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Association Between Blinking Rate and Computer Vision Syndrome Among Digital Device Users: A Cross-Sectional Study at Pakistan Institute of Community Ophthalmology, Hayatabad Medical Complex

Mr. Syed Kabir Shah
Clinical Optometrist, Buner Medical Complex, Daggar Buner. skabirs092@gmail.com
Dr. Fawad Ahmad Safi
Basir Safi Eye Specialized Clinic, Jalalabad, Afghanistan. fawadsafi107@gmail.com
Dr. Omaimah Qamar*
Consultant Opthalmologist, Jammiyat Hospital, Lahore. Corresponding Author Email: omaimah.qamar@gmail.com
Ashar Saeed
Optometrist , Hayatabad Medical Complex, Peshawar. asharsaeedkhattak@gmail.com
Dr. Hamid Arshad
Jinnah Hospital Lahore, Pakistan. hamidarshad1044@gmail.com
Muhammad Zafar
LRBT (Layaton Rahmatullah Benevolent Trust). Email: muhammadzafarzarkoon88@gmail.com

Author Details

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Corresponding E-mails & Authors*:
Dr. Omaimah Qamar
omaimah.qamar@gmail.com

Abstract

Objective: To determine the association between blinking rate and computer vision syndrome (CVS) among digital device users at the Pakistan Institute of Community Ophthalmology (PICO), Hayatabad Medical Complex, Peshawar. **Study Design:** Institution-based, cross-sectional descriptive study. **Place and Duration of Study:** Demonstration room of PICO, Hayatabad Medical Complex, Peshawar, over six months from 12 Feb 2024 to 12 July 2024. **Methodology:** A total of 123 students (sample drawn from a population of 160) were enrolled by non-probability convenience sampling. Blinking rate during screen use was recorded and a self-administered questionnaire on CVS symptoms, screen settings, device type, awareness and attitude was completed. Blinking rate was classified as 15 blinks/min or <15 blinks/min. Data were analysed using SPSS version 29; frequencies, percentages, mean and standard deviation were calculated

and associations were tested with p <0.05 as significant. **Results:** Mean age was 20.80 ± 2.04 years and 62 (50.4%) participants were male. Ninety-four participants (76.4%) experienced CVS symptoms during screen use. Headache (18.7%) and multiple symptoms (18.7%) were the most frequent presentations, followed by dry eye (8.9%) and near-vision discomfort (8.1%). Smartphones were the commonest device (70; 56.9%) and 57 (46.3%) made no adjustment to their screen. Only 2 participants (1.6%) maintained a blinking rate of 15 blinks/min, while 121 (98.4%) blinked <15 times/min. Blinking rate was not significantly associated with age (p = 0.12), gender (p = 0.90), screen-setting adjustment (p = 0.22) or CVS symptoms (p = 0.40). Awareness of CVS (30.1%) and of the 20-20-20 rule (29.3%) was low, yet 76.4% were willing to reduce screen time. **Conclusion:** CVS symptoms were highly prevalent and reduced blinking during screen use was almost universal in this group of students; no statistically significant association between blinking rate and CVS symptoms could be demonstrated, probably because nearly all participants blinked below the normal rate. Awareness of CVS and ergonomic practices was poor, and educational programmes promoting regular blinking, the 20-20-20 rule and sound screen habits are recommended.

Keywords: Computer vision syndrome; Digital eye strain; Blinking rate; Screen time; Smartphone; Students; Pakistan.

INTRODUCTION

In the digital age, computers, smartphones and other electronic devices have become integral to daily life, and computer vision syndrome (CVS) is a growing concern.[1] CVS, also known as digital eye strain, encompasses a range of eye and vision-related problems that arise from prolonged use of these devices.[2] Its symptoms are commonly grouped into asthenopic symptoms (tired and sore eyes), binocular vision and accommodation problems, ocular surface symptoms (dry, watery or irritated eyes, particularly with infrequent blinking), visual disturbances (blurred vision, slow change of focus, double vision) and extra-ocular symptoms such as neck, back and shoulder pain attributed to poor posture.[3] The condition affects not only adults but also children and young people, especially with the widespread adoption of smartphones and increasing screen time in the younger generation.[4]

Blinking is a vital ocular function that moistens and protects the ocular surface; however, prolonged screen use is accompanied by a reduced blink rate, which contributes to dry eye symptoms and may aggravate CVS.[5] Smartphone viewing adversely affects the ocular surface, causing discomfort, eye strain, sore and dry eyes, and altered tear-film function and blinking.[6] One hour of smartphone gaming caused young adults, especially university students, to blink less than when they were at rest or

listening to study explanations.[7] Studies from Africa, Asia and Pakistan report a high prevalence of CVS among computer users, ranging from 63% to 89%.[8]

