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PREVALENCE AND RISK FACTORS OF COMPUTER VISION SYNDROME AMONG UNIVERSITY STUDENTS DURING THE COVID-19 PANDEMIC: A CROSS-SECTIONAL STUDY

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Abstract: Online schooling and prolonged screen time can cause eye strain, dry eyes, watery eyes, itching, and headaches in college students. This study investigates how spending more time on screens during online classes affects the eye health of university students in South Africa. The study involved 349 university students attending online classes during the COVID lockdown. Data were collected via questionnaires, and univariate and multiple logistic regression analyses were used to evaluate association strengths. The prevalence of Computer Vision Syndrome among students was 68%, a higher prevalence of CVS was found among female students (63%) compared to male students (37%). Results from the adjusted model showed that female students were more likely to report CVS than male students (OR = 1.70, 95% CI: 1.07-2.67, p=0.023). Students within the age group 26-35 were less likely to report CVS as compared to students within the age group 18-25 (OR = 0.40, 95% CI: 0.22-0.72, p =0.002). Postgraduate students were less likely to report CVS than undergraduate students (OR = 0.41, 95% CI: 0.25-0.67, P <0.001). Students with more than one gadget were more likely to report having CVS, 2 gadgets (OR = 2.73, 95% CI: 1.32-5.62, p=0.007) and >2 gadgets (OR = 2.47, 95% CI: 0.99-6.14, P= 0.005). Students with family history of eye-defect were more likely to report eye defect (OR = 2.59, 95% CI: 1.53-4.38. P<0.001). CVS has a high prevalence amongst university students. Frequent pauses during screen use using customized apps or the 20-20-20 rule (to focus on 20 feet every 20 minutes for 20 seconds) should be performed by students while using their gadgets.

Keywords: computer vision syndrome, university students, COVID-19, screen time, digital eye strain, health interventions

1. Introduction

During the COVID-19 epidemic, computers, laptops, e-books, tablets, and smart phones are replacing books. Many media outlets and countries have stated that gadget use harms vision (Mehra & Galor,

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2020). Electronic devices are one reason more individuals use glasses (Cherinet et al., 2018). Electronic device use causes refractive errors like long-sightedness, short-sightedness, and astigmatism (Cherinet et al., 2018). The aim of this study was to examine the relationship between prolonged screen time and self-reported CVS amongst university learners at a South African University. This study examined how prolonged screen usage affects self-reported CVS in South African university students.

Computer Vision Syndrome (CVS), also known as digital eyestrain, is a condition caused by staring at a computer or other display device for long periods and the eye's muscles being unable to recover from the constant tension required to focus on a close object (Klamm & Tarnow, 2015). CVS is a kind of repetitive motion injury acquired either while at workplace or at home working on assignments and this happens because the eyes follow the same path over and over. The longer the eye movement continues, the worse the eye condition gets. Even after quitting working with the screen, recurrent and constant eye strain caused by CVS can result in diminished visual acuity and blurred distance vision and if the problem is not addressed, the situation may deteriorate (Chiemeke et al., 2007). CVS has also been linked to poor sleep quality and insomnia, as evidenced by several studies (Kawashima et al., 2016). As of 2009, CVS was projected to impact over 60 million people worldwide among computer users who logged more than 3 hours each day. Additionally, a new case of CVS was diagnosed in roughly one million people annually (Wimalasundera, 2009).

Prolonged staring at a digital screen without blinking the eyes or taking a break from looking at the screen, and extended periods of computer use are risk factors. Students use smartphones, computers, televisions, and video game consoles for learning, accessing other websites, connecting with friends, watching movies, listening to music, and gaming (Vejmelka et al., 2020). Thus, spending 6–7 hours a day on these devices. Students who utilized the computer more than three hours each day were more likely to have CVS symptoms (Klamm & Tarnow, 2015). This event also shortened their time of sleep. Al Rashidi and Alhumaidan (2017) found severe digital eye strain in most Saudi university students, especially those who use computers all day. More screen time puts a student at risk.

Since the COVID-19 pandemic, university students are at risk from prolonged computer screen exposure (Al Rashidi & Alhumaidan, 2017). The COVID-19 pandemic has increased screen time and CVS worldwide (Cartes et al., 2022; Regmi et al., 2022). Due to the COVID-19 epidemic, students must attend online lectures at home on laptops and computers. According to Regmi et al. (2022), students utilize their computers longer than before the COVID-19 pandemic. Dry eyes, eye strain, discomfort, and redness were observed by many university students (Mohan et al., 2021). Online school's strain and close-up work may cause eye disorders that last a lifetime (Usgaonkar et al., 2021).

