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Research Article

The Unforeseen Digital Eye Strain of Children: A Review

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ABSTRACT

People of all ages are using mobile devices more frequently, and more children are reportedly using digital media as well, which raises the risk of Digital Eye Strain (DES). There have been few studies on how often DES affects children particularly post-pandemic. The purpose of this study is to review published literature concerning DES, including its pathogenesis and therapy options. A literature search was performed based on PubMed, EMBASE and Scopus databases published from 2003 to 2023 using the broad search term "digital eye strain", "ocular asthenopia secondary to digital gadgets", "computer vision syndrome", "eye strain post-computer or mobile use", "visual weariness", and "children" in all fields. Of the 163 articles retrieved, 107 were retained for inclusion in this review. The result reveals that there is an urgent need to inform parents, caregivers, and youth about setting screen time limits and applying ergonomic practices due to the recent surge in digital electronic gadget usage among kids and young adults.

Keywords: *Ophthalmic complaints, tears, young population*

INTRODUCTION

The coronavirus disease (COVID-19) was officially declared as emerging global health threat since December 2019 (Umakanthan et al., 2020). This was followed by prohibition of outdoor activities including working and studying (Chu et al., 2022). Education is yet another industry that has undergone a paradigm shift, teachers have also been encouraging students to study online from their homes (Camargo et al., 2020). Schools, colleges, and universities all over the world have been utilizing video conferencing instruments such as Google Meet, Zoom, etc (Mohan et al., 2022). Compared to pre-lockdown levels, internet service utilization for all age groups increased from 40% to 100% (Mccrann et al., 2021). Unfortunately, as the amount of time that children must spend at home grows, so does their time spent on screens (Chang et al., 2018; Liu et al., 2021). Hence, the amount of digital devices utilization among children increased rapidly to 50-60% (Kaur et al., 2022). Digital eye strain is now a potential public health risk factor in the environment for variety of eye- and vision-related symptoms including myopia in children (Aldukhayel et al., 2022; Gupta et al., 2021).

Since it was first identified as a health issue more than 20 years ago, digital eye strain is defined by a variety of eye- and vision-related symptoms due to excessive use of smartphones, desktops, laptops, tablets, e-readers, and other digital devices (Bhattacharya et al., 2020; Mohan et al., 2021). The terms “digital eye strain”, “ocular asthenopia secondary to digital gadgets”, “computer vision syndrome”, “eye strain post-computer or mobile use”, and “visual weariness: have been used interchangeably. Eye strain, eye tiredness, burning sensations, eye irritation, eye watering, eye redness, impaired vision, and dry eyes are among the DES symptoms, along with additional issues (Buckley, 2018; Chan et al., 2019). Other than that, those additional issues occur due to DES include headache (Aldukhayel et al., 2022), neck and back pain (Al-Juhani et al., 2015), obstructive sleep apnoea (OSA) (Lee et al., 2022) and restless sleep in children (DelRosso et al., 2021).

New-onset of digital eye strain have been one of the most severe ocular health effects of the COVID-19 endemic. Digital Eye Strain Report which contained survey responses from over 10,000 persons in the USA in 2016 reveals that females were more likely to experience this condition than males (69% prevalence vs. 60% prevalence) (Kaur et al., 2022). By 2050, it is expected that approximately five billion people would be DES, making it a major public health issue with enormous social, educational, and economic ramifications (Mccrann et al., 2021). The age at which DES first appears has also altered, which is concerning because younger children show a more rapid progression of DES and are more likely to develop higher degrees of DES (Aldukhayel et al., 2022; Mohan et al., 2021). This can significantly raise the chance of later-life sight-threatening disorders such myopia maculopathy, glaucoma, cataract, and retinal detachment (Mccrann et al., 2021). However, the literature of DES among children is less to be identified. Hence, the aim of this study is to conduct this literature review of digital eye strain (DES) among children, including its pathogenesis and suggested therapies.

