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Impact of adherence to American Optometric Association guidelines on computer vision syndrome and dry eye

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Background: Prolonged digital device use among university students has been linked to computer vision syndrome (CVS) and dry eye disease (DED).

Aim: This study aimed to assess adherence to the American Optometric Association (AOA) guidelines and its impact on CVS and DED among male university students.

Setting: The study was conducted at Qassim University.

Methods: This cross-sectional study involved 290 male students. Data were collected through validated questionnaires assessing symptoms of CVS and DED, along with self-reported adherence to AOA ergonomic guidelines. A statistical analysis was used to correlate ergonomic practices.

Results: The study found high frequency of CVS (80.34%) and DED (68.28%) among participants. Eye irritation, headache, burning in the eye and tearing were the common reported symptoms of CVS, with a frequency of 43.35%, 41.20%, 36.10% and 35.62%, respectively. Significant reductions in CVS symptoms were noted among students who maintained at least 50 cm screen distance (P = 0.047) and those taking regular breaks (P = 0.000), highlighting the effectiveness of these ergonomic interventions. However, there was no significant reduction in DED symptoms among students who followed the recommended guidelines.

Conclusion: The high frequency of CVS and DED among students underscores the need for increased awareness and implementation of ergonomic practices. Thus, public health initiatives must enhance ergonomic education to improve student ocular health in digital environments.

Contribution: The study showed high frequency of CVS and DED among university students. Significant reductions in CVS symptoms were noted among students who maintained at least 50 cm of screen distance and those taking regular breaks.

Keywords: computer vision syndrome; dry eye diseases; American Optometric Association; students; symptom; quality of life.

Introduction

Computers and digital devices have developed and enriched education and healthcare systems, and have improved our quality of life.[1] Despite the enormous benefits of technology in our lives, there is evidence that excessive exposure to digital devices has health effects.[1,2] The impact of these digital devices can either be mental or physical and can eventually lead to depression, eye strain, headaches, hearing loss, neck and back strains, childhood obesity and language pathology in young children.[1,2,3,4,5,6]

Prolonged digital device use has been linked to the dry eye disease (DED). The DED is a condition that arises from an imbalance in the tear film, either from a lack of tears or excessive evaporation.[7] Additionally, individuals with DED often experience a reduced quality of life, particularly when performing near-vision tasks or working on video terminals, which can impose restrictions on their daily activities and living environment.[8] The condition causes discomfort and damage to the surface of the eye, particularly in the area between the eyelids. A recent systematic review and meta-analysis estimated the global prevalence of DED to be approximately 11.59%.[9]

Computer vision syndrome (CVS), the main concern for excessive computer prolonged use, has been heavily investigated in the past two decades.[10,11] Patients usually attend eye clinics with symptoms including eyestrain, tired eyes, irritation, redness, blurred vision and double vision.[6,12,13] Upon examination, CVS symptoms are usually accompanied by dry eye.[14,15] Excessive exposure to digital screens alters blinking dynamics, reducing it from an average blink of 17 times/min to as low as 12 blinks/min, contributing to dry eye development.[16,17] Computer vision syndrome can affect anyone working 3 h or more a day on computers. It is estimated that around 70% of office workers globally are at risk of developing CVS.[18] This number will likely increase as more jobs become dependent on computers and networks in the future.

Previous studies have shown that routine use of computers and smart devices strongly correlates with CVS symptoms. Among 100 medical students in Nepal, 74% who spent 2 or more hours on their daily digital screens complained of one or more CVS symptoms. Eye strain and burning eyes were the symptoms of CVS reported most by the participants in that study.[19] Another study on medical students at Ajman University, United Arab Emirates, found that 72% of students reported frequent interruptions while studying from computers because of CVS symptoms.[20] Among 200 computer professionals, a study in India revealed that 67% reported ocular discomfort while working on computers.[12] Professional work on computers for more than 4 h was associated with ocular discomfort, musculoskeletal disorder and stress.[21]

