Original Article

Digital eye strain among medical students associated with shifting to e-learning during COVID-19 pandemic: An online survey

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Purpose: This study aimed to determine the prevalence, risk factors, symptoms, and awareness of computer vision syndrome (CVS) among medical students during the coronavirus disease 2019 (COVID-19) pandemic. **Methods:** A cross-sectional observational study was conducted among 283 undergraduate medical students at a tertiary healthcare center. An electronic survey was conducted to collect the data. Data were analyzed using Statistical Package for Social Sciences (SPSS version 23). The Chi-square test (Fisher's exact test when required) was used to study the significance of associations. A *P* value <0.05 was considered statistically significant. **Results:** A high prevalence of CVS was observed in which 92% reported at least one symptom while using a digital device, the most frequent being eye strain (49%). Among extraocular complaints, joint pain in the wrist and fingers was most frequent. Significant association ($P < 0.05$) of CVS was found with increased duration of digital device usage, refractive error, use of glasses or contact lens, preexisting dry eye disease, and use of topical eye drops. 37% of the participants were aware of the 20-20-20 rule, while only 11% followed it. **Conclusion**: CVS is a common health concern among medical students. Hence, to increase the productivity of work, significant risk factors need to be addressed and awareness must be raised.

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The development of technology in education has led to the rise of a significant health-related concern known as computer vision syndrome (CVS). This is defined as "a complex of eye and vision problems related to near work experienced during computer use" by the American Optometric Association (AOA).[1] Around the world, about 60 million computer workers experience discomfort from CVS. According to the AOA, the most common symptoms associated with digital eye strain (DES) are eyestrain, headaches, blurred vision, dry eyes, and pain in the neck and shoulders.[2]

Nowadays, university students including medical students are spending more time staring at the screen for studying and for research work. There have been several studies reporting an increased prevalence of CVS among computer users, specifically medical students.[3,4]

The 2016 Digital Eye Strain report, which included survey responses from over 10 000 US adults, identified an overall self-reported symptom prevalence of 65%, with females more commonly affected than males. DES was reported more frequently by individuals who used two or more devices simultaneously, compared with those using just one device at a time, with prevalence of 75% and 53%, respectively. It is one of the rising health concerns related to technology due to the increased use of digital devices, especially among students in the post-coronavirus disease 2019 (COVID-19) era.[5,6]

CVS symptoms precipitate when there is a need to enhance the visual demand to the extent that it exceeds the person's visual ability.[1] The image on any digital screen is produced by thousands of pixels combined to form an image, in which the margins are not very well defined and are dependent on the resolution, the contrast of the background, and glare from the screen. The abovementioned factors increase the visual demand to perceive good images, which is not required for printed documents.[1,7,8] In addition, CVS can also be explained by decreased blinking reflex while staring at the screen, leading to dry eyes or exacerbating preexisting dry eye.[8] Other factors such as the duration of usage, frequency of breaks, working distance from the screen, screen brightness, illumination of the surrounding, and sitting posture were discussed in several previous studies and were considered known risk factors of CVS.[3,9-12]

Although most CVS symptoms are transient and no permanent visual damage was reported in previous studies, some workers still experience visual difficulty after work.[1,13] Ocular and musculoskeletal discomfort associated with CVS may result in reduced productivity by 40% of users.[7,14] Additionally, Shantakumari *et al*. noted that more than 70% of university students were having frequent interruption of computer work caused by CVS symptoms.[12]

DES can be evaluated by subjective methods and objective methods. It is commonly managed non-pharmacologically

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and pharmacologically; non-pharmacological management includes correct ergonomic practices, maintaining normal blinking, the use of appropriate lighting, careful positioning of the digital device, adjusting image parameters (resolution, text size, contrast, luminance), and taking breaks, while pharmacological management strategies include using artificial tears.[15]

To the best of our knowledge, this is the first study conducted on the effects of digital eye strain on undergraduate medical students at a tertiary care center in western India. Very few studies have been conducted so far on the effects of prolonged computer usage on Indian medical college students. The aim of this study was to determine the prevalence of CVS among undergraduate medical students, associated risk factors, and most commonly associated symptoms and to assess the proper practice of using computers for studying among medical students. The findings of this study will help to assess the awareness among undergraduate medical students regarding DES and the practices to prevent it.

