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ORIGINAL ARTICLE

Determinants of digital eye strain among university students in a district of India: a cross-sectional study

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Abstract

Aim Digital device usage, especially during the pandemic, has catapulted into a new age problem, the computer vision syndrome. This study aimed to quantify the prevalence and determinants of digital eye strain (DES).

Subject and Methods A total of 345 university students in India were surveyed in June–July 2022, by a validated tool, the Computer Vision Syndrome Questionnaire (CVS-Q) © in this cross-sectional study. According to American Optometric Association, digital eye strain and computer vision syndrome are synonyms. Non-parametric tests of medians were used to compare the median DES scores, Chi square test to compare categorical variables, and binary logistic regression to find the determinants of DES.

Results The average age of the study participants was 21.0 ± 2.2 years, ranging between 18–26 years with 52.8% females and 47.2% males. The prevalence of DES was 45.5% (CI 95% = 40.2%–50.8%). Any existing eye disease (p-value = 0.000, OR = 0.41, 95% CI = 0.26–0.65), average daily screen time (p-value = 0.001, OR = 1.61, 95% CI = 1.22–2.13) and using gadgets in the dark (p-value = 0.000, OR = 0.37, 95% CI = 0.23–0.61) were significant determinants of the same.

Conclusion Framing guidelines limiting the hours allotted for online classes for university students are imperative, with promotion of ergonomic practices for digital device usage such as blue light filters and night mode on devices.

Keywords Computer vision syndrome · Digital eye strain · Online classes · Internet · Students · COVID-19

Introduction

The American Optometric Association defines computer vision syndrome (CVS) or digital eye strain (DES) as a collection of visual and ocular symptoms arising due to prolonged use of digital electronic devices (American Optometric Association (n.d.). The 16 symptoms defining CVS are: 1) burning, 2) itching, 3) feeling of a foreign body 4) tearing, 5) excessive blinking, 6) eye redness, 7) eye pain, 8) heavy eyelids, 9) dryness, 10) blurred vision, 11) double vision, 12) difficulty focussing for near vision, 13) increased sensitivity to light, 14) coloured halos around objects, 15) feeling that eyesight is worsening, 16) headache.

Smart phone addiction is a real problem today (Parke et al. 2006). Internet gaming disorder has been listed in the research criteria of DSM-5 (Ma 2021). Worldwide, the prevalence of CVS is 66% (95% CI: 59.74), whereas for India it is 65% (95% CI: 49.81), (Anbesu and Lema 2023).

The COVID-19 pandemic restrictions in the form of nationwide lockdown began since March 2020. Students of both schools and colleges were left in the lurch for their studies, attending online classes and submissions. Professionals employed in the IT sector, teachers, lawyers and many more employees were working remotely via the internet.

According to the Telecom Regulatory Authority of India (TRAI), there are 502.53 million subscribers in urban areas

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and 322.77 million subscribers in rural areas. The total number of internet subscribers per 100 population is 60.73 (Bhawan 2021). According to National Family Health Survey 5, 57.1% of men and 33.3% of women in the age group of 15–49 years have ever used the internet (International Institute for Population Sciences 2021).

According to the College Crisis Initiative, in the United States, 44% of institutions adapted fully to online learning tools (University of Davidson 2021). A report by Class Central, a platform for MOOC (massive open online course) users, indicated that in 2021, 40M new learners signed up for at least one MOOC (Shah 2021).

To limit screen time, schools have been asked to hold live online classes for a maximum of 1.5 hours per day for Classes 1–8, and three hours per day for Classes 9–12, according to the PRAGYATA guidelines for digital education, released by the Ministry of Human Resource Development, India (MHRD). Ergonomic practices for digital screen use in schools are also being promoted by the Ministry (Department of School Education & Literacy 2020). India is a country with a predominantly young population. It has witnessed a transition in the mode of teaching, from traditional blackboard teaching to online classes. The lockdown due to COVID-19 pandemic has increased this trend.

The mode of medical education has transformed recently. It has incorporated digital devices for imparting lectures via digital display screens, students taking notes on tablets/iPads, solving problems, and taking exams on computers. The National Medical College Network (NMCN) was launched in 2019 for advancing tele-education in medical universities. Medical students in India undertake coaching/preparation classes for post graduate (PG) residency entrance exams which are delivered online nowadays.