MATERIAL AND METHODS

Study design

Review eligibility was defined according to the PICOS criteria (population, intervention, comparison, outcomes, and study design) (Amir-Behghadami & Janati, 2020): Population (children aged less than 18 years with digital eye strain issues); Intervention (suggested therapy of DES for children); Comparison (comparisons with different clinical groups, within the same group, or with healthy controls, as well as descriptive studies that do not compare data with any control group); Outcomes (the primary outcome was to assess the occurrence of “DES” for children in the academic literatures; Secondary outcomes were to identify the association of “DES” with other health issues of children.

Search strategies and selection criteria

Utilizing electronic databases published from 2013 to January 1st, 2023, PubMed, EMBASE (including the Cochrane library), and Scopus, a thorough literature search was conducted (Fig. 1). *Inclusion criteria*: This review was ensured that each searching article referencing DES for children in the title or abstract was retrieved by using the general search term "digital eye strain”, “ocular asthenopia secondary to digital gadgets”, “computer vision syndrome”, “eye strain post-computer or mobile use”, “visual weariness”, and “children". A citation search was done after looking through reference lists. *Exclusion criteria*: Adult studies, animal studies, research in languages other than English, and studies with less than five participants were all excluded. The following items were also excluded: review papers, congress proceedings, directives, editorials, abstracts, comments, and statements. To prevent data duplication, this review only included the dataset that contained the most pertinent data for our systematic review if the same participants were mentioned in more than one publication.

Data extraction and analysis

Eligible studies' full texts were collected, and two reviewers were randomly assigned to each publication. They worked separately to analyse the information and enter it into the extraction form. Reviewers did not evaluate any of the works they had written. For the purposes of this review, these items were reorganized into the following categories: "*pathogenesis of DES for children" and "therapy options".* The table contains descriptive analyses outlining the summary of the publications examined. The written report was submitted to be published in a journal after being approved by all authors.

RESULTS AND DISCUSSION

A total of 1.394 publications were collected for thorough assessment (Fig. 1); 1.389 of them were disqualified because they failed to meet the predetermined criteria for inclusion. The remaining 5 investigations were mostly observational, three were cross section. Finally, studies are summarized and classified under various pathology/condition categories.