Methods

A cross-sectional descriptive study conducted included 283 undergraduate medical students from various semesters at a tertiary healthcare center in western Rajasthan. An electronic data collection form adapted from previous literature research on CVS was used for data collection. The duration of digital device usage per day before and after the emergence of COVID-19 pandemic was recorded. Surrounding illumination, timing of usage, and whether continuous or interrupted use were also taken into account. The questionnaire also included demography, history of preexisting dry eye disease, use of lubricating eye drops, type of refractive error and the type of refractive correction used, and preventive measures taken to reduce the symptoms. CVS symptoms were categorized into ocular and extraocular. Ocular symptoms included dry eyes, red eye, burning sensation, foreign body sensation, blurred vision, increased sensitivity to light, excessive tearing, itching, ocular pain, change in visualizing colors, difficulty in refocusing, and double vision. Extraocular symptoms included headache, neck, shoulder, or back pain, and numbness of the hands or fingers. Medical students were also asked about the knowledge and practice of the 20-20-20 rule and whether they would make changes in their lifestyle to reduce CVS symptoms. The inclusion criteria were undergraduate medical students who used their laptops or tablets or mobile phones or any video terminal devices during studying for at least one month before the study. Data were analyzed using Statistical Package for Social Sciences (SPSS version 23). The Chi-square test (Fisher's exact test when required) was used to study the significance of associations. A *P* value <0.05 was considered statistically significant.

Results

A total of 283 medical students participated in the study with the mean being 21.67 years. 54.06% (153) of the participants were males, and 45.94% (130) were females. In regard to demographic data in this study, the male gender (54.06% (153)) was observed to have a higher risk of CVS ($P < 0.0001$) [Table 1].

Table 1: Age and gender distribution of the study population according to digital time usage in the pre-COVID-19 and COVID-19 period (*n*=283)

Pre-COVID-19 period	≤24 yrs	>24 yrs	Total
Pre-COVID-19 period			
<1 h	52	0	52
1–2 h	136	1	137
3–4 h	49	6	55
4–6 h	12	10	22
>6 h	12	5	17
Total	261	22	283
COVID-19 period			
<1 h	25	0	25
1–2 h	41	0	41
3–4 h	54	4	58
4–6 h	86	10	96
>6 h	55	8	63
Total	261	22	283

Duration	Male		Female		Total		*P*
	n	%	*n*	%	*n*	%	
<1 h	5	20.00	20	80.00	25	8.83	<0.0001
1–2 h	14	34.15	27	65.85	41	14.49	
3–4 h	29	50.00	29	50.00	58	20.49	
4–6 h	69	71.88	27	28.13	96	33.92	
>6 h	36	57.14	27	42.86	63	22.26	
Total	153	54.06	130	45.94	283	100.00	

A high prevalence of CVS was observed, and 92% (260) reported at least one symptom while using a digital device. Ocular symptoms as reported by our study population in decreasing order of frequency were eye strain (49% (139)), headache (37% (105)), fatigue (32% (91)), dry eye (21% (60)), difficulty in refocusing (20% (57)), eye redness or itching (18% (51)), and double vision (5% (14)). While 51% (143) of study participants had no extraocular symptoms, the most frequently reported extraocular symptoms in decreasing order of frequency were joint pain in finger and wrists (20% (57)), difficulty to write (13% (36)), shoulder pain (11% (31)), and inability to hold objects well (6% (16)) [Table 2].

Fifty-nine percent (59%) (168) of participants had a refractive error, and it was strongly associated with a higher prevalence of CVS ($P < 0.0001$). A similar association was also found with the use of spectacles and/or contact lens. The use of antireflective coating or screen filters did not show any significant association with CVS. While 39% (111) of participants were using topical lubricating drops with varying frequency, preexisting dry eye disease was present in 35% (100) of our study population and was strongly associated with CVS ($P < 0.001$). The majority of the participants, that is, 63% (178), were using digital devices during the day time with 57% (162) using digital devices when the illumination from the device was more than the surrounding illumination, both factors having a strong association with CVS. 68% (191) of the study population was taking breaks in between digital

Table 2: Details of digital screen usage and extraocular symptoms associated with it according to the duration of screen time (*n*=283)