There are no formal guidelines in place for screen time exposure for university students in India. Furthermore, DES is a less explored topic in India. Hence, this research was conducted on medical students in India.

The aims and objectives of the study were to determine the prevalence of DES in students at a medical college in Haryana and identify the determinants for the same.

Methods

The present study was a cross-sectional study conducted at Pt B. D. Sharma Post Graduate Medical Sciences Rohtak, Haryana, India. Taking the prevalence of digital eye strain as 33.2% in the general public (Ganne et al. 2020), the sample size was estimated as follows: sample size = ZPQ/ L^2, where Z = 1.96, P = 33.2%, Q = 66.8, L = 5%. For 95% confidence interval, sample size = 341.

The list of all the currently enrolled undergraduate (UG) students pursuing Bachelor of Medicine and Bachelor of Surgery (MBBS) at Pt. B.D. Sharma Post Graduate Institute of Medical Sciences Rohtak, was obtained from the institute office. Of the 998 such students, 373 students were approached by the investigator, of whom 345 participants agreed to participate (non-response rate 8%). These 345 students were selected based on simple random sampling using a freely available software package, Research Randomizer (Urbaniak and Plous 2019). They were apprised of the study. Those willing to give written informed consent were included. For those refusing, a new number was generated using the software and the next person was incorporated in the study.

Segui et al's Computer Vision Syndrome Questionnaire (CVS-Q©) (Seguí et al. 2015) was used for data collection: CVS-Q© is a screening tool. It is a pre-validated questionnaire used to assess the level of DES symptoms. The students present in college were provided with a printed CVS-Q, and the survey was conducted in a paper and pen mode. UG medical students were purposely selected because postgraduate (PG) residents have varied teaching schedules and diverse competencies. To maintain uniformity and availability of the sample, the entire UG students were chosen. Data was collected from June to July 2022.

Participants indicative of CVS were referred to Ophthalmology for further workup.

The questionnaire has three parts, namely the demographic details, pattern of device usage, and degree of eye strain experienced. Grading of DES was estimated using the frequency and intensity of the 16 symptoms described previously. It was scored as follows:

- Frequency: never (score 0), sometimes (score 1) (once a week, sporadic episodes), and always (score 2) (more than 2–3 times a week).

The intensity was graded as moderate (score 1) and intense (score 2).

- The intensity was graded as moderate (score 1) and intense (score 2).
- The result of (frequency X intensity) was re-coded as: 0 = 0; 1 or 2 = 1; 4 = 2.

Final DES was estimated as follows:

$$\text{DES score} = \sum_{1}^{16} (\text{Frequency X Intensity})$$

DES score ≥ 6 was indicative of digital eye strain.

The devices considered were personal digital devices such as mobile phones, tablets, laptops, desktops, and digital screen displays such as television

Statistical methodology

The DES score is ordinal data, and hence we used non-parametric median tests of 2 or k independent samples to compare the median DES score between two or more groups. We used Spearman's correlation to test the relationship between average daily screen times and age. Binary logistic regression analysis was performed for predictors of DES. Independent variables found significant at univariate analysis were included in logistic regression analysis. These were age, any known eye disease, average daily screen time, taking a break, and using devices in the dark. All analysis was performed using IBM-SPSS version 24 (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, USA).

A p-value less than 0.05 was considered significant.

Written informed consent was taken from all the participants prior to enrolment in the study and confidentiality was assured.

Results

The study comprised 345 participants with a mean age of 21.0 ± 2.2 years, the majority of them (52.8%) females. The prevalence of digital eye strain was 45.5% (CI 95% = 40.2%–50.8%). It was higher among females than males, 50.0% (CI 95% = 42.7%–57.3%) vs 40.5% (CI 95% = 32.9%–48.1%) respectively, although this difference in prevalence was not statistically significant (p-value = 0.455).

Table 1 illustrates the ocular demographic variables of the study participants. A total of 47.5% participants reported having an eye disease, myopia being the most common (45.5%), The average daily screen time and average screen distance were 4–6 hours and < 20 cm for the majority of them. Usage of devices in the dark was reported by 63.5%.