The COVID-19 pandemic has led to a dramatic increase in screen time due to the shift to online learning and remote work, which has significantly contributed to the rise in eye-related health issues, including CVS (Victor et al., 2023). However, despite the growing prevalence of these issues, there remains a gap in the literature concerning how the pandemic specifically exacerbated CVS risks among university students, particularly in the South African context. This demographic has been underrepresented in current studies, with most research focusing on general populations or younger age groups (Alexander & Currie, 2004). Hence this study aims to identify and evaluate the factors that have impacted visual impairments in university learners in South Africa. The secondary objective will include identifying preventive measures and high-risk groups. This will provide up-to-date information that can be used to

assess necessary precautions to prevent the serious impact of CVS on productivity and sustainable economic development, thus forming an important basis for global public health policy recommendations.

2. Materials and Methods

Ethics approval and consent to participate: The study protocol was reviewed and approved by University of Johannesburg Research Ethics committee (approval number: REC-1545-2022) and North-West University Health Research Ethics Committee (approval number: NWU-00117-22-A1). All methods were carried out in accordance with relevant guidelines and regulations of the faculty of health sciences-REC, University of Johannesburg. Written informed consent was obtained from all the study participants for participation in the study. The self-administered questionnaire was completed on an individual anonymous basis to allow for confidentiality.

Study design and setting: The selected study design was a cross-sectional study. The study was conducted at a South African University. The site is a higher learning institution that discharged lessons to its students via electronic means during the COVID-19 pandemic (year 2020/2021). The tertiary institution is a comprehensive institution which focuses on undergraduate education whereby programs are registered for contact and distance learning. The uniqueness for registering students for contact learning by the institution strike an interest as the Covid-19 pandemic affected the mode of learning of all institutions and were forced to make decisions about teaching and learning thereby transferring all contact learners to online learners during the pandemic.

Study participants: the study included males and females who were actively studying. The study was conducted in the university campus and student residences. The basis of their involvement as a target population was on the following: active studentship, level of study (undergraduate and postgraduate students) and the mode of learning during the COVID year 2020/2021 (online). Students comprising the study population should be able to have a perception concerning their mode of learning during the year 2020/2021.

Sample selection: The selection and ascertainment of a study participant refer to the manner on which participants are enrolled on the study in a way that is compatible with the aims of the research. The study participants should be well represented by the population of interest so that the findings can be generalized with the population of interest. Study participants were selected through a random sampling selection. Students were approached randomly within the school premises, irrespective of their faculty or level of study. A random selection ensures that every person that follows the inclusion and exclusion criteria of the study has an equal chance of being selected to participate in the analysis of the study (Martínez-Mesa et al. 2016).

Sample size: The sample size was calculated using the prevalence formula.

$$\text{Sample (N)} = \frac{(Z_{1-\alpha/2})^2 P(1-P)}{d^2}$$

$Z_{1-\alpha/2}$ = is standard normal variate at 5% type I error (P< 0.05) and it is 1.96

P = Expected prevalence in population based on a previous study

d = Absolute error or precision (which is 5%)

Using the prevalence of 76.6 % obtained in the study by Canto-Sancho et al., (2021) in Spain

$$\text{Sample (N)} = \frac{(1.96)^2(0.766)(1-0.766)}{(0.05)^2} = 275.4$$

To cater for the 80% response rate, the sample size was augmented to 275/0.8 = 344.

Hence, the study had a total number of 344 study participants.

Data Collection

Prior to data collection, a pilot study was conducted to access the readability of the questionnaire, test logistics and gather information before the research study. Primary data was then collected using a self-administered questionnaire. The data collection instrument collected information on socio-demographic and learning factors that may contribute to eye defects in university learners.

Data Analysis

Data collected from the questionnaire were entered into an Excel sheet and then transferred to Stata version 17 for analyses. As appropriate, descriptive statistics such as mean, median, percentages, and frequencies were used to summarize data and determine prevalence. Also, graphs such as pie charts, and bar charts were used to illustrate data. Univariate analysis was used to obtain crude odd ratios, after which multivariate analysis was done to obtain adjusted odd ratios. To obtain adjusted ratios, the effect of confounding variables on the outcome variable was placed in an initial multiple logistic regression analysis model. This was followed by the addition of a potential confounder in a stepwise manner starting with the most statistically significant from the univariate analysis. Each time a new potential confounder was added to the model, if the effect estimates between the outcome and the confounding variable already in the model changed by more than 5%, the additional confounding variable was retained in the final multiple logistic regression analysis. The most parsimonious multivariate regression analysis model was reported, that is those with variables having a p-value of less than 0.05.