In Edinburgh, 20% of young children were reported to have eye-strain symptoms attributable to digital eye strain even before the pandemic.[9] Normal blink rates are about 10–15 per minute but fall by up to 60% during prolonged computer use, leading to dry eye symptoms.[10] Studies from India, China and Nepal link screen-use habits to ocular health: close screen proximity, inadequate lighting and prolonged use without breaks are associated with headache, eye strain and discomfort.[11,12] In Pakistan, studies among medical students in Karachi, Lahore and other cities consistently report a high prevalence of digital eye strain symptoms (74.1% to 98.7%), with headache a common complaint.[13,14]

Although CVS is common, local data linking objectively observed blinking rate with post-task symptoms among students of ophthalmic sciences are scarce. This study therefore aimed to determine the association between blinking rate and CVS among digital device users at PICO, Hayatabad Medical Complex, Peshawar, to describe screen-use habits and awareness of the 20-20-20 rule, and thereby to suggest preventive measures and promote ergonomic practices.

MATERIALS AND METHODS

Study design, setting and duration

This institution-based, cross-sectional descriptive study was conducted in the demonstration room of the Pakistan Institute of Community Ophthalmology, Hayatabad Medical Complex, Peshawar, over a period of six months. Data were collected from students of the first, second, fourth and seventh semesters during the ongoing academic session.

Sample size and sampling technique

The sample size was calculated using OpenEpi version 3 for a population of 160, a hypothesised frequency of 50% ± 5%, a design effect of 1 and a confidence level of 97%, giving a minimum of 123 participants. The 123 students were selected from the population of 160 by non-probability convenience sampling.

Eligibility criteria

Students of either gender aged 15 to 24 years or above, who used digital multimedia devices and had myopia, hypermetropia or corrected refractive error (spectacles), were included. Individuals with known eye disease affecting blinking rate or causing digital eye strain, those aged below 15 or above 30 years, contact-lens users and those taking medications related to eye disease were excluded.

Data collection

Ethical approval was obtained from the research committee of the undergraduate section of PICO. Participants were briefed on the study procedures, oral informed consent was obtained and confidentiality was assured. A pilot study on 15 subjects was carried out to assess feasibility. A detailed history was taken from every participant to confirm eligibility. Visual acuity was assessed with standard charts and cards, anterior segment examination was performed with a slit lamp, and posterior segment examination with a slit lamp and additional lenses. Subjective and objective refraction was carried out where visual acuity was below normal.

Blinking rate during screen use was observed with a camera system and counted using a stopwatch; a rate of 15 blinks/min was considered normal and <15 blinks/min reduced. Data on CVS symptoms, screen settings, device type, daily screen time, awareness of CVS and of the 20-20-20 rule, and willingness to reduce screen time were collected with a self-administered questionnaire.

Statistical analysis

Data were analysed using SPSS version 29. Frequencies, percentages, mean and standard deviation were calculated for descriptive variables. Associations between blinking rate and age, gender, screen-setting adjustment and CVS symptoms were assessed with appropriate tests of association, and a p-value <0.05 was taken as statistically significant.

RESULTS

A total of 123 students were included. The mean age was 20.80 ± 2.04 years; 70 (56.9%) were aged 21–23 years, 40 (32.5%) were aged 18–20 years and 13 (10.5%) were above 24 years. There were 62 males (50.4%) and 61 females (49.6%) (Table 1, Figure 1). Daily screen time was 4–6 hours in 52 (42.3%), 6–8 hours in 42 (34.1%), 2–4 hours in 19 (15.4%) and 8–10 hours in 10 (8.1%), with no significant difference between genders (p = 0.97) (Table 2, Figure 2).

Table 1: *Demographic characteristics of participants (n = 123)*

Variable	Male n (%)	Female n (%)	Total n (%)
Age group (years)			
18–20	20 (16.2)	20 (16.2)	40 (32.5)
21–23	34 (27.6)	36 (29.2)	70 (56.9)
Above 24	8 (6.5)	5 (4.0)	13 (10.5)
Semester of study			

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Variable	Male n (%)	Female n (%)	Total n (%)
First	20 (16.2)	20 (16.2)	40 (32.5)
Second	15 (12.2)	25 (20.3)	40 (32.5)
Fourth	17 (13.8)	5 (4.1)	22 (17.9)
Seventh	10 (8.1)	11 (8.9)	21 (17.1)
Total	**62 (50.4)**	**61 (49.6)**	**123 (100)**

Mean age 20.80 ± 2.04 years. Percentages are of the total sample (n = 123).