Table 2 shows that the mean age of the participants who had a screen time greater than 10 hours (21.17 ± 0.753 years) was more than that of those whose screen time was less than 2 hours/day (19.81 ± 1.721 years) ($p < 0.01$). Final year undergraduates spend long hours on digital devices attending online classes for postgraduate entrance exams.

Table 2 Average screen time and age of the participants

Average daily screen time	Number (n = 345)	Mean age	Standard deviation
< 2 hours	21	19.81	1.721
2–4 hours	114	20.87	2.147
4–6 hours	151	21.17	2.163
6–10 hours	53	21.36	2.370
> 10 hours	6	21.17	0.753
Total	345	21.02	2.170

Table 1 Ocular demographics of the study participants

Ocular demographic variable	Total (n = 345)		DES score < 6 (n = 191)		DES score ≥ 6 (n = 154)	
	n	%	n	%	n	%
Eye diseases among participants						
Participants with eye disease	164	47.5%	75	39.3%	89	57.8%
Types of eye disease						
Myopia	157	45.5%	70	36.6%	87	56.5%
Asthenopia	1	0.3%	1	0.5%	0	0.0%
Astigmatism	2	0.6%	2	1.0%	0	0.0%
Conjunctivitis	1	0.3%	0	0.0%	1	0.6%
Glaucoma	1	0.3%	1	0.5%	0	0.0%
Keratoconus	2	0.6%	1	0.5%	1	0.6%
Digital device usage pattern						
Average daily screen time						
< 2 hours	21	6.1	13	6.8%	8	5.2%
2–4 hours	114	33	81	42.4%	33	21.4%
4–6 hours	151	43.8	74	38.7%	77	50.0%
6–10 hours	53	15.4	23	12.0%	30	19.5%
> 10 hours	6	1.7	0	0.0%	6	3.9%
Average screen distance						
< 20 cm	251	72.8	23	12.0%	30	19.5%
20–37 cm	83	24.1	157	82.2%	119	77.3%
> 37 cm	11	3.2	11	5.8%	5	3.2%

Table 3 Univariate analysis for predictors of digital eye strain (DES)

Variable	DES score < 6 (*n* = 191)		DES score ≥ 6 (*n* = 154)		*P*-value
Sex					
Male	98	51.3%	65	42.2%	0.092
Female	93	48.7%	89	57.8%	
Age (years)					
18–20 years	92	48.2%	52	33.8%	0.007
21–26 years	99	51.8%	102	66.2%	
Any known eye disease	75	39.3%	89	57.8%	< 0.001
Average daily screen time (hours)					
≤ 4 hours	94	49.2%	41	26.6%	< 0.001
> 4 hours	97	50.8%	113	73.4%	
Average screen distance (cm)					
< 20 cm	23	12.0%	30	19.5%	0.057
≥ 20 cm	168	88.0%	124	80.5%	
Take break					
Frequently	147	77.0%	104	67.5%	0.050
Infrequently/never	44	23.0%	50	32.5%	
Use devices in the dark	103	53.9%	116	75.3%	< 0.001

Table 4 Logistic regression analysis for predictors of DES

Parameters	Adjusted odds ratio	95 % CI
Any known eye disease	0.41	(0.26–0.65)
Average daily screen time	1.61	(1.22–2.13)
Use devices in the dark	0.37	(0.23–0.61)

Average screen time is significantly correlated with age (correlation coefficient, $R^2 = 0.137$, $p < 0.011$).

In Table 3, upon univariate analysis, any known eye disease, average daily screen time, and use of devices in the dark are significant predictors for DES.

In Table 4, upon logistic regression analysis, the significant predictors of DES were any existing eye disease (p-value = 0.000, OR = 0.41, 95% CI = 0.26–0.65), average daily screen time (p-value = 0.001, OR = 1.61, 95% CI = 1.22–2.13) and using devices in the dark (p-value = 0.000, OR = 0.37, 95% CI = 0.23–0.61).

Variables entered were age, any known eye disease, average daily screen time, taking a break, use of devices in the dark.