The American Optometric Association (AOA) highlights the importance of environmental and personal adjustments in preventing CVS, focussing on the ergonomic setup and viewing habits.[22] The optimal positioning of the computer screen is critical; it should be placed 15 to 20 degrees below eye level, about 4 or 5 inches from the centre, and 20 to 28 inches from the eyes, allowing for a comfortable downward gaze.[23] A key aspect of these recommendations is ensuring proper lighting within the workplace. The workspace must be illuminated with soft, indirect light to minimise stark contrasts and shadows that could lead to eye strain. To minimise glare, the screen should avoid direct exposure to overhead lighting and windows, and use screen glare filters to reduce light reflection from the screen.[22,23] Additionally, the AOA also recommends adhering to the 20-20-20 rule, taking a 20-s break to look at an object 20 feet away every 20 min to counteract the effects of prolonged screen time.[10]

The purpose of this research was to investigate whether students adhere to the AOA recommendations as routine practices during computer use and to analyse the relationship between not following these guidelines and the occurrence of CVS symptoms and dry eye.

Research methods and design

Study design

This cross-sectional study of 290 college students was conducted at Qassim University, Saudi Arabia, between January 2023 and May 2023.

Inclusion and exclusion criteria

The inclusion criteria for the study were as follows: (1) male students in the third academic year and above; (2) emmetropes or participants with visual acuity of 0.1 logMar monocularly and binocularly with spectacle correction; and (3) no strabismus or history of strabismus surgery. The study, however, excluded the following: (1) refractive error that could not be fully corrected; (2) history of refractive surgery or any ocular surgeries; (3) any ocular disease that is known to affect vision; (4) medications that are known to cause dry eye; and (5) history of migraine and any muscular disorder.

Sample size

The present sample size was determined using the single population proportion formula (Equation 1):

$$N = \frac{Z^2 \times (\mathrm{P}) \times (1 - \mathrm{P})}{\mathrm{C}^2} \quad \text{[Eqn 1]}$$

With a confidence level of 95%, a value of Z statistic = 1.96, a proportional outcome assumed to be 77.6%[21] and a maximum acceptable sampling error of 5%, the resulting sample was 267, accounting for a 10% non-participation rate. Thus, the final estimated sample size was 294 participants.

Study protocol

Participants from the College of Computer Science and College of Applied Medical Sciences underwent a comprehensive eye examination to determine eligibility before enrolment, including: (1) detailed medical and ocular history, (2) objective and subjective refraction, (3) Simultaneous Prism Cover Test, and (4) slit-lamp examination.

Eligible participants completed two validated questionnaires, which were the Ocular Surface Disease Index (OSDI) and CVS. The OSDI questionnaire has been used in several studies to estimate the prevalence of DED. The questionnaire consists of three broad categories on a 5-point Likert scale: (1) ocular symptoms since the last 1 week prior to completing the questionnaire; (2) effects of ocular symptoms on daily activities in the last 1 week; and (3) effects of specific situations on eye comfort (windy conditions, low humidity and air conditioning). Participants had to choose one of five responses to each of these questions, extending from 'all of the time' to 'none of the time'. The scores of these responses range from 4 to 0, with a higher score indicating an increased frequency of the symptom. Once the questionnaire is completed, a total score can be computed by adding up the subtotal scores of the three categories. The total score is then assessed on a scale

between 0 and 100, with a higher final score indicating a more significant impact. On the other hand, participants were also asked to complete the CVS questionnaire, which was adopted from a recently published study among university students in Jeddah, Saudi Arabia.[19] The questionnaire included questions about CVS symptoms and digital screens' routine usage in addition to demographic data. Demographic data includes age, gender, participant's college and type of digital device routinely used. Computer vision syndrome symptoms included the presence and frequency of a burning sensation in the eye, sore and/or irritated eyes, foreign body sensation, epiphora, dry eyes, headaches, blurred near and distance vision, redness in the eyes and double vision. Additionally, risk factors related to ergonomics, including length of use of digital devices, utilising posture, presence and duration of breaks, lighting in the workplace, brightness of the screen and anti-reflection filter use, were included in the questionnaire.

The Arabic versions of the two questionnaires were previously used and validated.[22,23] Participants were provided with two Arabic questionnaires in an envelope to complete and return in the same envelope. Completed questionnaires were checked for any missing information to be excluded before transferring data to an Excel sheet for analysis.