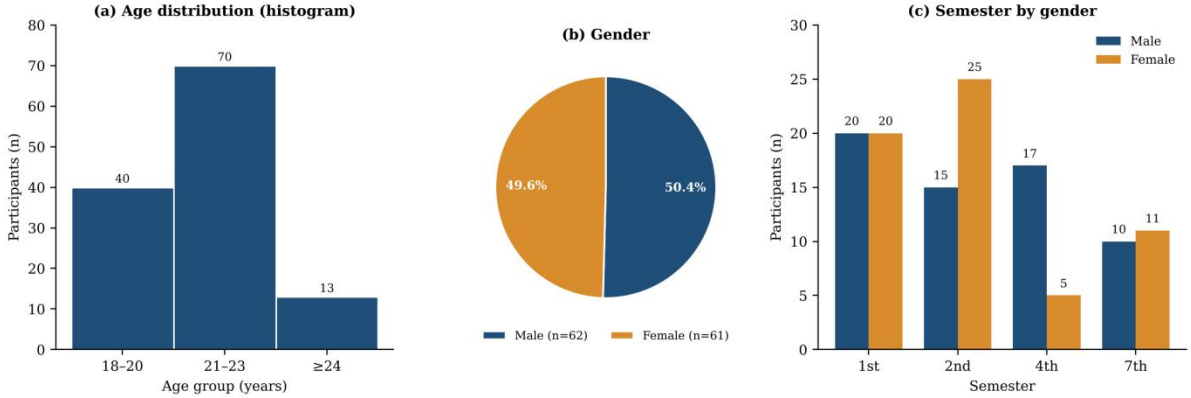

Figure 1: Demographic profile of participants: (a) age distribution, (b) gender, (c) semester of study by gender (n = 123).

Table 2: *Daily screen use and gender-wise CVS symptoms during screen use*

Variable	Male n (%)	Female n (%)	Total n (%)
Daily screen time (p = 0.97)			
2–4 hours	11 (8.9)	8 (6.5)	19 (15.4)
4–6 hours	24 (19.5)	28 (22.8)	52 (42.3)
6–8 hours	22 (17.9)	20 (16.3)	42 (34.1)
8–10 hours	5 (4.1)	5 (4.1)	10 (8.1)
CVS symptoms during screen use (p = 0.50)			
Blurred vision	4 (3.2)	2 (1.6)	6 (4.9)
Double vision	3 (2.4)	2 (1.6)	5 (4.1)
Near vision discomfort	4 (3.2)	6 (4.9)	10 (8.1)
Dry eye	6 (4.9)	5 (4.1)	11 (8.9)

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Variable	Male n (%)	Female n (%)	Total n (%)
Eye redness	5 (4.1)	1 (0.8)	6 (4.9)
Unclear objects after screen use	2 (1.6)	2 (1.6)	4 (3.3)
Irritation	2 (1.6)	4 (3.2)	6 (4.9)
Headache	10 (8.1)	13 (10.6)	23 (18.7)
Multiple symptoms	14 (11.4)	9 (7.3)	23 (18.7)
No symptoms	12 (9.8)	17 (13.8)	29 (23.6)
Total	**62 (50.4)**	**61 (49.6)**	**123 (100)**

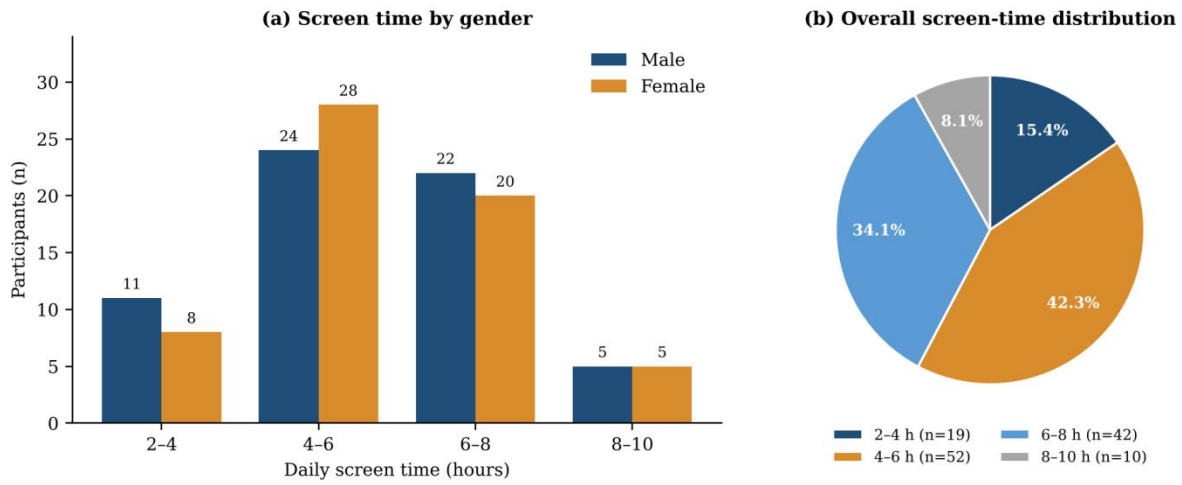

Figure 2: Daily screen time: (a) by gender, (b) overall distribution (n = 123).

The most frequently reported CVS symptoms were headache (23; 18.7%) and multiple symptoms (23; 18.7%), followed by dry eye (11; 8.9%), near-vision discomfort (10; 8.1%), blurred vision (6; 4.9%), eye redness (6; 4.9%), irritation (6; 4.9%), double vision (5; 4.1%) and unclear objects after screen use (4; 3.3%); 29 participants (23.6%) reported no symptoms. Symptom distribution did not differ significantly by gender (p = 0.50) (Table 2, Figure 3).