	The hours you spend on your digital screen are				Total		*P*
	Continuous		Interrupted				
	n	%	*n*	%	*n*	%	
<1 hr	10	40.00	15	60.00	25	8.83	0.056
1–2 hrs	17	41.46	24	58.54	41	14.49	
3–4 hrs	24	41.38	34	58.62	58	20.49	
4–6 hrs	21	21.88	75	78.13	96	33.92	
>6 hrs	20	31.75	43	68.25	63	22.26	
Total	92	32.51	191	67.49	283	100.00	
	Are you spending most of your screen time during the day or during the night?				Total		*P*
	Day		Night				
	n	%	*n*	%	*n*	%	
<1 hr	9	36.00	16	64.00	25	8.83	0.0003
1–2 hrs	25	60.98	16	39.02	41	14.49	
3–4 hrs	49	84.48	9	15.52	58	20.49	
4–6 hrs	60	62.50	36	37.50	96	33.92	
>6 hrs	35	55.56	28	44.44	63	22.26	
Total	178	62.90	105	37.10	283	100.00	

	Describe the detail of the objects you see after prolonged hours on your digital screen						Total	
	Blurred		Clear		Hazy			
	n	%	*n*	%	*n*	%	*n*	%
<1 hr	0	0.00	52	100.00	0	0.00	52	18.37
1–2 hrs	16	11.68	104	75.91	17	12.41	137	48.41
3–4 hrs	13	23.64	34	61.82	8	14.55	55	19.43
4–6 hrs	1	4.55	16	72.73	5	22.73	22	7.77
>6 hrs	5	29.41	12	70.59	0	0.00	17	6.01
Total	35	12.37	218	77.03	30	10.60	283	100.00

	After using my smartphone for prolonged hours, I am complaining of					Total
	Difficulty to write	Inability to hold objects well	Joint pain in fingers and wrist	Shoulder pain	No complain	
<1 hr	7	0	15	2	28	52
1–2 hrs	13	12	20	15	77	137
3–4 hrs	11	4	9	5	26	55
4–6 hrs	1	0	5	8	8	22
>6 hrs	4	0	8	1	4	17
Total	36	16	57	31	143	283

device usage, which was not associated with a higher risk of CVS [Table 3].

Seventy-four percent (74%, 208) of our study population used mobile phones (either Android or iPhone) for studying, which had a significant association with CVS ($P < 0.001$); other digital devices used were laptops (15% (43)) and tablets or iPad (11% (32)). There was a significant increase in digital screen time after the emergence of COVID-19 as earlier 66% of students spent <2 hrs a day as compared to 56% of students who spend >4 hrs per day in post-COVID-19 times. 66% (184) of participants used both books and digital screen for their study, and it was also associated with high CVS prevalence ($P < 0.001$) [Table 4].

65% (184) of the participants affirmed that increased digital device usage duration affects their lifestyle and eye health. 36% (103) were aware of the 20-20-20 rule, which is practiced to reduce CVS symptoms, but only 11% (31) followed it during any period of time. Around three-fourths of the study population, that is, 213 participants, were willing to reduce screen time and follow healthy practices to guard against CVS symptoms [Table 5].

Discussion

Among the 283 medical students participating in the study, a high prevalence of CVS was observed (92% (260)). Similar high prevalence rates of CVS have also been shown by studies

Table 3: Association of the presence of refractive error and use of glasses with the duration of digital device usage (*n*=283)

	Do you have any refractive error?						Total		*P*
	Yes		No		I don't know				
	n	%	*n*	%	*n*	%	*n*	%	
<1 hr	6	24.00	12	48.00	7	28.00	25	8.83	<0.0001
1–2 hrs	15	36.59	18	43.90	8	19.51	41	14.49	
3–4 hrs	30	51.72	17	29.31	11	18.97	58	20.49	
4–6 hrs	71	73.96	16	16.67	9	9.38	96	33.92	
>6 hrs	46	73.02	16	25.40	1	1.59	63	22.26	
Total	168	59.36	79	27.92	36	12.72	283	100.00	
	Do you wear glasses or contact lens						Total		P
	Contact lens		Glasses		None				
	n	%	*n*	%	*n*	%	*n*	%	
<1 hr	3	5.77	26	50.00	23	44.23	52	18.37	<0.0001
1–2 hrs	7	5.11	79	57.66	51	37.23	137	48.41	
3–4 hrs	14	25.45	30	54.55	11	20.00	55	19.43	
4–6 hrs	0	0.00	11	50.00	11	50.00	22	7.77	
>6 hrs	0	0.00	13	76.47	4	23.53	17	6.01	
Total	24	8.48	159	56.18	100	35.34	283	100.00	
	Do you use antirefractive coating glasses?				Total				*P*
	Yes		No						
	n	%	*n*	%	*n*	%			
<1 hr	19	36.54	33	63.46	52	18.37			0.472
1–2 hrs	70	51.09	67	48.91	137	48.41			
3–4 hrs	25	45.45	30	54.55	55	19.43			
4–6 hrs	9	40.91	13	59.09	22	7.77			
>6 hrs	8	47.06	9	52.94	17	6.01			
Total	131	46.29	152	53.71	283	100.00			