Statistical analysis

To facilitate data analysis, the data were cleaned to incorporate the most relevant data to the objectives of this study. Therefore, five questions from the CVS questionnaire that correspond directly to the AOA's main guidelines on optimal routines and practices for computer use were chosen. These questions are initially formatted to elicit yes or no responses, with 'yes' indicating adherence (a positive response) and 'no' indicating non-adherence (a negative response). This setup enabled us to compute a total adherence score for each participant, reflecting the degree to which they follow recommended practices during computer use.

Furthermore, our analysis evaluated nine questions concerning the history of CVS symptoms experienced by participants during or after computer use. These questions are designed to be answered with a 'yes' for the presence of a symptom (a negative indicator) or a 'no' for its absence (a positive indicator). We counted the symptoms reported as 'yes' for each participant, allowing us to determine the prevalence of CVS symptoms across the study cohort.

To enhance the depth of our study, we analysed both the scores related to risk factors, indicative of adherence to preventive guidelines, and the CVS symptom scores for each participant. This detailed examination aimed to assess the impact of adhering to guidelines on the manifestation of CVS symptoms, as indicated by participants' answers (the aggregate score from the nine questions on CVS symptoms) alongside the total scores from the OSDI assessing dry eye conditions. By drawing correlations between adherence levels to the guidelines and both symptom and OSDI scores, our goal was to determine the efficacy of implementing the AOA's recommended practices in daily computer use for the mitigation or prevention of CVS and dry eye symptoms. The analysis was performed using Statistical Package for the Social Sciences (SPSS) software package version 25.0 (SPSS, Inc., Chicago, IL, United States), and descriptive statistics were used to assess risk factors and odds ratios (OR) for the development of CVS and DED. At the same time, MedCalc statistical software for Windows calculated the prevalence of CVS and DED.

Ethical considerations

The research protocol and informed consent for this study were approved by the Institutional Review, and ethical approval was obtained from the Committee of Health Research Ethics, Deanship of Scientific Research, Qassim University (reference no.: 23-60-10). This research was conducted in accordance with the Code of Ethics of the World Medical Association, and all participants provided written informed consent before participation.

Results

Sociodemographic characteristics

A total of 294 students from the Qassim University were requested to participate in the study. Four incomplete surveys with missing essential data were excluded from the 294 questionnaires that were returned; thus, 290 completed questionnaires were included in final data analysis, giving a response rate of 98.6%. The study contained 165 (56.9%) students from the College of Computer Science and 125 (43.1%) students from the College of Applied Medical Sciences; their mean age was 22.28 ± 1.69 years, as shown in Table 1.

Behavioural and environmental features of electronic device users

More than half (54.50%) of the students reported spending most of their time on a used smartphone, while only 25.86% reported using a desktop. Regarding the daily hours usually spent on electronic devices, more than half (55.86%) of the students reported using electronic devices more than 6 h daily, and 41.72% used 3–6 h daily. Approximately two-thirds (61.72%) of the students used electronic devices for entertainment, while only 33.10% used them for study purposes. About 60% of the students reported keeping the screen of their electronic devices around 20 degrees below their eyes when performing near-sighted activities. More than half (59%) of the students said they kept approximately

TABLE 1: Sociodemographic characteristics of electronic device users (N = 290).

Variable	Category	Mean	s.d.	Min	Max	*n*	%
Age (years)	-	22.28	1.69	19.00	27.00	-	-
College	Computer Science	-	-	-	-	165	56.9
	Applied Medical Sciences	-	-	-	-	125	43.1

s.d., standard deviation; Min, minimum; Max, maximum.

50 cm between the screen and their eyes, while 41% reported not following this instruction. About 52.8% of the students reported taking frequent breaks while using the electronic device, whereas 47.2% said they did not. More than half (56.9%) of the students adjusted the screen's brightness according to the existing lighting; however, about 43.1% did not adjust the brightness. Most students (79%) reported not using an anti-glare filter for the electronic device screen, while only 21% said they were using anti-glare filter protection, as shown in Table 2.