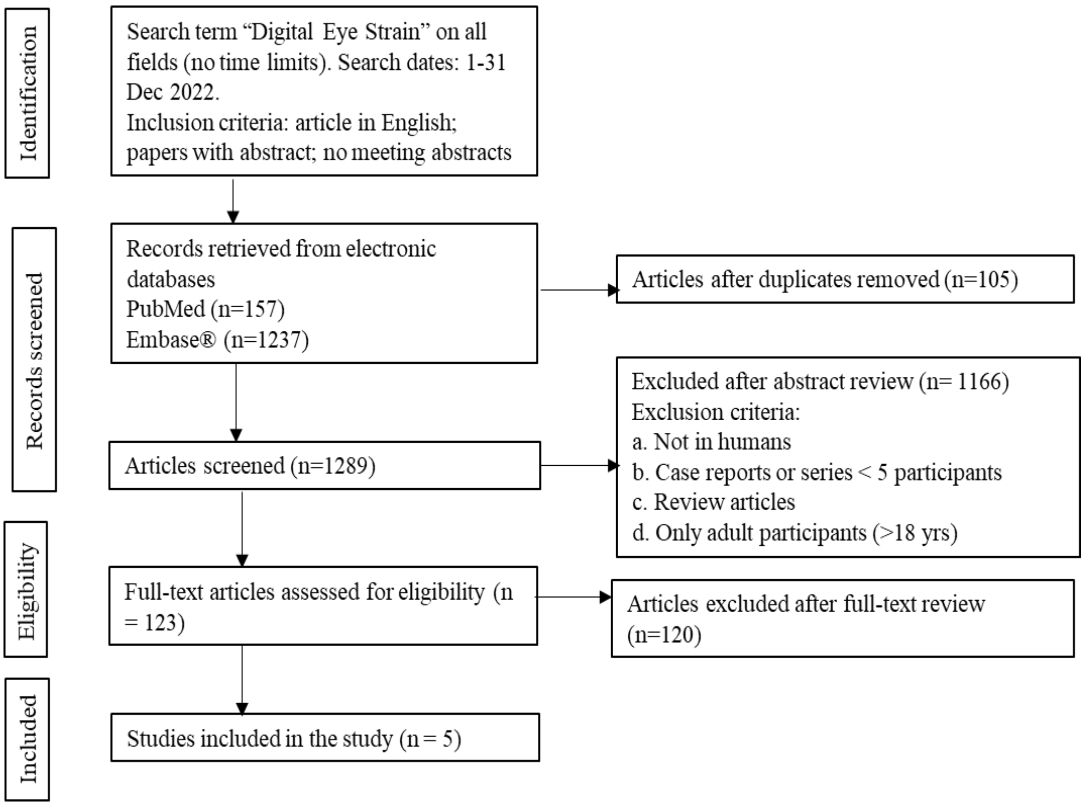

Figure 1. Flowchart of the article search and selection strategy

Five papers characterized digital eye strain as follow.

Table 2. Characteristics of digital eye strain according to pooled articles

No.	Paper (s)	Method (s)	Result(s)
1	(Mohan et al., Sen, Shah, Jain, & Jain, 2021)	The Google app was used to create the online survey form. The length of time spent using digital devices both before and during the COVID era was requested from kids and parents. The Computer Vision Syndrome Questionnaire was used to record and gauge the intensity and frequency of DES symptoms.	Smartphones were the most often utilized digital device (n = 134, 61.7%). One hundred eight kids (49.8%) attended online sessions for more than two hours every day. Our cohort had a prevalence of DES of 50.23% (109/217). Of these, 11.1% were classified as severe, 12.9% as moderate, and 26.3% as mild. Itching and headache were the most prevalent symptoms (n = 117, 53.9%).
2	(Zheng et al., 2021)	Homeschooled grade 7 students at 12 middle schools in southern China were enrolled in a cluster randomized controlled trial and randomly assigned by the school to receive either (1) health education information only or (2) health education information and access to a digital behavior change intervention with live streaming and peer sharing of encouraged activities (intervention) (control).	On March 16, 2020, 1009 kids were assessed, and 954 (94.5%) of them who were eligible and came from willing families were used in the analysis. 52.3% (n=499) of the children in the intervention group (n=485, 6 schools) and the control group (n=469, 6 schools) were male and had an average age of 13.5 (SD) years. 896 kids completed the prescribed interventions (intervention: n=467, 96.3%; control: n=429, 91.5%). Square-root-transformed self-reported anxiety levels changed more over the course of two weeks in the intervention group (-0.23, 95% CI -0.27 to -0.20) than in the control group (0.12, 95% CI 0.09-0.16), with a difference of -0.36, 95% CI -0.63 to -0.08 and a P value of.02 between the two groups. In comparison to controls, there was a substantial decrease in square-root-transformed ocular strain in the intervention group (-0.08, 95% CI -0.10 to 0.06) (difference: -0.15, 95% CI).
3	(Mohan, Sen, Shah, Datt, et al., 2021)	Children with recently developed asthenopia symptoms between the ages of 10 and 17 were included. The Convergence Insufficiency Symptom Survey (CISS) questionnaire was used to assess symptoms. CISS scores of 16 or higher were regarded as symptomatic. Vergence and accommodation parameters for binoculars were assessed with objectivity. Children were split into two groups for	A total of 46 kids, whose ages ranged from 14.47 to 1.95, were assessed. In comparison to before the COVID-19 pandemic (0.58 0.71 hours/day, P .00001), the average length of online classes increased during the COVID-19 pandemic to 3.08 1.68 hours/day. Children who used digital devices for less than 4 hours per day received mean CISS scores of 21.73 12.81, while those who used them for 4 hours or more received scores of 30.34 13.0 (P =.019). Between the two groups, there were differences in mean near exophoria (P =.03), negative fusional vergence (P

	the purpose of comparison: those who used digital devices for 4 hours or more per day and those who used them for 4 hours or less per day.	=.02), negative relative accommodation (P =.057), and accommodation amplitude (P =.002).

