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ORIGINAL PAPER

The impact of the COVID-19 pandemic on the prevalence of computer vision syndrome among medical students in Riyadh, Saudi Arabia

Abdullah N. Almousa · Munirah Z. Aldofyan · Bushra A. Kokandi · Haneen E. Alsubki · Rawan S. Alqahtani · Priscilla Gikandi · Shatha G. Alghaihb

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Abstract

Purpose To estimate the prevalence of computer vision syndrome (CVS) among university medical students in Riyadh, Saudi Arabia, after establishing remote learning during COVID-19 pandemic and to compare settings of electronic device usage and patterns of CVS protective measures applied by students before and during this pandemic.

Methods This is an observational descriptive cross-sectional study which included 1st to 5th year medical students who were actively enrolled at the governmental colleges of medicine in Riyadh, Saudi Arabia, during the COVID-19 lockdown. The sample size was estimated to be 287 medical students. Participants were asked to volunteer and fill an electronic online questionnaire.

Results A total of 300 medical students were included in this study. 94.0% reported at least one symptom of CVS, while 67% reported having more than three symptoms. The most frequently reported symptoms were musculoskeletal pain (84.3%), headache (71.1%) and dry eyes (68%). Thirty-eight percent of the students experienced more severe symptoms, while 48% experienced more frequent symptoms during the COVID-19 pandemic. Risk factors for having three or more symptoms were being a female ($p < 0.001$) and using electronic devices for longer periods (6.8 h ± 2.8) during COVID-19 lockdown ($p < 0.001$).

Conclusion CVS prevalence during COVID-19 era among medical students is high. This necessitates increasing the awareness of CVS and its preventive measures.

Keywords Computer vision syndrome · Electronic devices · Medical students · COVID-19

A. N. Almousa (✉) · P. Gikandi
Ophthalmology Department, College of Medicine, King Saud University, P.O. BOX 245, Riyadh 11411, Saudi Arabia
e-mail: anmousa@ksu.edu.sa

P. Gikandi
e-mail: pgikandi.c@ksu.edu.sa

M. Z. Aldofyan · B. A. Kokandi · H. E. Alsubki · R. S. Alqahtani · S. G. Alghaihb
College of Medicine, King Saud University, Riyadh, Saudi Arabia
e-mail: Munirah.Aldofyan@gmail.com

B. A. Kokandi
e-mail: Bushrakokandi@gmail.com

H. E. Alsubki
e-mail: haneen.alsubki@gmail.com

R. S. Alqahtani
e-mail: ra1.s.alqahtani@gmail.com

S. G. Alghaihb
e-mail: shathamed436@gmail.com

Introduction

Nowadays, looking at electronic screens has become an inseparable part of our lives. This was more

exaggerated ever since the beginning of the coronavirus disease of 2019 (COVID-19) Pandemic. In March 2020, The Saudi government announced a lockdown; thus, the Ministry of Education directed all universities to shift teaching to remote learning [1].

Extended hours of studying and spending leisure time on electronic screens may lead to increased prevalence of computer vision syndrome (CVS) which is known as digital eye strain. It is defined by the American Optometric Association as "a group of eye-and vision-related problems that result from prolonged computer, tablet, e-reader and cell phone use" [2]. The most common manifestations of CVS are eye strain, headache, blurred vision, dry eyes as well as neck and shoulder pain. Additionally, poor lighting, glaring at digital screens, improper viewing distances and poor sitting posture may exacerbate and worsen these symptoms.

A study published from Al-Majmaah University, Saudi Arabia, prior to the pandemic concluded that the prevalence of visual symptoms related to computer use was 54.8% among university students [3]. Another study conducted in Nepal has estimated the prevalence of CVS in medical students to be 71.6% [4]. Furthermore, a study in Chennai, India, found that 78.6% of medical students had CVS [5]. During the COVID-19 pandemic, few studies assessed the prevalence of CVS among students. Two studies conducted in India and one in Pakistan showed a high prevalence of CVS with 88%, 93.6% and 98.7% of their participants, respectively, had at least one eye symptom [6–8].