by Hassan *et al*. who reported a prevalence of 90.5% among medical students in Pakistan and Reddy *et al*. who had a prevalence of 89.9% among university students in Malaysia.[3,10]

In our study, the male gender 54.06% (153) was observed to have a higher risk of CVS ($P < 0.0001$). This is in accordance with the study conducted by Logaraj *et al*. in Chennai where 52.5% of the study population were males.[4]

The most frequently reported ocular symptoms in our study population were eye strain (49% (139)), headache (37% (105)), and fatigue (32% (91)). Sen and Richardson reported headache in 61% of participants among undergraduates. The burning sensation was reported in higher frequency compared with our study in 33% of medical and dental students, 54.8% of university students, and 32.3% of medical students.[4,9,12] Blurred vision and dry eye each were reported by 21% (60) of participants. A higher frequency of dry eye disease was observed by Hassan *et al*.[3] in 49.2% of medical students. Among the 49% of study population that reported extraocular symptoms, the most frequently reported were joint pain in the finger and wrists (20% (57)), difficulty to write (13% (36)), shoulder pain (11% (31)), and inability to hold objects well (6% (16)). It was in accordance with study conducted by Noreen *et al*.[9] who also had a higher frequency of ocular symptoms than headache, and neck, shoulder, or back pain (12%) in medical and dental students.

It is widely stated that uncorrected refractive errors including myopia, hyperopia, and astigmatism contribute to the symptoms of CVS, which was shown in our study. Similar findings were obtained in a study conducted by Iqbal *et al*.,[10] which demonstrated that ametropia was an important risk factor for various complaints, including headache, blurring of vision, dry eye disease (DED), and refocusing difficulties ($P = 0.007$, 0.003, 0.002, and 0.001, respectively).

A similar association was also found with the use of spectacles and/or contact lens. It was observed in a study from Chennai that students using corrective lens either spectacle or contact lens (n = 176) showed a higher risk of developing headache (OR = 1.8, 95% CI = 1.2–2.6, $P < 0.01$) and blurred vision (OR = 2.1, 95% CI = 1.4–3.4, $P < 0.001$), which was statistically significant.[4]

The duration of studying using video display terminals was the most significant risk factor, in which the longer the time spent, the more prevalent and extensive the symptoms. There was a significant increase in digital screen time after the emergence of COVID-19 as earlier 66% of students spent <2 hrs

Table 4: Association of type of study material and digital device with the duration of screen time in pre-COVID-19 and COVID-19 period (*n*=283)

Pre-COVID-19 period	Duration					Total
	<1 hr	1–2 hrs	3–4 hrs	4–6 hrs	>6 hrs	
Mouse and keyboard	0	0	3	1	0	4
Note pen	5	9	0	6	0	20
Touchpad	3	8	4	0	4	19
Touchpad and note pen	0	4	0	0	0	4
Touch screen	31	59	40	13	4	147
Touch screen, mouse, and keyboard	0	3	1	0	9	13
Touch screen and touchpad	13	43	7	2	0	65
Touch screen, touchpad, and note pen	0	11	0	0	0	11
Total	52	137	55	22	17	283

In the COVID-19 period	The frequent computer digital screen you use				Total	*P*
	Android phone	iPhone	Laptop	Tablet or iPad		
<1 hr	7	6	3	9	25	
1–2 hrs	15	17	6	3	41	<0.0001
3–4 hrs	29	10	7	12	58	
4–6 hrs	47	35	11	3	96	
>6 hrs	9	33	16	5	63	
Total	107	101	43	32	283	