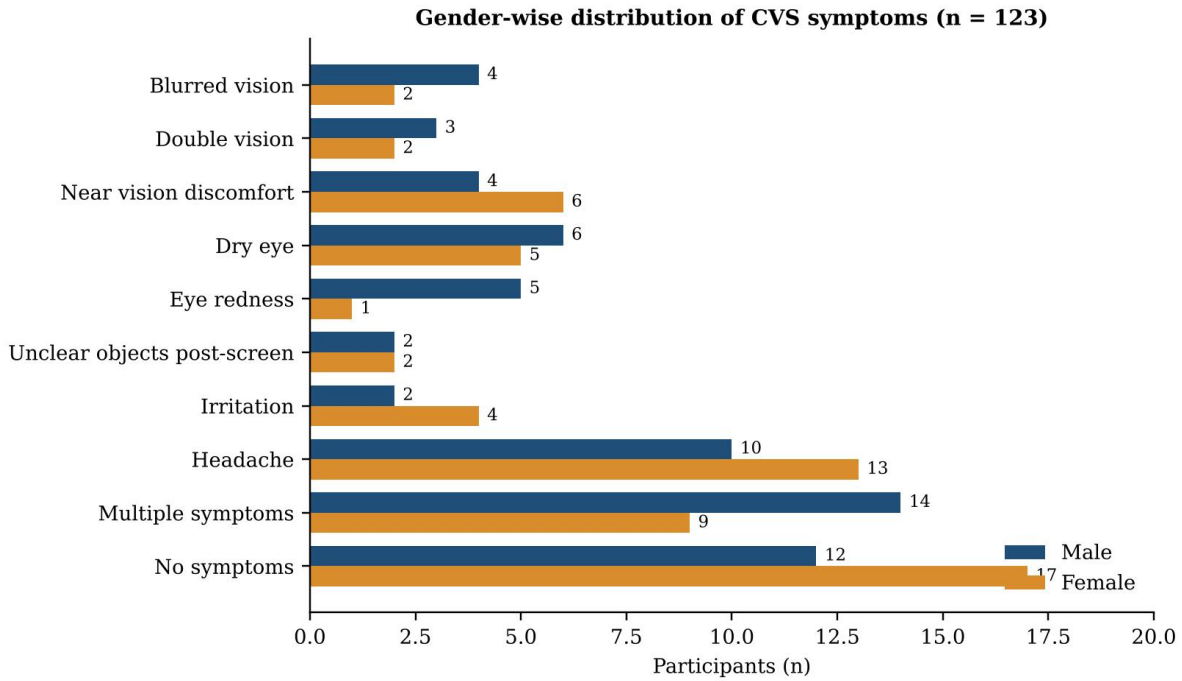

Figure 3: Gender-wise distribution of CVS symptoms during screen use (n = 123).

Regarding screen settings, 57 participants (46.3%) made no adjustment, 43 (35.0%) used night mode, 15 (12.2%) kept a sensible distance and 8 (6.5%) used an anti-reflective protector. Overall, 94 students (76.4%) experienced CVS symptoms during screen use (50 males, 40.7% of the sample; 44 females, 35.8%). Only 37 (30.1%) were aware of CVS and 36 (29.3%) knew of the 20-20-20 rule, while 94 (76.4%) were willing to decrease their screen time (Table 3, Figure 4).

Table 3: *Screen settings, awareness, willingness to reduce screen time and symptom status (n = 123)*

Variable	Yes / n	%
Screen settings during multimedia use		
No adjustment of screen	57	46.3
Night mode on screen	43	35.0
Keeps a sensible distance	15	12.2
Uses anti-reflective protector	8	6.5
Awareness and attitude		
Aware of computer vision syndrome	37	30.1

Variable	Yes / n	%
Aware of the 20-20-20 rule	36	29.3
Willing to decrease screen time	94	76.4
CVS symptoms during screen use		
Symptomatic: total	94	76.4
Male (of 62)	50	80.6
Female (of 61)	44	72.1
Asymptomatic	29	23.6

Percentages are of the total sample (n = 123) except gender rows, which are of each gender group.