The COVID-19 pandemic has raised awareness of the DES and the disease burden associated with it, particularly in the younger generation. Digital eye strain is defined as time spent in front of a screen, including time spent watching television, using a computer, laptop, or tablet, using a smartphone, and playing video games. It is an excessively sedentary lifestyle habit that has negative effects on ocular health. People have turned to television and social media for entertainment due to a lack of outside activities and social connection, which has unwittingly increased dependence on these tools. According to reports of Bhattacharya et al. (2020), 87% of people between the ages of 20 and 29 report using two or more digital devices at once, which highlights how pervasive social media use is among younger folks. Prior to the COVID-19 pandemic, there have been reports of a highly varied prevalence of DES symptoms in children ranging from 5 to 65% (Kaur et al., 2022). Moon et al. (2014) found that children older than 14 years had more dry eye symptoms than younger children because older kids use their smartphones more frequently. The most important risk factors for developing DES in children are using digital devices for more than four hours each day.

The Pathophysiology of DES

There are three potential pathways that can contribute to computer vision syndrome symptoms: the extraocular mechanism, the accommodative mechanism, and the ocular surface mechanism (Bhattacharya et al., 2022). Digital eye strain can cause non-ocular symptoms like a stiff neck, overall exhaustion, headaches, and backaches (Mohan, Sen, Shah, Datt, et al., 2021). These symptoms are associated to postural and lighting issues brought on by improper computer screen positioning, an inappropriate table or chair height, or an inaccurate distance between the eye and the screen, which causes needless forward bending or stretching that frequently results in a sprained muscle (Aldukhayel et al., 2022).

The accommodative mechanism are symptoms of a delayed change in focus such as blurred vision, double vision, presbyopia, and myopia (Bhattacharya et al., 2020). This delayed change is a slowly adaptation process as a result of continuous use of digital devices (Mohan et al., 2022). When using a digital instruments for extended periods of time, symptoms including blurry close vision, blurry distance vision, and difficulties refocusing may be caused by accommodation abnormalities (Zheng et al., 2021). After prolonged computer use, an ocular surface mechanism results in symptoms like dry eyes, redness, a gritty feeling in the eye, sensitivity to bright lights, ocular discomfort and burning (Gupta et al., 2021).

Through the entire cycle of tear secretion, ocular surface wetting, ocular surface evaporation, and eventually tear drainage, eyeblink assists in maintaining a normal ocular surface (Mohan et al., 2022). Other factors that may contribute to digital eye strain include increased corneal surface exposure from horizontal computer screen gaze, decreased tear production brought on by aging and contact lens use, and more (Moon et al., 2014).

Digital eye strain may also reduce the blink rate of children. A study conducted by Mohan et al. (2021) that the blink rate drastically decreases while using a computer, going from 18.4 to 3.6

blinks per minute in one study to 22 to 7 blinks per minute in another. According to Mohan et al. (2022), reduced blinking and squinting have a bimodal pathophysiology that increases visual acuity when there is a refractive error and decreases retinal illumination when using a source with glare in the superior visual field. An incomplete blink, when the upper eyelid does not completely cover the corneal surface, may be more significant to dry eye than a lower blink rate since the tear film stability can be maintained with a reduced blink rate, provided that most blinks are complete (Mohan, Sen, Shah, Datt, et al., 2021).