In our study, we aim to estimate the prevalence of CVS among university medical students in Riyadh, Saudi Arabia, after establishing remote learning during COVID-19 pandemic. We also compared settings of electronic devices used and patterns of CVS protective measures applied by the students before and during COVID-19 pandemic. The symptoms severity and frequency were reported.

Methods

Inclusion and exclusion criteria

This is an observational descriptive questionnaire-based cross-sectional study. The participants were 1st to 5th year male and female medical students of any age. All students were actively enrolled in remote learning at one of the governmental colleges of medicine in Riyadh: King Saud University (KSU), King Saud Bin Abdulaziz University for Health Sciences (KSAUHS), Imam Mohammad Ibn Saud Islamic University (IMSIU) and Princess Nourah Bint Abdulrahman University (PNU).

Exclusion criteria included students with known ocular pathology like glaucoma, strabismus, severe trauma, undergone refractive surgery for vision correction within the last 6 months or other ocular or eyelid surgeries that may affect the ocular surface health. Also, students with underlying systemic illness like hypertension, diabetes, autoimmune disorders or using medications that have known visual side effects like (isotretinoin, bisphosphonates, cyclosporine, tetracyclines, hydroxychloroquine, anti-tuberculosis and anticholinergics) and those who apply topical eye drops other than artificial tears (corticosteroids, antibiotics, antivirals, glaucoma medications, anesthetics or mydriatics) were excluded from the study.

All procedures performed in the study involving human participants were in accordance with the ethical standards of the Institutional Review Board (IRB) of the College of Medicine, King Saud University (approval No. E-21-5842) and in accordance with the 1964 Declaration of Helsinki.

Sample size estimation

The sample size of the study was estimated based on the average prevalence of computer vision syndrome among medical students (75.1%) [4, 5], with a precision of ±5%, and 95% confidence interval. The minimal sample size required was calculated to be 287 participants. However, considering an additional 20% participants to have an adequate sample size and to enhance the generalizability of the results, the final sample size was estimated to be 345 participants.

Data collection tool

The data of the study were collected through a questionnaire which was adapted from two validated questionnaires of previously published papers [9, 10]. The final questionnaire consisted of 3 sections: first section collected demographic and basic information such as gender, age, use of medications that might affect vision and any ocular diseases [9]. The

second section assessed the awareness, frequency (never, occasionally, often, always) and severity (no symptoms, mild, moderate, severe) of eye symptoms such as headache, burning eye sensation, eye dryness and musculoskeletal pain before and during COVID-19 pandemic [10].

However, the last section inquired about the patterns of CVS protective measures applied and settings of electronic devices used for studying before and during COVID-19 pandemic. Therefore, we have asked the participants to answer questions regarding the pre-pandemic times, and the same questions regarding the last 3 months during the pandemic. Those questions were about the time spent on electronic devices, total hours of studying per day, taking breaks, screen location during studying, screen brightness and room illumination [10].

The developed questionnaire was then reviewed by two senior faculty members, an ophthalmologist consultant and a public health faculty member. They have reviewed the questions accuracy and arranged them in a sequential manner.

A pilot study was conducted on 15 students to assess their understanding and the time needed to complete the questionnaire. No language or understanding difficulties were noted, the average time needed to complete the survey was five minutes.

Data collection

Data collection was carried out in the period from April to May 2021 through an electronic self-administered questionnaire distributed to medical students through the medical students' council of every college and social media platforms.

An online informed consent form appeared on the first page of the electronic questionnaire; the informed consent was obtained from all individual participants included in the study. The participants had a clear explanation of the benefits of their participation and any potential risks. The participation in the study was completely voluntary and the participants had the right not to complete the study at any time. Confidentiality and privacy of each participant have been assured. The participants' details have been completely anonymous, and they have been used for data analysis only.

Statistical analysis

Data were collected, managed and coded in a spreadsheet using Microsoft Excel 2010® software and they were analyzed using SPSS® version 21.0 (*IBM* Inc., Chicago, Illinois, USA).