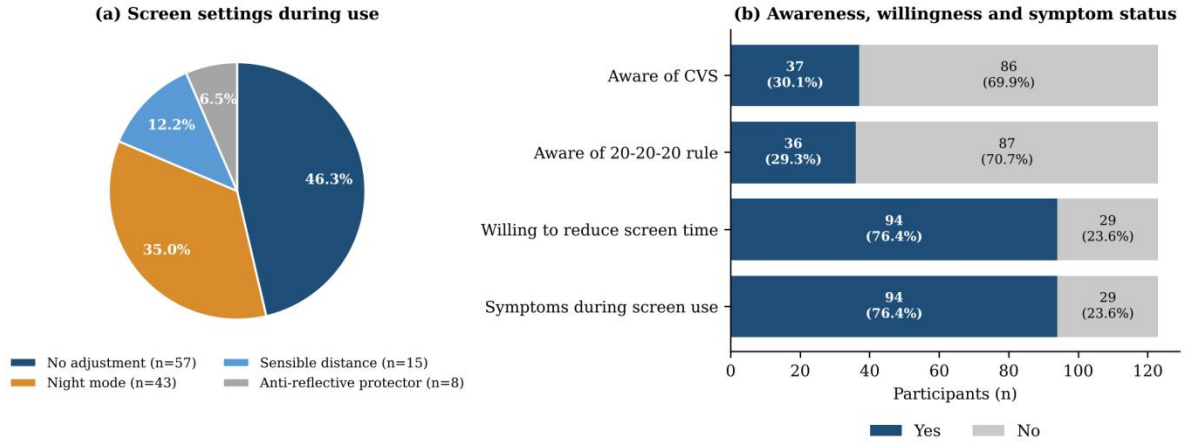

Figure 4: (a) Screen settings used during multimedia use; (b) awareness, willingness to reduce screen time and symptom status (n = 123).

Symptoms were most often associated with smartphone use (70; 56.9%), followed by multiple-screen use (34; 27.6%), laptops (11; 8.9%), tablets (7; 5.7%) and desktop computers (1; 0.8%). Among symptomatic students, 55 used smartphones and 25 used multiple screens (Table 4, Figure 5).

Table 4: *CVS symptoms according to type of device used (n = 123)*

Device	With symptoms n (%)	Without symptoms n (%)	Total n (%)
Desktop computer	1 (0.8)	0 (0)	1 (0.8)
Laptop	8 (6.5)	3 (2.4)	11 (8.9)
Tablet	5 (4.1)	2 (1.6)	7 (5.7)
Smartphone	55 (44.7)	15 (12.2)	70 (56.9)

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Device	With symptoms n (%)	Without symptoms n (%)	Total n (%)
Multiple screens	25 (20.3)	9 (7.3)	34 (27.6)
Total	**94 (76.4)**	**29 (23.6)**	**123 (100)**

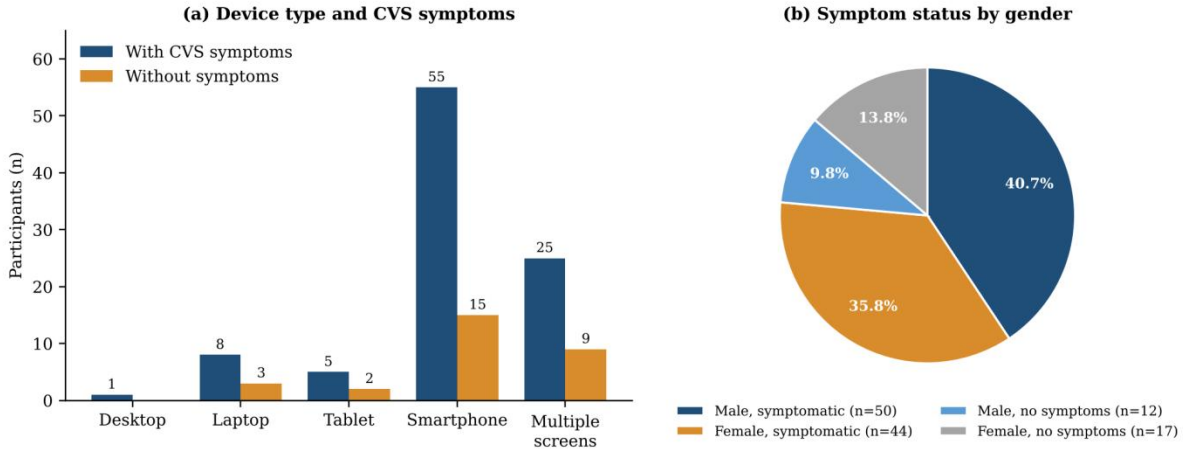

Figure 5: (a) CVS symptoms by type of device; (b) symptom status by gender (n = 123).

Only 2 participants (1.6%) had a normal blinking rate of 15 blinks/min, whereas 121 (98.4%) blinked <15 times/min. By age, 2 of the 40 participants aged 18–20 years blinked 15 times/min, whereas all participants aged 21–23 (n = 70) and above 24 years (n = 13) blinked <15 times/min (p = 0.12). By gender, 1 male and 1 female had a normal rate and 61 males (49.6%) and 60 females (48.8%) had a reduced rate (p = 0.90) (Table 5, Figure 6).

Participants who kept a sensible distance (15), used an anti-reflective protector (8) or used night mode (43) all blinked <15 times/min, while the 2 participants with a normal rate made no screen adjustment; 55 of 57 students (96.5%) who made no adjustment had a reduced rate (p = 0.22) (Table 5, Figure 7). No participant with blurred vision, double vision, near-vision discomfort, dry eye, eye redness, unclear objects after screen use, irritation, multiple symptoms or without symptoms had a normal blinking rate. The two participants with a normal rate both reported headache, whereas 21 other participants with headache had a reduced rate (p = 0.40) (Table 5).