The frequency of computer vision syndrome among electronic device users

In the present study, 80.34% (95% CI: 70.36, 91.35) of electronic device users self-reported having CVS. Eye irritation, headache, burning in the eye, blurred vision and tearing were the most common reported symptoms of CVS, with a frequency of 43.35%, 41.20%, 36.10% and 35.62%, respectively, as shown in Figure 1.

The frequency of dry eye diseases among electronic device users

In general, the frequency of DED according to the OSDI questionnaire finding was 68.28% (95% confidence interval [CI]: 59.10, 78.48) among electronic device users. Regarding the severity of DED, the OSDI score showed that the frequency of mild, moderate and severe DED among the students was 36.20%, 30.00% and 2.10%, respectively.

TABLE 2: The condition of the working environment and risk factors for computer vision syndrome among the participants.

Variables	*n*	%
Type of electronic devices		
Smartphone	158	54.50
Desktop	75	25.86
Laptop	32	11.03
Tablet	25	8.61
Number of hours spent on the electronic device per day		
> 6	162	55.86
3–6	121	41.72
< 3	7	2.41
The main purpose of using electronic device		
Entertainment	179	61.72
Study	96	33.10
Other	15	5.17
Keeping the screen around 20 degrees below your eyes		
Yes	174	60.00
No	116	40.00
Keeping 50 cm between the screen and your eyes		
Yes	171	59.00
No	119	41.00
Taking frequent breaks from your electronic device		
Yes	153	52.80
No	137	47.20
Adjusting electronic device brightness		
Yes	165	56.90
No	125	43.10
Using an anti-glare filter for electronic device screen		
Yes	61	21.00
No	229	79.00

Risk factors estimation and odds ratio for computer vision syndrome among electronic device users

The OR of developing CVS among students who used smartphones were 81.6% (OR 0.84, 95% CI: 0.47–1.50) higher than those who used desktops, laptops or tablets, which were 78.8%; the difference was not statistically significant (P = 0.542). Students who used electronic devices for more than 6 h and for 3–6 h per day were at some risk of developing CVS (OR: 1.03, 95% CI: 0.56–1.86), P = 0.575.

The OR of developing CVS among students who regularly kept 50 cm between the screen decreased by 15.8% (OR: 1.80, 95% CI: 1.00–3.22); the change was statistically significant (P = 0.047). Furthermore, the students who kept the screen around 20 degrees below their eyes were 16.7% less likely to develop CVS (P = 0.117). Interestingly, the OR of developing CVS among students who regularly took breaks from their electronic device decreased by 27.5% (OR: 0.33, 95% CI: 0.17–0.62). The decreases in the symptoms of CVS were highly significant (P = 0.000). Students who adjusted their electronic device brightness were 17.0% less likely to develop CVS, but the change was not statistically significant (P = 0.186). While the OR of developing CVS among students who used an anti-glare filter for the electronic device screen decreased by 16.4% (P = 0.471), as shown in Table 3.

Risk factors estimation and odds ratio for dry eye disease among electronic device users

Students who used smartphones had 69.6% higher OR of developing DED compared to those who used desktops, laptops or tablets (OR 0.87, 95% CI: 0.53–1.43), while the OR among the latter group were 66.7%. However, the difference was not statistically significant (P = 0.590). Students who used electronic devices for more than 6 h and for 3–6 h per day were at some risk of developing DED (OR: 1.16, 95% CI: 0.82–1.65), P = 0.395.

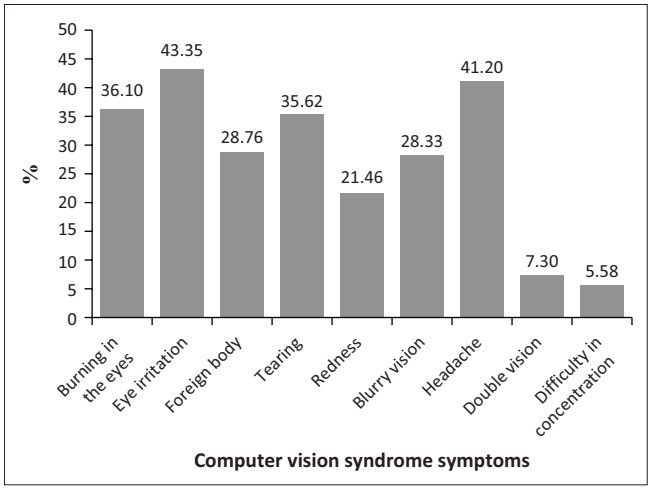

FIGURE 1: Percentage of computer vision syndrome symptoms among the students (N = 233).