3. Results and Discussion

3.1 Prevalence of CVS amongst study participants

A total of 349 participants were recruited in this study. All participants had undergone online classes in the year 2020 and 2021. The prevalence of reported CVS among study participants was characterized by the presence of two or more symptoms of CVS, 113 students (32%) showed ≤1 symptoms of CVS, hence they were regarded as "CVS negative" while 236 students (68%) showed ≥ 2 symptoms of CVS and so were regarded as "CVS positive. Therefore, prevalence of CVS symptoms among study

participants was 68% (Figure 1). This confirmed the finding that the prevalence of CVS among computer users is greater than 50 % (Sheppard and Wolffsohn, 2018), likewise, according to Mohan et al. (2021), the prevalence of digital eye syndrome was found to be 50.23 %. The increased prevalence in our study is likely attributable to the increased visual demand of digital device use in the era of COVID online classes. Even though recent research showed a prevalence below 70%, prior research indicated a higher incidence among computer users. In 2014, Logaraj et al. (2014) reported a CVS prevalence of 80.3 % among medical and engineering college students in Chennai, while Reddy et al. (2013) reported a prevalence of 89.9% among Malaysian university students in 2013. Also, a high prevalence was reported by Alemayehu et al. (2014) with 73.9 % of study participants self-reporting CVS in 2014 as well.

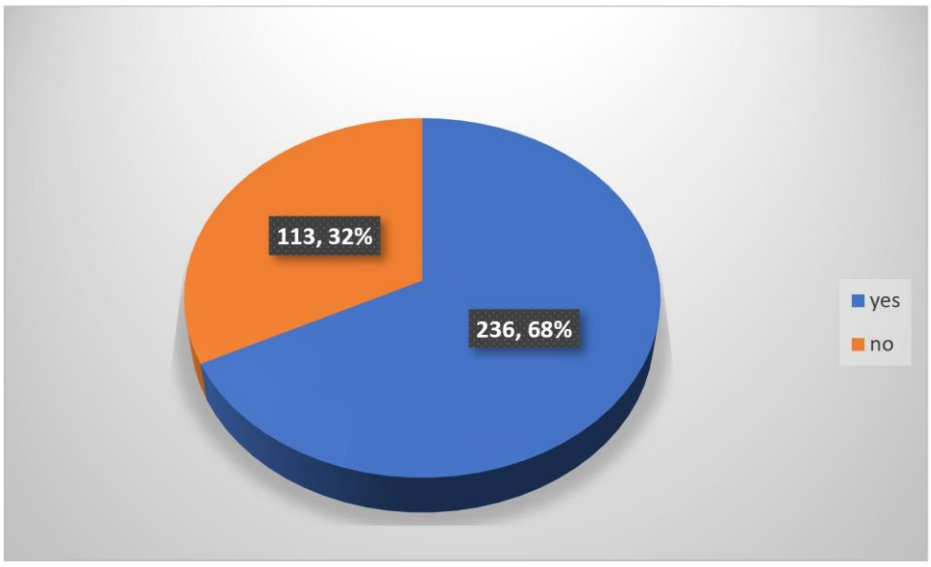

Figure 1 Prevalence of reported CVS among study participants at a South African University

3.2 Descriptive characteristics of study participants and reported symptoms

A total of 349 responses were gotten from students. The demographics showed that the majority of study participants were female (203, 58.33 %), and the rest male (145, 41.67 %), a similar study on another South African university students showed the same difference in sex proportion with males 41% and females 58% (Chipeta et al. 2016). Also, more than half (n=261; 74.79 %) of the study participants were within the age range of 18-25. The tertiary institution is known for undergraduate teaching and learning and so this age group isn't farfetched in terms of their proportion within the school premises.

During the pandemic year, students who signified to have spent 5-6 hrs on their computers for studying were 180 which accounted for 51.58% of study participants, while 47.28% thought that the time allocated was too much. However, based on the effect of the online learning on the student's eye-sight, 203 students (58.7%) preferred contact learning to online leaming.