Descriptive analysis was done, where categorical variables were presented in the form of frequencies and percentages. Data exploration using Shapiro–Wilk test was done for the continuous variables where the data were found to be normally distributed. Mean ± SD [Range] was reported, otherwise median (interquartile range) (IQR) was reported. Independent *t* test and paired samples *t* test were used for comparisons between two groups for the continuous variables and Chi-squared test for comparing proportions among the studied groups. Any output with a *p* below 0.05 was interpreted as an indicator of statistical significance.

Results

A total of 300 respondents out of 375 medical students were included in this study. Seventy-five responses were excluded after applying the exclusion criteria. The majority of respondents were females, (58.6%). (Table 1). When assessing the awareness of CVS, 76.3% of our participants never heard of the syndrome. Ninety-four percent of the participants reported at least one symptom of CVS, while 67% of them reported more than three CVS symptoms. The most frequently reported symptoms in our study were musculoskeletal: neck, shoulder and back pain (84.3%), headache (71.1%) and dry eyes (68%). (Fig. 1).

The risk factors for experiencing three or more symptoms of CVS were more prevalent among females (p value < 0.001) OR 3.29 [2.00–5.43] 95% CI and students who used electronic devices for longer periods (6.8 h ± 2.8) during COVID-19 (p value < 0.001) OR 1.21 [1.09–1.35] 95% CI. Refractive errors: myopia, hyperopia and astigmatism were all non-significant factors to have more CVS symptoms (Table 2).

Our study explored the frequency and severity of CVS symptoms among study participants. During the COVID-19 pandemic, symptoms were reported to be more severe and more frequent by 38% and

Table 1 Demographic data

Characteristic	*n* (%)
Age in years, mean ± SD [Range], median (IQR)	21.5 ± 1.9 (18–29), 21 (20–33)
Gender	
Male	124 (41.3)
Female	176 (58.7)
Ocular diseases	
Nearsightedness (myopia)	111 (37.0)
Astigmatism	41 (13.7)
Farsightedness (hyperopia)	22 (7.3)
Vision corrective surgery within the last 6 months; like LASIK	1 (0.3)
None	164 (54.7)
Artificial tears use	
Yes	132 (44)
Corrective lens use	
Yes	161 (53.7)
Type of corrective lens ($n = 161$)	
Eye glasses	151 (93.8)
Contact lens	10 (6.2)

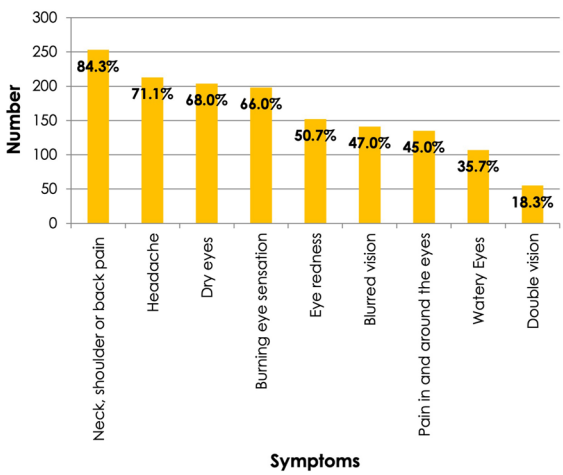

Fig. 1 The most frequently reported symptoms

48.3% of students, respectively, as compared to pre-pandemic levels (Table 3). Medical students, who reported longer duration of use, experienced more severe and frequent symptoms (p value < 0.001)

Table 2 Risk factors of having more than 3 symptoms

Risk factor	≤ 3 symptoms ($n = 99$) n (%)	> 3 symptoms ($n = 201$) n (%)	*P* value
Gender			
Male ($n = 124$)	60 (48.4)	64 (51.6)	< 0.001*
Female ($n = 176$)	39 (22.2)	137 (77.8)	
Myopia			
Yes ($n = 111$)	35 (31.5)	76 (68.5)	0.678
No ($n = 189$)	64 (33.9)	125 (66.1)	
Hyperopia			
Yes ($n = 22$)	6 (27.3)	16 (72.7)	0.553
No ($n = 278$)	93 (33.5)	185 (66.5)	
Astigmatism			
Yes ($n = 41$)	11 (26.8)	30 (73.2)	0.366
No ($n = 259$)	88 (34.0)	171 (66.0)	
Use of corrective lens			
Yes ($n = 161$)	50 (31.1)	111 (68.9)	0.441
No ($n = 139$)	49(35.3)	90 (64.7)	
Duration of device use in hours pre-COVID-19 Mean ± SD	4.9 ± 2.0	5.3 ± 2.1	0.164
Duration of device use in hours during COVID-19 Mean ± SD	5.6 ± 2.3	6.8 ± 2.8	< 0.001*
P value	0.023*	< 0.001*	