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Table 5: *Association of blinking rate with age, gender, screen settings and CVS symptoms*

Variable	15 blinks/min n (%)	<15 blinks/min n (%)	Total n (%)	p
Age group (years)				
18–20	2 (1.6)	38 (30.9)	40 (32.5)	0.12
21–23	0 (0)	70 (56.9)	70 (56.9)	
Above 24	0 (0)	13 (10.6)	13 (10.6)	
Gender				
Male	1 (0.8)	61 (49.6)	62 (50.4)	0.90
Female	1 (0.8)	60 (48.8)	61 (49.6)	
Screen-setting adjustment				
Keeps sensible distance	0 (0)	15 (12.2)	15 (12.2)	0.22
No adjustment	2 (1.6)	55 (44.7)	57 (46.3)	
Anti-reflective protector	0 (0)	8 (6.5)	8 (6.5)	
Night mode	0 (0)	43 (35.0)	43 (35.0)	
CVS symptoms				
Blurred vision	0 (0)	6 (4.9)	6 (4.9)	0.40
Double vision	0 (0)	5 (4.1)	5 (4.1)	
Near vision discomfort	0 (0)	10 (8.1)	10 (8.1)	
Dry eye	0 (0)	11 (8.9)	11 (8.9)	
Eye redness	0 (0)	6 (4.9)	6 (4.9)	
Unclear objects after screen use	0 (0)	4 (3.3)	4 (3.3)	
Irritation	0 (0)	6 (4.9)	6 (4.9)	
Headache	2 (1.6)	21 (17.1)	23 (18.7)	
Multiple symptoms	0 (0)	23 (18.7)	23 (18.7)	
No symptoms	0 (0)	29 (23.6)	29 (23.6)	
Total	**2 (1.6)**	**121 (98.4)**	**123 (100)**	

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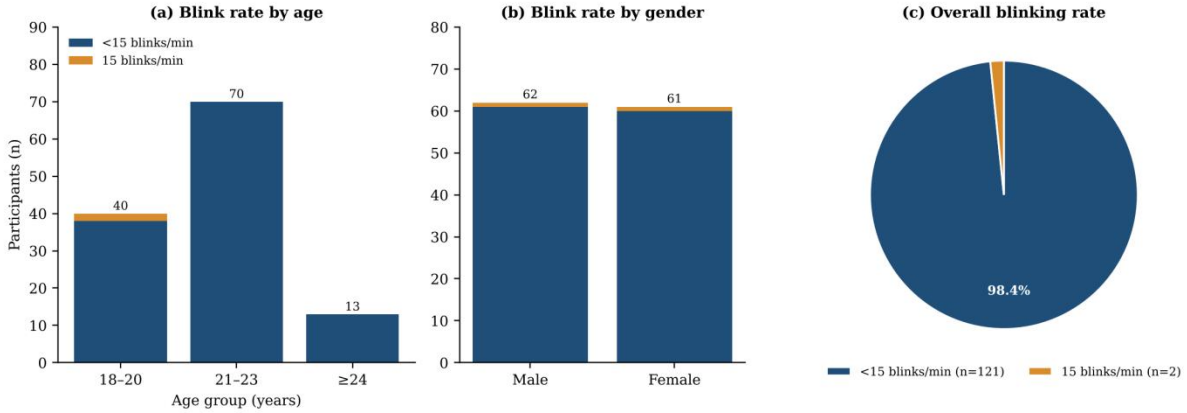

Figure 6: Blinking rate during screen use: (a) by age group, (b) by gender, (c) overall (n = 123).

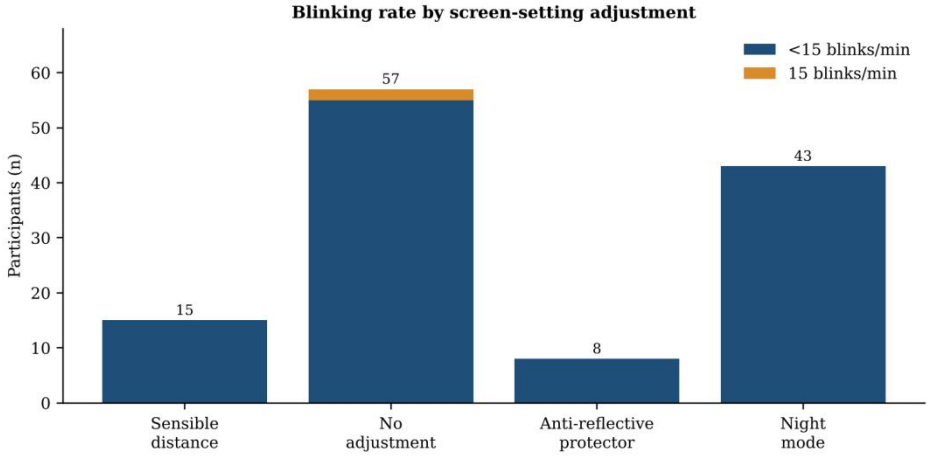

Figure 7: Blinking rate according to screen-setting adjustment (n = 123).