The study also characterized the participants in terms of the types and number of gadgets owned by study participants. While 318 students (91.12%) revealed that they own a laptop, majority of the

students (330, 94.56%) owned a smartphone, however, a small percentage of the students (25, 7.16%) own a tablet. Also, data obtained showed that a larger proportion (267, 76.50%) of the study participants own 2 gadgets which was mainly a smart phone and a laptop while 48 students (13.83%) own >2 gadgets and 34 students (9.74%) had just 1 gadget.

While 230 students (65.90%) do not have a family history of eye defects, 100 students (28.65%) revealed to have an history of eye defects, however, 19 students (5.44%) were not sure of their family status. The development of eye problems during the online learning period brought about by COVID restrictions was assessed amongst students, 204 students (58.45%) responded in the affirmative to have developed eye problems since the year 2021 till the time of study. However, 125 students (35.82%) had not developed any eye complication in the last 1 year while 20 students (5.73%) were not sure. While 169 students (48.42%) stated that the eye complication was due to the prolonged use of technological gadget for learning, 18.05% were not sure of the origin. From the study, it was observed that majority of study participants (232, 66.48%) had never visited the eye clinic, while 28.3% of study participants visited the clinic about 2 times in the last 1 year. Also, most students (87.68%) reported to take regular breaks while working on their laptops.

The symptoms of Computer Vision Syndrome (CVS) are categorized into 2 groups according to Portello et al. (2012), Group 1 involves symptoms related to accommodation e.g., blurred vision for near objects, headache, and eyestrain while group 2 are symptoms related to dryness e.g., burning sensation, foreign body sensation, itching, watering, intolerance to light. Based on this categorization, this study assessed the presence of some of the symptoms in both categories amongst the study participants (Figure 2). Participants experienced at least one symptom related to digital screen usage since the pandemic. Previous studies reported an average of 2.3±1.5 symptoms observed by study participants (Agarwal et al., 2022). The most common reported symptoms were "tired eyes" (61.03%) followed by "eye itching" (57.88%) and "watery eye" (54.73%), this was in accordance with a study that reported eye itching (53.9%) as the most common symptom among children using online e-learning during the COVID-19 pandemic in India (Mohan et al., 2021) while Akinbinu and Mashalla (2013), reported the most experienced symptoms of CVS amongst computer users to be headache and eye strain.

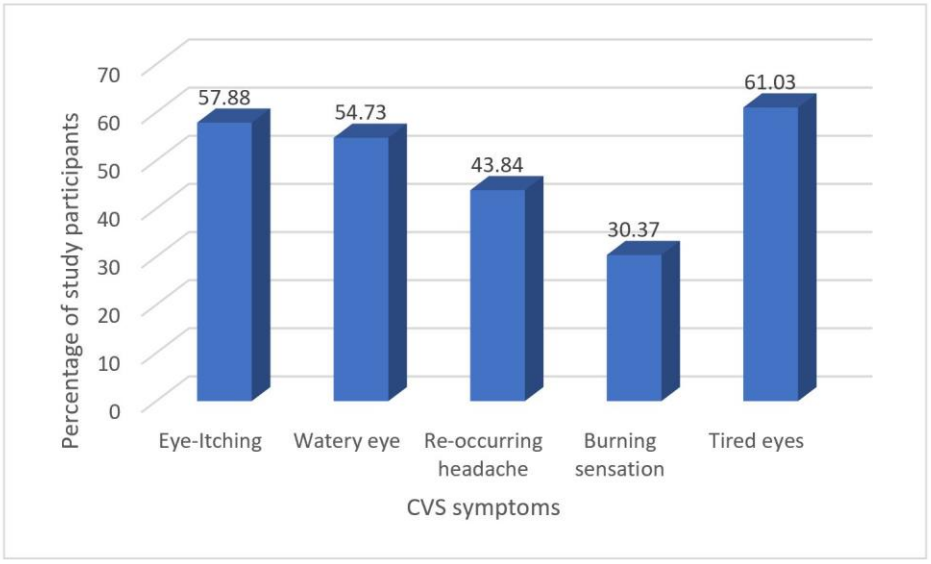

Figure 2: CVS Symptoms amongst study participants

3.3 Risk factors associated with CVS

Non modifiable (e.g., age female gender, and race) and modifiable factors (e.g., computer use, baseline symptoms, and history of eye defects) have been consistently identified to be associated with eye defects (Korpole et al., 2022; Palm & Risberg, 2007). In terms of age of participants', majority (74.79%) of the study participants were within the age range of 18 – 25; when compared to this age group, participants within the age group of 26-35 were less at risk of CVS, $p < 0.05$. This might be due to the fact that undergraduates who are majorly within the age group 18-25 have more modules while learning as compared to postgraduate students who make up the age group of 26-35 and so they (undergraduates) have longer duration of online classes than in the postgraduate levels, this was evident in the crude OR as postgraduate students were less likely to report CVS than undergraduate students (OR = 0.24, 95% CI: 0.09-0.63, P= 0.003).