Duration	Study material						Total		*P*
	Book		Both		Screen				
	n	%	*n*	%	*n*	%	*n*	%	
<1 hr	15	60.00	4	16.00	6	24.00	25	8.83	<0.0001
1–2 hrs	9	21.95	23	56.10	9	21.95	41	14.49	
3–4 hrs	3	5.17	43	74.14	12	20.69	58	20.49	
4–6 hrs	1	1.04	67	69.79	28	29.17	96	33.92	
>6 hrs	4	6.35	49	77.78	10	15.87	63	22.26	
Total	32	11.31	186	65.72	65	22.97	283	100.00	

a day as compared to 56% of students who spent >4 hrs per day in post-COVID-19 times. This finding is consistent with the findings of a report by the AOA and also supported by studies conducted by Noreen *et al*. and Logaraj *et al*.[3,4,9]

The majority of the participants were using digital devices during the day time with the illumination from the device being more than the surrounding illumination, both factors having a strong association with CVS. In our study, the majority of the study population used the device intermittently. This was consistent with the findings of Cacodcar *et al*. where only 21 (19.4%) of the 108 students viewed the devices continuously, while the majority, that is, 87 (80.6%), used digital devices intermittently.[16]

About one-third of our study population were aware of the 20-20-20 rule, which is practiced to reduce CVS symptoms, but only 11% (31) followed it during any period of time. Similar findings were reported by Mohammed *et al*.[17] A study conducted on medical students in Paraguay showed that taking breaks when using electronic equipment at least every 20 min reduces the prevalence of CVS by 7% (PR = 0.93; 95% CI: 0.87–0.99).[18] Thus, the implementation of short, frequent breaks was found to enhance working efficiency, adequately compensating for time spent away from the screen.

Conclusion

CVS is very common among undergraduate medical students, with eye strain, headache, and fatigue being the most common ocular symptoms, while extraocular symptoms included joint pain in the fingers and wrist, difficulty to write, and shoulder pain. A significant association of CVS was observed with refractive error, longer duration of computer use, higher brightness of the screen, type of digital device used, and preexisting dry eye disease. The most significant preventive measures, which can be taken by students, are following the 20-20-20 rule and using adequate brightness of the screen compared with the surrounding area.

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Table 5: Association between duration of screen time and awareness about digital screen practices and its prevention (*n*=283)

Duration	Do you feel that digital screen affects your lifestyle and eye health				Total	
	Yes		No			
	n	%	*n*	%	*n*	%
<1 hr	24	46.15	28	53.85	52	18.37
1–2 hrs	85	62.04	52	37.96	137	48.41
3–4 hrs	45	81.82	10	18.18	55	19.43
4–6 hrs	17	77.27	5	22.73	22	7.77
>6 hrs	13	76.47	4	23.53	17	6.01
Total	184	65.02	99	34.98	283	100.00
	Are you aware of the 20-20-20 rule?				Total	
	Yes		No			
	n	%	*n*	%	*n*	%
<1 hr	5	9.62	47	90.38	52	18.37
1–2 hrs	57	41.61	80	58.39	137	48.41
3–4 hrs	22	40.00	33	60.00	55	19.43
4–6 hrs	6	27.27	16	72.73	22	7.77
>6 hrs	13	76.47	4	23.53	17	6.01
Total	103	36.40	180	63.60	283	100.00
	Do you follow the 20-20-20 rule?				Total	
	Yes		No			
	n	%	*n*	%	*n*	%
<1 hr	0	0.00	52	100.00	52	18.37
1–2 hrs	12	8.76	125	91.24	137	48.41
3–4 hrs	10	18.18	45	81.82	55	19.43
4–6 hrs	5	22.73	17	77.27	22	7.77
>6 hrs	4	23.53	13	76.47	17	6.01
Total	31	10.95	252	89.05	283	100.00
	Are willing to decrease your screen hours to guard against computer vision syndrome (CVS)				Total	
	Yes		No			
	n	%	*n*	%	*n*	%
<1 hr	41	78.85	11	21.15	52	18.37
1–2 hrs	99	72.26	38	27.74	137	48.41
3–4 hrs	38	69.09	17	30.91	55	19.43
4–6 hrs	18	81.82	4	18.18	22	7.77
>6 hrs	17	100.00	0	0.00	17	6.01
Total	213	75.27	70	24.73	283	100.00

from: https://www.aoa.org/healthy-eyes/eye-&-vision-conditions/computer-vision-syndrome?sso=y.

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