of DES and the duration spent in front of a monitor, according to findings from a different study that showed similar results (Mohan et al., 2021; Kanitkar et al., 2005). In our study, a quarter of children who used devices for watching movies expressed severe eye strain, compared to no eye strain in those who used them for recreational reading; however, no link was found between the duration of watching TV and playing video games and the risk of developing DES. An Indian study found playing mobile games >1 hour a day was an important factor leading to DES (Mohan et al., 2021).

In this study, tablets and smartphones were the most frequently used appliance for online classes (47.6% and 40.6%, respectively). These results were consistent with several studies conducted across India (Mohan et al., 2021; Ichhpujani et al., 2019; Amarnath et al., 2021). However, in another study conducted in the Qassim region of SA, tablets were the most frequently used during online classes, while smartphones were the least used device among their children (Aldukhayel et al., 2021). In our study, the children's use of smartphones was identified as a risk factor for developing DES. Also, smartphones were found to be statistically significant for DES in many studies (Kim et al., 2016; Simon & Paul, 2021; Ganne et al., 2021; Moon et al., 2014). This can be related to the fact continuous smartphone use decreases the blink rates which causes the problem of dry eyes, an important factor in DES (Mohan et al., 2021).

When using digital devices, the 20-20-20 rule has been proposed to lessen DES symptoms. Focus on a distant object that is 20 feet away after every 20 minutes spent on a screen has been found to reduce eye pain and headaches (Simon & Paul, 2021). In our study, children who take breaks were more likely to have no eye strain compared to their counterparts (39.3% vs. 20.9%). And less likely to suffer from severe eye strain (11.7% vs. 20.9%). These results were similar to other studies (Mohan et al., 2021; Simon & Paul, 2021). However, the duration of a break was not significantly associated with the severity of eye strain. In Al-Qassim region, research found that 70% of students used their digital devices at <45 cm.[27] This is consistent with our results, in which 51% of children used devices at <45 cm. Conversely, several studies showed most of their participants used their devices at >45 cm (Ichhpujani et al., 2019; Amarnath et al., 2021; Aldukhayel et al., 2021). The viewing distance and DES among children were not related in our study. Comparable research was done in Kerala, where it was discovered that using digital devices at distance < 18 inches, was a statistically significant risk factor for developing DES (Simon & Paul, 2021).

In the current study, the most commonly prevalent eye strain symptoms were headache, excessive blinking, redness and itching (27.5%, 25.6%, 25.3% and 24.8%, respectively). This agrees with two other studies conducted in India, which showed headache and itching were the most reported symptoms (Mohan et al., 2021; Simon & Paul, 2021). In contrast, excessive blinking and redness had a lower prevalence rate (53% and 48.4%, respectively) as reported by a study targeting the Saudi general population. This discrepancy might be due to their larger sample size and different age groups (Turkistani et al., 2021). A pale level of brightness was associated with no eye strain. However, the use of blue light filters and regular cleaning of the screen did not show a significant association with severity (Mohan et al., 2021). Regarding parents' awareness about DES, our study revealed that 31.8% of parents had heard of DES and 31.6% knew about effects of blue light emitted from devices, though only 26% are aware of its symptoms. The first two parameters of parents' awareness were not significantly associated. Conversely, there is an association between parents' awareness and symptoms. To the authors' knowledge, there is a lack of relevant studies investigating parental awareness of symptoms and the impact of digital devices. Therefore, more education is needed regarding the effects of devices and how to avoid DES. As a result, this study emphasizes the significance of trying to raise children's awareness about symptoms and ergonomic measures when using digital devices.

Our study had several strengths, was first in Al-Madinah region, had a large sample size (443) and a high response rate. Furthermore, uncovered some of the key DES factors, including the preference for smartphones and tablets, being at <45 cm distance and a rise in duration using devices. Moreover, we have included a section on parental awareness of DES and helping practices to avoid it. This study had four limitations. Firstly, the research was carried out in Medina region; therefore, results may not be generalized to children studying worldwide. Secondly, our survey was distributed through social media for parents, but we couldn't tell if who responded was a parent or a guardian. A symptom-based questionnaire in which respondents were asked to estimate the occurrence and severity of symptoms, which is a subjective experience and might lead to recall bias. Also, the impact of refractive errors was not examined.

Recommendations

There are limited relevant studies that investigate parents' awareness of DES symptoms and how digital devices affect their children's vision. As a result, more health education is required about the effects of prolonged computer usage on the eyes, as well as how to avoid the circumstances that may contribute to DES symptoms. In order to fully understand DES and how it affects eye health, more evidence-based research is needed. All doctors (general practitioners, family physicians, pediatricians and ophthalmologists) in addition to optometrists, health workers, educational authorities and policy planners should make a concerted effort to raise awareness of DES and the negative health effects it has on school children among families and teachers. This would give them the ability to monitor and optimize children's usage of digital devices and control this issue at the primary level of prevention. Furthermore, we advise having children checked and treated for refractive errors, as they have a significant role in the development of DES symptoms and are a major cause of the condition.

5. CONCLUSION

A high prevalence of DES has been reported among children who attended online classes and have used electronic devices for a long period of time during the COVID-19 pandemic. Headache, excessive blinking, eye redness and eye itching were the most commonly encountered symptoms. Having multiple breaks while using electronics, viewing computers at a suitable distance and using screen protectors were significant practices to alleviate eye discomfort. DES awareness programs should be prioritized by ophthalmologists. This is especially important during the global COVID-19 pandemic when the usage of electronic devices has increased.

Author's contribution

Rawabi Albeladi: Study proposal
Razan Alharbi: Study questionnaire
Ahmed Alrehaili: Introduction
Rahaf Afandi: Methodology
Montaser Alshawawreh: Results
Fai Mahrous: Statistical analysis
Majed Alharbi: Conclusion
All authors wrote the first and final draft of the study abstract and discussion sections. Also, they have critically reviewed and approved the final draft of the study and are responsible for the content and similarity index of the manuscript.

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Abbreviations

DES: Digital eye strain
COVID-19: Coronavirus disease of 2019
SARS-CoV-2 virus: severe acute respiratory syndrome coronavirus 2
UK: United Kingdom
CVS-Q: Computer Vision Syndrome Questionnaire
SPSS: Statistical Package for Social Sciences
SD: Standard Deviation
TV: Television
VDU: Visual Display Unit
USA: United States of America

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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