The distribution of symptoms across screen settings and devices is summarised in Table 6 and Figure 8. Headache was most frequent among smartphone users (16; 13.0%), those making no adjustment (12; 9.8%) and night-mode users (7; 5.7%). Dry eye was most frequent among smartphone users (8; 6.5%) and those making no adjustment (5; 4.1%). Multiple symptoms were commonest among smartphone users (15; 12.2%) and those making no adjustment (12; 9.8%), and near-vision discomfort among smartphone users (7; 5.7%). No blurred vision was recorded among students who kept a sensible distance or used a desktop computer or laptop, and no dry eye among desktop and anti-reflective-glasses users. The overall association was not statistically significant ($p = 0.604$).

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Table 6: *Distribution of CVS symptoms by screen-setting adjustment and device used, n (%)*

CVS symptom	Sensible distance	Desktop	No adjust-ment	Anti-reflective glasses	Laptop	Smart-phone	Night mode	Multi-screen
Blurred vision	0 (0)	0 (0)	3 (2.4)	1 (0.8)	0 (0)	3 (2.4)	2 (1.6)	3 (2.4)
Double vision	0 (0)	0 (0)	2 (1.6)	0 (0)	3 (2.4)	0 (0)	3 (2.4)	2 (1.6)
Near vision discomfort	1 (0.8)	0 (0)	2 (1.6)	3 (2.4)	0 (0)	7 (5.7)	4 (3.3)	3 (2.4)
Dry eye	2 (1.6)	0 (0)	5 (4.1)	0 (0)	2 (1.6)	8 (6.5)	4 (3.3)	1 (0.8)
Eye redness	0 (0)	0 (0)	3 (2.4)	0 (0)	0 (0)	2 (1.6)	3 (2.4)	3 (2.4)
Post-screen blur	0 (0)	0 (0)	2 (1.6)	0 (0)	0 (0)	3 (2.4)	2 (1.6)	0 (0)
Irritation	0 (0)	1 (0.8)	4 (3.3)	0 (0)	0 (0)	1 (0.8)	2 (1.6)	4 (3.3)
Headache	3 (2.4)	0 (0)	12 (9.8)	1 (0.8)	3 (2.4)	16 (13.0)	7 (5.7)	2 (1.6)
Multiple symptoms	5 (4.1)	0 (0)	12 (9.8)	2 (1.6)	0 (0)	15 (12.2)	4 (3.3)	7 (5.7)
No symptoms	4 (3.3)	0 (0)	12 (9.8)	1 (0.8)	3 (2.4)	15 (12.2)	12 (9.8)	9 (7.3)
Total	**15 (12.2)**	**1 (0.8)**	**57 (46.3)**	**8 (6.5)**	**11 (8.9)**	**70 (56.9)**	**43 (35.0)**	**34 (27.6)**

Screen-setting and device categories are not mutually exclusive (a participant may appear in more than one column); p = 0.604. Percentages are of the total sample (n = 123).

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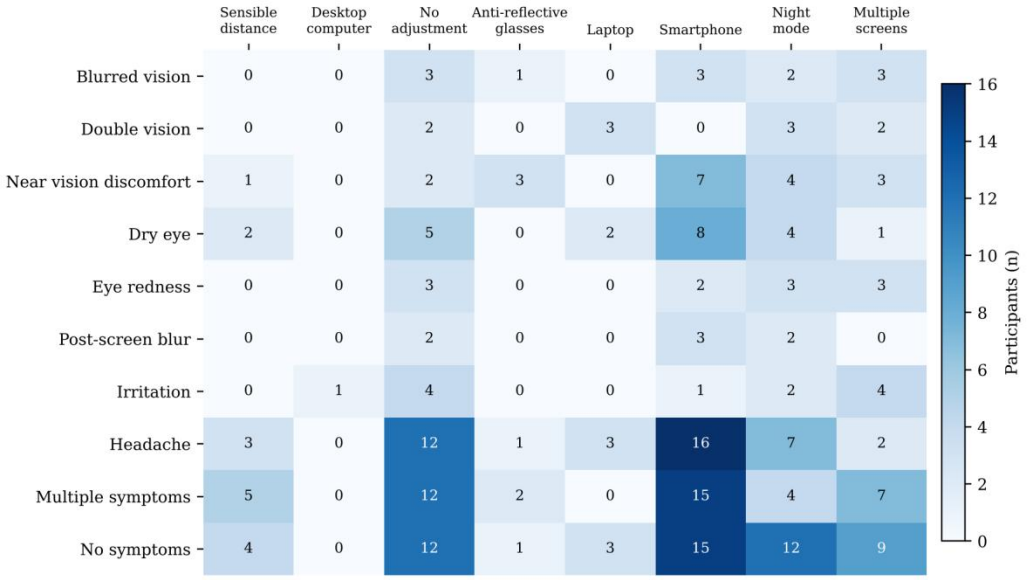

Figure 8: Heat map of CVS symptoms by screen-setting adjustment and device used (counts; categories are not mutually exclusive).