*Statistically significant at 5% level of significance

(Table 4). On the other hand, the association between taking breaks and severity and frequency of symptoms was not statistically significant.

In comparing the settings of electronic device usage before and during COVID-19 pandemic, one quarter (26%) of the respondents reported spending 8 h or more on electronic devices pre-COVID-19. During the pandemic, the percentage increased up to 56.7% (p value < 0.001). Also, the average of total studying hours on devices was 5.1 h pre-COVID-19 had increased to 6.4 h during the pandemic (p value < 0.001). The preferred monitor brightness and room illumination variance before and during the pandemic was not statistically significant (Table 5).

Minute differences were found in application of CVS protective measures before and during COVID-19 pandemic with no statistical significance as shown in Table 6.

Table 3 Frequency and severity of eye symptoms

Question	*n* (%)
How often do you experience these symptoms during/after the use of electronic devices, in the last 3 months?	
Always (symptoms occurring almost everyday)	26 (8.7)
Often (symptoms occurring 2–3 times a week)	94 (31.3)
Occasionally (symptoms in occurring sporadic episodes or once a week)	141 (47.0)
Never	39 (13.0)
In comparison with pre-COVID-19 era, have you noticed the symptoms listed above becoming more severe during COVID-19 pandemic than before?	
They became more severe	115 (38.3)
No change in severity	168 (56.0)
They became less severe	17 (5.7)
In comparison with pre-COVID-19 era, have you noticed the symptoms listed above becoming more frequent during COVID-19 pandemic than before?	
They became more frequent	145 (48.3)
No change in frequency	147 (49.0)
They became less frequent	8 (2.7)

Table 4 Association between severity and frequency of symptoms and duration of device use

	More severe ($n=115$)	Remains same or less severe ($n=185$)	*P* value
Duration of device use in hours pre-COVID-19 Mean ± SD	5.4 ± 1.8	5.0 ± 2.2	0.055
Duration of device use in hours during COVID-19 Mean ± SD	7.5 ± 2.8	5.8 ± 2.5	**< 0.001***
P value	< 0.001*	0.001*	
	More frequent ($n=145$)	Remains same or less frequent ($n=155$)	
Duration of device use in hours pre-COVID-19 Mean ± SD	5.3 ± 1.9	4.9 ± 2.2	0.094
Duration of device use in hours during COVID-19 Mean ± SD	7.1 ± 2.8	5.9 ± 2.4	**< 0.001***
P value	< 0.001*	< 0.001*	

*Statistically significant at 5% level of significance

Discussion

The Ministry of Education of Saudi Arabia directed the universities and schools to shift to remote learning, so students can attend all their classes from home via electronic platforms like blackboard, ZOOM and Microsoft Teams to ensure their safety and health. But the continuation of E-learning during the COVID-19 era has some drawbacks.

High prevalence of CVS was observed. In our study, 282 students reported at least one symptom (94%). This is consistent with the prevalence reported during COVID-19 pandemic in Pakistan (98.7%) and India (88%). [6, 7] This was also similar to the prevalence in Jeddah, Saudi Arabia, before the pandemic (97.3%) [11]. However, in the previous study, there was no exclusion of students with ocular or systemic illness or to those applying medications with known visual side effects. However, in our study, all those confounders were eliminated.

Moreover, 67% of our participants reported having more than three symptoms of CVS. To the best of our knowledge, no previous study has calculated the prevalence based on having more than three symptoms.