The students who kept the screen around 20 degrees below their eyes were 33.9% less likely to develop DED; the change was not statistically significant (P = 0.328). While students who maintained a screen-to-eye distance of 50 cm had 32.2% lower OR of developing CVS (OR 0.95, 95% CI: 0.58–1.58) compared to those who did not (P = 0.847). Regular breaks from electronic devices reduced the OR of developing CVS in students by 30.1% (OR: 1.18, 95% CI: 0. 72–1.93), P = 0.521, as shown in Table 4.

Discussion

In the present study, a significant frequency of CVS and DED was observed among university students who use digital devices. The study demonstrated that adherence to ergonomic guidelines recommended by the AOA significantly mitigated symptoms of CVS and DED. These findings underscore the importance of ergonomic practices in preventing visual and ocular discomfort associated with prolonged digital device use.

Specific risk factors significantly affected the incidence of CVS and DED. The data highlighted that those students who kept a 50 cm distance between their eyes and the screen experienced a 15.8% decrease in the likelihood of developing CVS, with the association being statistically significant (P = 0.047). Similarly, students who regularly took breaks from their electronic devices showed a substantial 27.5% reduction in CVS symptoms, a relationship that was highly significant (P = 0.000). Similar correlations regarding the importance of ergonomic practices have been observed in recent studies, suggesting widespread incorrect ergonomic habits that contribute to these conditions.[24,25,26] These findings underscore the critical importance of adhering to ergonomic practices, such as maintaining an appropriate screen distance and integrating frequent breaks into prolonged usage sessions, to mitigate the risks associated with CVS and DED effectively.

The frequency of CVS and DED observed in the study is comparable to findings from various global studies, indicating a common trend among university students irrespective of geographic location. For example, the prevalence of CVS among engineering students in Chennai, reported by Logaraj et al.[27] at 81.9%, aligns closely with the 80.34% found in our study, suggesting similar patterns of digital device usage and related eye health impacts across different academic disciplines. Similarly, the recent studies conducted in Saudi Arabia by Almousa et al.[26] and Abdulrahman et al.[28] which reported a 60.8% and 67.0%, respectively, the prevalence of CVS among medical students in Riyadh city, although lower, still reflects substantial CVS issues within university environments, emphasising the widespread nature of this condition. Furthermore, Al Darrab et al.[24] reported a higher prevalence rate of 96.0% among college students in Saudi Arabia, further underscoring the variability yet comparability in CVS prevalence, highlighting shared risk factors and the pervasive impact of digital device usage on student eye health globally. These parallels suggest that the findings from (redacted for review) can be seen as part of a broader, global pattern of student eye health affected by digital device use.

Our study demonstrated that adherence to ergonomic guidelines recommended by the AOA significantly reduced symptoms of CVS. However, these practices did not significantly impact DED symptoms. The lack of impact on DED suggests the need for further investigation into additional or alternative strategies to reduce the effect of

TABLE 3: Risk factors estimation and odds ratio for computer vision syndrome among electronic device users.

Variables	CVS				
	Yes (%)	No (%)	OR	95% CI	*P*-value
Type of electronic devices					
Smartphone	81.6	18.4	0.84	0.47, 1.50	0.542
Desktop, Laptop or Tablet	78.8	21.2	-	-	-
Number of hours spent on the electronic device per day					
> 6	80.1	19.9	1.03	0.56, 1.86	0.575
3–6	80.6	19.4	-	-	-
Keeping the screen around 20 degrees below your eyes					
Yes	83.3	16.7	1.59	0.89, 2.85	0.117
No	75.9	24.1	-	-	-
Keeping 50 cm between the screen and your eyes					
Yes	84.2	15.8	1.80	1.00, 3.22	**0.047**
No	74.8	25.2	-	-	-
Taking frequent breaks from your electronic device					
Yes	72.5	27.5	0.33	0.17, 0.62	0.000
No	89.1	10.9	-	-	-
Adjusting electronic device brightness					
Yes	83.0	17.0	1.48	0.83, 2.64	0.186
No	76.8	23.2	-	-	-
Using anti-glare filter for electronic device screen					
Yes	83.6	16.4	1.32	0.62, 2.79	0.471
No	79.5	20.5	-	-	-

CI, confidence interval; OR, odds ratio; CVS, computer vision syndrome.