In relation to sex, over two-thirds (63%) of the CVS - positive participants in this study were female, while only 37% were male. Several studies also reported a higher prevalence of CVS in female compared to males (Alexander & Currie, 2004; Palm & Risberg, 2007) 21 22. Shi et al. (2021) reported the prevalence of myopia to be higher in girls than in boys (43.5 % vs. 33.6 %). As opposed to what was reported by Hassan et al. (2016), where the prevalence of CVS was 75% among males and 25% among females. Although Mohan et al. (2021) reported that males were more likely to have CVS, our study found that females actually had a higher risk ($P < 0.005$, OR, 1.94). Among high school students in Shangdong, China, 51.7% prevalence was found in male and 48.3% in female, $p = 0.234$ (Zhang et al., 2012). Furthermore, Supiyaphun et al. (2021) found a slightly higher proportion of Dry Eye Disease DED in male (9.13%) compared to female (7.72%). There may be an explanation for the contradictory findings in this study, as there was a higher age group represented. When compared to previous studies of high school males, the older male in the current study engages in more extracurricular activities outside the digital world. According to the findings of our study, female students are more involved in digital device tasks, putting them at greater risk. In addition, eye-health disparities are prevalent for women, due to their sex steroid hormones further making them more at risk (Korpole et al., 2022).

Furthermore, in this study, students spend 5-6 hrs while working on their gadget for learning. This is similar to the findings of Agarwal et al. (2022), where 63.2% of participants spent 2–6 hours on screen per day. A study in Saudi Arabia showed 56.30% of study participants used digital gadgets for > 6 hours each day (Abuallut et al., 2022). Another similar study in Thailand reported screen time of >8 amongst university students (Supiyaphun et al., 2021).

The present study found that students who were using the computer for 5 to 6 hours were insignificantly more likely to report CVS. Akinbinu and Mashalla (2013), reported that participants who spend 6 to 8 h average daily on the computer experienced more CVS symptoms. In the study reported by Rahman and Sanip (2011), respondents who used computer for more than 5 h/day were at higher risk of developing CVS while Reddy et al. (2013) reported more than 2 hours continuous use of computer was significantly associated with occurrence of CVS symptoms.

The majority (76.50%) of participants in this study own 2 gadgets which was mainly a smart phone and a laptop, with 318 (91.12%) using a laptop and 330, (94.56%) using a smartphone. This finding supported the high prevalence of gadget usage as reported in a study conducted in Ghana by OseiFrimpong and Asare (2020) where 273 (89.2%) used laptops, and mobile phones (61.8%). Furthermore, the use of multiple gadgets increases the prevalence and likelihood of developing CVS, the use of more than 1 gadget was found to be associated with CVS in this study (P<0.05), similarly multiple devices (dual or triple screening) was found to be related to increase in DES symptoms (P = 0.002) as found in the study of Agarwal et al. (2022).

History of eye defects was found to be a significant predictor of current CVS (p 0.001). This finding could be attributed to the genetic predisposition to conditions like dry eyes, refractive errors, or ocular surface diseases, which might predispose individuals to more severe symptoms of CVS. According to Sheppard and Wolffsohn (2018), individuals with a history of eye conditions tend to have more pronounced symptoms of digital eye strain due to the compounded effect of their pre-existing conditions and the added strain from prolonged screen exposure. Additionally, studies have showned that having an eye defects family history increases the risk of eye defects among students as reported by Osman et al. (2021) with the adjusted ORs (95% CI) of 8.48 (4.98, 14.45). Similarly, myopia is more likely to develop in children whose parents also have the condition, as children of myopic parents are more likely to pick up their parents' bad reading and writing habits (Shi et al., 2021).Further exploration of genetic factors and their interactions with environmental stressors like screen time may provide insights into why some students, particularly those with a family history of eye problems, are more susceptible to CVS.

In conclusion, CVS amongst university students were significantly associated with female sex (P =0.027, AOR 1.82), level of study (p= 0.003, AOR 0.24), Eye defect history (P < 0.001, AOR 3.69), use of 2 technological gadgets (P = 0.006, AOR 3.31), and use of more than 2 technological gadgets (P = 0.014, AOR 3.96) as shown in Table 1.