Table 5 Settings of electronic device usage before and during COVID-19 pandemic

Variable	Group	Pre-COVID-19 n (%)	During COVID-19 n (%)	*P* value
In general, how many hours do you spend on electronic devices a day?	Less than 2 Hours	6 (2.0)	3 (1.0)	0.314
	2 < 4 Hours	21 (7.0)	2 (0.7)	< 0.001*
	4 to < 6 Hours	96 (32.0)	24 (8.0)	< 0.001*
	6 to < 8 Hours	99 (33.0)	101 (33.7)	0.856
	8 h or more	78 (26.0)	170 (56.7)	< **0.001***
	On average, total hours of studying hours per day, mean ± SD [range], median (IQR)	5.1 ± 2.1 (1–15), 5 (4–6)	6.4 ± 2.7 (1–20), 6 (5–8)	< **0.001***
Which of the following is the most device you use?	Desktop	18 (6.0)	21 (7.0)	0.620
	Laptop	41 (13.7)	55 (18.3)	0.125
	iPad/tablets	137 (45.7)	155 (51.7)	0.142
	Smartphone	104 (34.7)	69 (23.0)	**0.002***
What is your preferred monitor brightness?	High brightness	39 (13.0)	35 (11.7)	0.629
	Moderate brightness	159 (53.0)	165 (55.0)	0.623
	Low brightness	102 (34.0)	100 (33.3)	0.856
How well illuminated is the room during your usage of electronic devices?	Highly illuminated	58 (19.3)	61 (20.3)	0.759
	Moderately illuminated	161 (53.7)	157 (52.3)	0.731
	Slightly illuminated	81 (27.0)	82 (27.3)	0.934

*Statistically significant at 5% level of significance

We believe this percentage might be more precise to estimate the prevalence of CVS syndrome.

In the current study, the most reported symptoms were neck, shoulder and back pain, headache and dry eyes, which is similar to what was reported in a previous study before the pandemic among business and medical college students in Riyadh, Saudi Arabia [10], but with a higher percentage in our study, it could be explained by the increase in duration of electronic devices usage during COVID-19 pandemic.

In our study, being a female increased the risk of having three or more symptoms with a statistical significance. It is matching with what was reported in multiple studies done in Majmaah and Jeddah between 2018 and 2020 [3, 9, 11]. This could be attributed to the higher prevalence of dry eyes, cosmetics use among females [12] and to the gender difference in response to pain [13].

The relation between refractive errors and developing CVS has conflicting results in the literature. In our study, we found that having refractive errors as myopia, hyperopia or astigmatism is not a risk factor for having more than three symptoms of CVS. This is almost similar to a national study conducted in Jeddah which found that myopia and hyperopia were not associated with CVS, but astigmatism showed significant association with more symptoms [9]. In contrast, in another national study in Al-Qassim region, there was a significant relation between myopia and CVS, especially those corrected with contact lenses reported more severe symptoms [14]. On the international level, a systematic review concluded that those who have refractive errors are at a higher risk to develop CVS or suffer from more severe symptoms of CVS [15]. Moreover, a study conducted in Nepal found that students who have myopia corrected with glasses are at higher risk to develop CVS. However, the study did not find a statistically significant difference between students who had high myopia and those who had low and moderate myopia in regard to developing CVS [16]. Differences might be due to sample size variation, or the variable use of corrective lenses while using electronic devices among the study populations.

Along with the increased dependence on online education during the pandemic, safe habits in digital device use have been recommended especially in regard to the duration of device usage as we found it to be one of the most statistically significant factors in our study. We found out that students who used electronic devices for longer durations during COVID-19 (6.8 h ± 2.8) reported 3 or more