TABLE 4: Risk factors estimation and odds ratio for dry eye disease among electronic device users.

Variables	DED				
	Yes (%)	No (%)	OR	95% CI	*P*-value
Type of electronic devices					
Smartphone	69.6	30.4	0.87	0.53, 1.43	0.590
Desktop, Laptop or Tablet	66.7	33.3	-	-	-
Number of hours spent on the electronic device per day					
> 6	66.3	33.7	1.16	0.82, 1.65	0.395
3–6	71.0	29.0	-	-	-
Keeping the screen around 20 degrees below your eyes					
Yes	66.1	33.9	0.78	0.47, 1.92	0.328
No	71.6	28.4	-	-	-
Keeping 50 cm between the screen and your eyes					
Yes	67.8	32.2	0.95	0.58, 1.58	0.847
No	68.9	31.1	-	-	-
Taking frequent breaks from your electronic device					
Yes	69.9	30.1	1.18	0.72, 1.93	0.521
No	66.4	33.6	-	-	-
Adjusting electronic device brightness					
Yes	69.1	30.9	1.09	0.66, 1.80	0.732
No	67.2	32.8	-	-	-
Using an anti-glare filter for electronic device screen					
Yes	70.5	29.5	1.14	0.62, 2.11	0.676
No	67.7	32.3	-	-	-

CI, confidence interval; OR, odds ratio; DED, dry eye disease.

DED. However, the relatively high frequency of CVS and DED observed in this study and similar research conducted in Saudi Arabia suggests that awareness of these guidelines needs to be improved among students. This lack of awareness might be attributed to the limited role that public health initiatives currently play in the field of eye care. There is a crucial need for enhanced public health interventions and educational programmes to promote better ergonomic practices and eye care among students, particularly in settings heavily reliant on digital devices. This could mitigate the high rates of CVS and DED, improving students' overall health and academic performance.

A notable limitation of our study was the exclusion of female participants, which was because of the segregated academic settings in Saudi Arabia, where male and female students attend classes in separate buildings. This separation may limit the generalisability of our findings as it excludes potentially differing impacts of digital device use on female students. Another limitation was the focus solely on students from the main campus of Qassim University. This restriction may not accurately reflect students' experiences from other campuses, potentially affecting the study's applicability to a broader student population. These limitations highlight areas for future research, particularly in exploring gender differences in CVS and DED prevalence and expanding the study to include a more diverse student sample across multiple locations. Additionally, future research could explore the effectiveness of various strategies to increase students' awareness of optimal ergonomic practices. Investigative efforts could focus on the impact of translated informational leaflets and educational courses tailored to student needs.

Conclusion

This study has demonstrated a significant frequency of CVS and DED among university students, correlating strongly with non-adherence to ergonomic guidelines recommended by the AOA. Notably, the study revealed that simple ergonomic practices, such as maintaining appropriate screen distances and taking regular breaks, can substantially mitigate symptoms of CVS and DED. Additionally, proactive public health initiatives and educational programmes are crucial to elevate the standard of eye care and ergonomic awareness, ensuring students can effectively minimise the risks associated with prolonged digital device usage.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

S. Aljohani and S.H.A. were responsible for the conceptualisation, data curation and formal analysis of the study. K.A., A.A., S. Alghamdi and M.A. contributed to the methodology section. S. Alghamdi and M.A. were responsible for the results section. S.H.A., S. Aljohani and K.A. were responsible for the validation and investigation of the study. K.A. and A.A. wrote the original draft of the article. S. Aljohani, S. Alrasheed and M.A. contributed to the review and editing of the article.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, S.H.A.

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