Discussion

The current study reported DES prevalence as 45.5% (CI 95% = 40.2%–50.8%) among the study participants. This was similar to the prevalence reported by Ganne et al. 2020 among students taking online classes during the pandemic. Logaraj et al. 2014 contrastingly reported a higher prevalence, 78.6%. Any existing eye disease (p-value = 0.000, OR = 0.41, 95% CI = 0.26–0.65), average daily screen time (p-value = 0.001, OR = 1.61, 95% CI = 1.22–2.13), and using devices in the dark (p-value = 0.000, OR = 0.37, 95% CI = 0.23–0.61) were significant determinants of digital eye strain in the current study.

Prolonged screen usage, especially in the pandemic, has changed the lifestyle of many people. Students and working professionals were bound to attend online classes or work assignments. These requirements have made the youth susceptible to DES. Studies published previously (Lee et al. 2019; Sánchez et al. 1996) have emphasised this fact and it was confirmed by this study too. Imprudent usage of technology has led the public to the brink of a collapse of their ocular health. Various ocular and non-ocular problems have been correlated with digital screen usage. These include eye strain (Sheppard and Wolffsohn 2018), retinal damage (Jaadane et al. 2015; Ham et al. 1976), progression of myopia (Guan et al. 2019), sleep disturbances (Tosini et al. 2016), musculoskeletal problems (Borhany et al. 2018), and behavioural abnormalities (Shokouhi-Moqhaddam et al. 2013). Stress from exams or a lack of sleep contributing to similar symptoms get ruled out by the fact that study subjects who had increased exposure to digital screen were noted to have higher DES scores. This means that screen time has a statistically significant association with DES. Holden et al. 2016 published a meta-analysis proclaiming doubling of myopia prevalence and a 7-times increase of visual loss by myopia by 2050. The current scenario of reckless device usage by the masses may accelerate this progression if timely efforts are not made to halt this progression.

The recommendations from this research are: (1) limitation of online classes by institutions to less than 4 hours a day (Lee et al. 2019), (2) providing adequate breaks in between lectures to let students look at distant objects (20–20–20 rule) (American Optometric Association 2017). According to the American Optometric Association, the 20–20–20 rule states that people should take a 20-second break, every 20 minutes, and look at something 20 feet away. Other measures are: (3) supplementary breaks and stretching exercises in between online classes (Galinsky et al. 2007), (4) propagating information education communication activities promoting ergonomic practices for digital device usage such as blinking eyes more frequently (Sheedy et al. 2005) and washing eyes with water in between digital device usage or applying eye lubricant drops to prevent dryness (Courtin et al. 2016), (5) Adjustment of ambient light to reduce glare (Leung et al. 2017), (6) use of an anti-glare filter to enhance contrast (Leung et al. 2017), (7) keeping computer screen at a distance greater than 36 inches and smartphone screen beyond 40 cm (Bababekova et al. 2011), (8) applying

computer glasses (blue light filters with anti-reflective coating) (Ide et al. 2015), and (9) operating devices on night mode, especially during the evening (Teran et al. 2020). All these are proven protective measures against digital eye strain.

Future research can be undertaken with a more objective methodology incorporating critical flicker–fusion frequency and blinking characteristics to ascertain DES (Sheppard and Wolffsohn 2018). Children form another vulnerable group and need to be studied for eye-strain risk (Palaiologou 2014). This study is the first to quantify DES in North India among medical students utilizing a validated method (Seguí et al. 2015).

The limitations of this study were (1) direction of association could not be ascertained due to this being a cross-sectional research project, (2) recall bias, and (3) only medical students were included.

Conclusion

Drawn from this study is framing of guidelines limiting digital device-dependent classes for medical students, hybrid format of lectures with more hours of physical classes, and reduction in general usage of screens for recreation and internet surfing to avoid eye strain. Information education communication activities promoting ergonomic practices for digital device usage are the need of the hour.

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Declarations

Ethical statement Approval was obtained from the Biomedical Research Ethics Committee Pt. B.D. Sharma Post Graduate Institute of Medical Sciences/University of Health Sciences Rohtak, IRB No. BREC/RES/22/127. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Conflict of interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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