DISCUSSION

This study examined the relationship between blinking rate and CVS among 123 students using digital devices. The mean age was 20.8 years and the sexes were almost equally represented. The commonest daily screen time was 4–6 hours (42.3%). A study at the Faculty of Medicine, Minia University, Egypt, found that 24% of students typically spent 2–3 hours on screens daily,[15] indicating that screen exposure in our students was at least as high.

We found that 76.4% of students had CVS symptoms. Previously reported prevalence rates vary: 68% among medical students in Karachi (2018), 69.5% among government office workers in Ethiopia (2018), 72% among university students in the UAE (2018), 80.3% among engineering students in India (2018), 67.4% among office workers in Sri Lanka (2018), 89.9% among students in Malaysia (2018) and 97.3% in Jeddah, Saudi Arabia.[16,17] Differences between studies may reflect differences in age group, study setting, case definition and sample size.

Headache (18.7%) and multiple symptoms (18.7%) were the most common presentations, followed by dry eye (8.9%), near-vision discomfort (8.1%), blurred vision (4.9%), eye redness (4.9%), irritation (4.9%), double vision (4.1%) and unclear objects after screen use (3.3%). A study at Sohag University Hospital reported higher frequencies of headache (26%), dry eye (28%), blurred vision (31%) and eye redness

(15%) but only 1% for double vision,[17] and the differences may be due to sample size, study duration and age group.

Awareness of CVS was low (30.1%) and only 29.3% knew of the 20-20-20 rule, yet 76.4% were willing to reduce their screen hours; the remaining 23.6% were not. This willingness is similar to that reported in a study from Europe.[21] Poor awareness among students of an ophthalmic institute is of particular concern, as these students will later counsel patients.

Only 1.6% of our participants maintained a normal blinking rate; 98.4% blinked <15 times/min, in keeping with a UK study that found a reduced blink rate during screen tasks compared with the normal 12 blinks/min.[18] Headache was the only symptom reported by participants with a normal rate, and it was also the most frequent symptom among those with a reduced rate. However, no statistically significant association was found between blinking rate and age, gender, screen-setting adjustment or CVS symptoms ($p = 0.12$, 0.90, 0.22 and 0.40, respectively). Because only two participants had a normal rate, the study had virtually no contrast group, and the absence of a significant association should not be interpreted as evidence that blinking is unrelated to CVS.

The lack of screen-setting adjustment was the most frequent abnormality: 55 students (44.7%) who made no adjustment had a reduced blinking rate, as did 43 (34.9%) who used night mode, which suggests that night mode alone does not protect against reduced blinking. In a study at Rawalpindi Medical University, 50% of participants made no adjustment to screen distance,[19] a finding similar to ours and showing that many users neglect screen-related measures that might limit eye strain.

Smartphone users contributed the largest share of symptoms for most complaints, particularly headache (16; 13.0%), dry eye (8; 6.5%), multiple symptoms (15; 12.2%) and near-vision discomfort (7; 5.7%), followed by users making no screen adjustment and users of multiple screens. Night-mode users reported headache (7; 5.7%) and multiple symptoms (4; 3.3%), and several symptom categories were absent among those who kept a sensible distance or used laptops. A study at Minia University found that 92% of students preferred touch screens,[20] which is consistent with the dominant role of handheld touch-screen devices in our symptomatic students.

Limitations

The study was conducted at a single institution with a small, non-randomly selected sample of students, which limits generalisability. Symptoms were self-reported, and blink rate was counted over a short observation period with a stopwatch, which may be affected by observer and task effects. Nearly all participants had a reduced blink rate, leaving too few with a normal rate for a meaningful comparison, and device and screen-

setting categories overlapped. Larger studies with objective, longer blink recording, validated CVS scoring and a comparison group are needed.

CONCLUSION

CVS symptoms affected three-quarters of the students (76.4%), with headache the most common single symptom, and almost all students (98.4%) blinked less than the normal rate during screen use. No statistically significant association between blinking rate and CVS symptoms, age, gender or screen-setting adjustment was demonstrated. Smartphones were the most common device associated with symptoms, nearly half of the students (46.3%) made no adjustment to their screen, and about 70% were unaware of CVS or the 20-20-20 rule. These findings underline the need for awareness programmes on CVS, conscious blinking, the 20-20-20 rule and healthy screen habits, and for larger studies to clarify the role of blinking in CVS.

DECLARATIONS

Ethical approval: Approved by the research committee of the undergraduate section, Pakistan Institute of Community Ophthalmology, Hayatabad Medical Complex, Peshawar (Ref. No. 079/SAS/PICO/24.

Informed consent: Oral informed consent was obtained from all participants.

Conflict of interest: The authors declare no conflict of interest.

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