Table 6 Pattern of CVS protective measures before and during COVID-19 pandemic

Phrase	Groups	Pre-COVID-19		During COVID-19		*P* value
		N	%	N	%	
You take short breaks every 20 min for 20 s and looking at objects that are at least 20 feet away (20–20-20 rule)	Always	5	(1.7)	9	(3.0)	0.294
	Usually	19	(6.3)	20	(6.7)	0.843
	Sometimes	51	(17.0)	42	(14.0)	0.310
	Rarely	76	(25.3)	78	(26.0)	0.845
	Never	149	(49.7)	151	(50.3)	0.883
You locate the screen to be 20–28 inches from the eyes (more than arm & forearm length)	Always	18	(6.0)	20	(6.7)	0.725
	Usually	31	(10.3)	36	(12.0)	0.509
	Sometimes	63	(21.0)	57	(19.0)	0.541
	Rarely	87	(29.0)	88	(29.3)	0.936
	Never	101	(33.7)	99	(33.0)	0.856
You locate the screen to be at the level of your face	Always	40	(13.3)	38	(12.7)	0.827
	Usually	51	(17.0)	61	(20.3)	0.300
	Sometimes	84	(28.0)	85	(28.3)	0.935
	Rarely	67	(22.3)	58	(19.3)	0.366
	Never	58	(19.3)	58	(19.3)	0.998
While using electronic devices, your seating position is up right with a straight back	Always	16	(5.3)	18	(6.0)	0.711
	Usually	53	(17.7)	57	(19.0)	0.681
	Sometimes	95	(31.7)	98	(32.7)	0.793
	Rarely	92	(30.7)	90	(30.0)	0.852
	Never	44	(14.7)	37	(12.3)	0.390
While using electronic devices, you use your corrective lens (contact lenses/ glasses)?	Always	82	(27.3)	87	(29.0)	0.644
	Usually	30	(10.0)	31	(10.3)	0.903
	Sometimes	29	(9.7)	30	(10.0)	0.902
	Rarely	27	(9.0)	21	(7.0)	0.367
	Never	132	(44.0)	131	(43.7)	0.941

symptoms of CVS with p value (<0.001). The percentage of our respondents who reported spending 8 h or more using electronic devices increased significantly from only 26% pre-COVID-19 to 56.7% during the pandemic (p value <0.001). Also, the average total studying hours increased from a mean of 5.1 h reported pre-pandemic to a mean of 6.4 h during this era with p value (<0.001).

The increase in symptoms due to longer device use is corresponding with previous studies that have reported participants experiencing more symptoms after using devices for more than six hours a day [17, 18].On the opposite side, one study reported that there is no association between the duration of usage of the device and the number of symptoms [11]. This could be explained by the fact that all previous studies relied on recalling subjective information rather than objective measurements of digital devices usage.

The patterns of CVS protective measures applied by our participants remained unchanged pre and during COVID-19. The majority of the study population were not following preventive measures such as using the 20–20–20 rule, locating the screen at 20–28 inch from your eyes, reducing hours of use, appropriate room illumination and monitor the brightness.

These results correlated with the poor level of awareness among our study participants. As 76.3% of our participants never heard of the syndrome. More awareness campaigns to educate the population about CVS protective measures and the proper use of electronic devices are needed.

Recommendations and limitations

- Our study highlights a high prevalence of CVS among medical students which was expected due to the COVID-19 pandemic lockdown and shifting to online education. Therefore, we encourage future researchers to perform larger community-based studies as there is an expected increase in digitalization for educational and recreational purposes as well.
- In our study, we addressed the pre-pandemic data by asking the participants to recall their experience prior to the pandemic in regard to frequency and severity of CVS symptoms. In addition, they were also asked to recall information about the sittings of electronic devices usage and pattern of CVS protective measures application in the 3-month period prior to the study. We believe this method may affect the accuracy and reliability of the results due to recall bias. Therefore, we encourage future researchers to follow more objective ways for assessment.
- We encourage future researchers to address any chronic musculoskeletal pain or primary headache to eliminate them as they work as confounders.

Conclusion

A high prevalence of CVS symptoms during COVID-19 pandemic was reported. The most commonly reported symptoms were musculoskeletal pain, headache and dry eyes. Risk factors for having three or more symptoms were being a female and using electronic devices for more than 6.8 h. The increased duration of electronic device usage during COVID-19 pandemic was associated with more frequent and severe CVS symptoms. The percentage of students spending 8 h or more on electronic devices doubled during the pandemic. Our study results reflected the need to increase the awareness of CVS and its protective measures through introducing the subject in university's curriculum and frequent awareness campaigns.

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Declarations

Conflict of interest All authors declare that they have no conflict of interest.

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