Table 1: Risk factors associated with CVS- unadjusted and adjusted analysis

Characteristics	ORs	(95%CI)	P-Value	AORs	95% CI	P-Value
sex						
Male	1			1	1	
Female	1.70	1.07-2.67	0.023	1.82	1.07 – 3.09	0.027
Age						
18-25	1			1	1	
26-35	0.40	0.22-0.72	0.002	0.86	0.32-2.32	0.773
36-45	0.58	0.24-1.40	0.227	1.63	0.44-6.12	0.467
46-55	0.75	0.13-4.17	0.740	1.04	0.12-9.30	0.973

Level of study						
Undergraduate	1			1	1	
Honors	0.94	0.35-2.50	0.895	1.01	0.35-2.91	0.985
Postgraduate	0.41	0.25-0.67	<0.001	0.24	0.09-0.63	0.003
Time spent in hours per day						
< 1hr	1			1	1	
2-4 hrs	0.38	0.09-1.46	0.160	0.32	0.07-1.35	0.122
5-6hrs	0.79	0.21-2.97	0.733	1.41	0.34-5.84	0.633
>6hrs	0.44	0.11-1.72	0.240	0.61	0.15-2.97	0.584
Number of gadgets owned						
1	1			1	1	
2	2.73	1.32-5.62	0.007	3.31	1.40-7.80	0.006
>2	2.47	0.99-6.14	0.005	3.96	1.32-11.88	0.014
History of family eye problem						
No	1			1	1	
Yes	2.59	1.53-4.38	<0.001	3.69	1.97-6.90	<0.001
Take regular breaks						
No	1			1	1	
Yes	1.25	0.55-2.82	0.59	1.07	0.42-2.79	0.877
Sometimes	2.55	0.58-11.18	0.21	8.13	1.45-45.95	0.018

The model is adjusted for sex, age, level of study, time spent on gadgets while studying, how many gadgets owned by students, history of eye defects and regular break time while working using gadgets.

4. Conclusion and Recommendations

The massive scale of the COVID-19 pandemic had repercussions for our daily lives and educational systems, such as the temporary and permanent closure of schools and the increased use of online learning platforms by university students. Regarding this, computer technology has been extremely helpful in reducing disruptions to school education; however, it is crucial to be aware of the impact that increasing reliance on digital devices, as well as the collateral impact of COVID-19-related policies, can have on various health outcomes, including CVS and other eye defects. And so, as a form of recommendation, more education about CVS should be provided to students, faculty, and university administration. Colleges and universities could help prevent this syndrome by, for example, launching awareness campaigns to teach students about its signs and symptoms prevention; Providing workshops or training sessions on proper screen ergonomics; providing and encouraging routine eye health consultations for students in university clinics. It would be phenomenal if college students were taught responsible technology use. If students use their devices for extended study sessions, they should take precautions to avoid developing CVS. Also, the 20/20/20 rule has been proposed to reduce CVS symptoms. After 20 minutes of screen time, take a 20-second break and look at a distance of 20 feet. In the same way, evaporative dry eye can be alleviated by releasing lipids from the meibomian gland, which can be done by encouraging complete, frequent, and forceful blinking, which is a common response to prolonged digital device use. Preservative-free lubricant eye drops and positioning the screen 4–5 inches below eye level can help prevent moisture loss from the cornea. Finally, CVS-related modules or resources should be integrated into university wellness programs. Overall, these measures will reduce the prevalence of CVS and contribute to improved student well-being and academic performance.

4.1 Limitation and future research

Study limitations: The data collection method used in this study is a questionnaire that was self-reported, so the information obtained cannot be independently verified. Also, several other variables and symptoms were not accounted for in the study as the data could not be collected from study participants due to ethical issues. The study was limited to only one university and so the results obtained might not be generalized to the total University students population in South Africa. Lastly, research participants might miss out on some questions or might answer some questions incorrectly. This may have produced a false-positive result after data analysis.

Future research: This can include longitudinal studies that could track the development of CVS symptoms over time in relation to increased screen use. Additionally, interventional trials aimed at reducing CVS symptoms could provide valuable insights. For instance, studies focusing on the effectiveness of interventions like regular screen breaks, the 20/20/20 rule, or the use of specialized eyewear could help determine the most effective strategies for preventing or alleviating CVS symptoms. Incorporating such studies would contribute to the growing body of evidence on managing CVS in the context of online learning and work. Future research can also explore other populations that heavily rely on screens, such as teachers, healthcare workers, and professionals in various fields.

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Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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