Suggested therapies of DES

Digital eye strain symptoms, such as asthenopia, headaches, neckaches, red eyes, watery eyes, or a burning feeling in the eyes, need to be made clear to screen users. The 20-20-20 rule (taking a 20-second break every 20 minutes to look at an object 20 feet away) and the use of ergonomic chairs should be encouraged in order to lessen eye strain (Khasanah, 2018). Other changes they should be encouraged to have better lighting, reducing glare, taking regular breaks from the screen, occasionally changing focus to a distant object, and taking regular breaks from their screens. There is also a need to emphasize blinking frequently. When utilizing screens, our normal blink rate drops to 4-6 times per minute from 14–16 (Kaur et al., 2022).

Another potential modifiable environmental risk factor that may raise the risk of myopia progression is the amount of time spent using digital screens. In order to reduce the risk of myopic macular degeneration, retinal detachment, glaucoma, and cataract, it has become a priority to stop myopia from progressing (Gupta et al., 2021; Aslan et al., 2022). Paediatricians and visual health professionals should educate parents and educators on how to spot these symptoms and take appropriate action, such as limiting screen time, utilizing larger high-resolution displays, altering the lighting, and spending more time outside (Ichhpujani et al., 2019).

The ergonomic usage of digital gadgets is one suggestion for easing DES. The amount of time spent on screens on average each day should be limited (B 4 h daily). Good digital device habits include situating the device in the right lighting, changing the image's quality, text size, contrast, and brightness, and taking regular pauses (20/20/20 method) (Cai et al., 2022). Screens should be placed 20 inches or less from the eyes while seated upright at a desk or table (Cai et al., 2022). The screen's height should be set such that it is 15-20 below eye level, or lower than the height of the viewer's eyes (Coles-Brennan et al., 2019). Eye blinking frequently reduces the likelihood of dry eye development (Sheppard & Wolffsohn, 2018). The reference materials need to be positioned below the level of the monitor and above the level of the keyboard (Ganne et al., 2021).

User performance has been shown to diminish in environments with illumination levels beyond 1000 lx (Hussaindeen et al., 2020). Most people find a contrast setting between 60 and 70% to bse comfortable (Coles-Brennan et al., 2019). It is important to adjust the monitor brightness so that it is consistent with the ambient lighting in the workstation. The quantity of light reflected from displays can also be decreased with anti-glare screens. Screen time tracking makes it possible to limit excessive screen time. It recommends limiting time spent on digital gadgets. The application of antireflective coating on glasses and the correction of refractive errors. Informing the public on the long-term impacts of excessive screen usage and promoting healthy lifestyle choices (Sheppard & Wolffsohn, 2018; Aldukhayel et al., 2022). Parents should be advised to keep an eye on their child's screen time and include family activities. Inspire kids to participate in outdoor recreational activities (Coles-Brennan et al., 2019).

CONCLUSION AND SUGGESTION

In the information age, technology has reshaped every aspect of our lives, including healthcare and education. Digital eye strain in young population needs to be brought to the attention of parents and other caregivers. Due to digital platform use, children now spend less time engaging in field activities. This reveals an additional risk factor for the onset or advancement due to intensive digital exposure, and it is a crucial study subject in light of prospective eye strain control techniques. There is a substantial information gap about DES and its potential impact, suggesting that this population needs to be made aware. Early warning indications that a kid may be squinting are important for parents and caregivers to recognize. Children frequently do not express ocular discomfort but may exhibit specific habits like forced blinking or avoiding screens or complain of temporary episodic eye pain, rubbing, or epiphora, which may signify eye strain. Targeting the young population at risk is necessary for eye-health programs and awareness efforts. The suggested therapy by conducting the formula 20-20-20 (taking a 20-second break every 20 minutes to look at an object 20 feet away) should be considered. The usage of optometrists, vision technicians, and nursing personnel as well as non-medical professionals (wellness practitioners) can help raise awareness among digital device users. It is crucial that specialists in vision health and eye care are knowledgeable about DES. There has to be more awareness of the negative consequences of excessive screen usage, ergonomics, and preventive actions. Further research should concentrate on suggestions for improving the comfort of seeing on digital screens, cutting-edge technology for eyeglass lenses, and built-in filters.

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