Population perceived eye strain due to digital devices usage during COVID-19 pandemic

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Abstract

Purpose To assess the magnitude severity and determinants of eyestrain and the use of digital devices in a Saudi population during the COVID-19 pandemic lockdown.

Methods This web-based survey was conducted in September 2020 and enrolled only Saudi nationals 15 years or older. Data were collected on demographics, eye strain related symptoms, severity, and the use of optical aids during the COVID-19 lockdown. The frequency and severity of eye strain were calculated. A Computer Vision Syndrome (CVS) score was graded as none/mild moderate and severe, based on the sum of 15-eye strain related signs and symptoms.

Correlation analysis was performed for determinants of CVS.

Results The study sample was comprised of 2009 individuals with median age of 20 years. Among those who used digital devices for more than 6 h daily, the main reasons for use were work and social purposes among 68.4%, and 61% of respondents, respectively. The prevalence of knowledge on CVS and the ‘20-20 rule for using digital devices’ was 9.4% and 6.9, respectively. The most common symptoms of eye strain from digital device usage were headache, burning, itching, tearing, and redness of eyes. Six hours of daily usage of digital devices was positively associated to the grade of eye strain severity during the COVID-19 lockdown (P < 0.05)).

Conclusion The Saudi population experienced eye strain during COVID-19 lockdown due to excessive digital devices usage. Longer duration of digital devices usage was associated with higher severity of eye strain.

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device usage was associated to eye strain. Health care providers should educate the general population on measures to mitigate eye strain due to digital devices.

**Keywords**  Computer vision syndrome · Visual problems · Digital devices · Digital eye strain · COVID-19 · Eye strain

**Introduction**

After nearly 100 years since the Influenza pandemic, the human population faced the COVID-19 pandemic in 2020 [1, 2]. To prevent high hospitalization rates and mortality, global health organizations recommended personal hygiene, social distancing and restricted mobility especially among high-risk groups [3]. Fortunately, there were alternatives to remain in contact with others by using digital devices such as computers, mobile phones and tablets. [4]. Prior to the pandemic, the estimated utilization of daily computer use was 75% [5, 6].

Factors that cause eye strain include, working with digital devices for a long time, poor illumination, usage at less than the recommended distances and not using the required visual aids for clear vision [7]. Eye strain from digital devices is called Computer Vision Syndrome (CVS) or digital eye strain (DES). CVS is defined as “a complex of eye and vision problems related to near work experienced during prolonged computer, tablet, e-reader and cell phone use” [8].

To combat the pandemic in Saudi Arabia, schools and colleges were initially closed and there was a subsequent transition to online education. This transition often resulted in an excessive use of internet platforms for schoolwork and homework. In the professional environment, many jobs transitioned to an online model mainly using videoconferencing. Thus, the risk of eye strain in the Saudi population increased during the lockdown and pandemic.

Prior to the pandemic, the prevalence of eye strain due to CVS among young Saudi students was 69.8%. [9]. More time spent on computers and digital devices was also found to be a risk factor for CVS. Thus, CVS in the Saudi population was likely to increase during the COVID-19 pandemic. During the period of COVID-19 lockdown, two studies were conducted to study the prevalence of CVS, it’s associated risk factors and common related symptoms associated with the prolonged use of electronic devices perceived signs and symptoms of CVS among the Saudi population aged 18–20 years or older [11, 12]. Known determinants of CVS include female gender, longer duration of work, type of work, refractive status and compliance to spectacle wear [10–13].

This study investigates the scoring for responses of the same CVS Questionnaire, the prevalence of knowledge of CVS and determinants of eyestrain among the Saudi population aged 15 years or older, during the same period.

**Materials and methods**

A cross-sectional survey was performed in September 2020. The study was approved by the Institutional Research Board (P 0436-20) and adhered to the tenets of the Declaration of Helsinki. Informed consent was electronically obtained from all participants after explaining the aims of the study. For children under 16 years of age, an electronic signature of the parent or legal guardian was obtained.

The study population was comprised of Saudi nationals 15 years or older who had access to digital devices during the study period. Sample size calculations, we assumed that there were 10 million Saudis (15 years or older) using digital devices. Previous literature indicated that the prevalence of eye strain during the COVID-19 pandemic and excessive use of digital devices would be 67.8% [14]. To achieve 95% confidence interval and 3% acceptable error margin with clustering factor of 2, at least 1,864 participants were required for the survey. To compensate for the incomplete data we increased the sample by 10%. Thus, the final sample for the proposed survey was 2,050 Saudi aged 15 years or older. Stat calculator to calculate the sample size for a cross-sectional study [15]. Subjects were excluded if they refused to participate in the study, were not able to complete survey data, had chronic ophthalmic diseases that resulted in vision that could not be fully corrected by spectacles or contact lenses (e.g. diabetic macular edema, macular scar, advanced glaucoma, etc.).

To quantify digital eye strain, the Computer Vision Syndrome Questionnaire (CVS) was used in this study [14]. The CVS has acceptable psychometric properties, making it a valid and reliable tool to
control for the visual health of workers who use computer terminals and this survey is appropriate for clinical trials and outcomes research [16].

The survey tool was a web-based questionnaire, which was designed by a research coordinator using a Google form. Investigators and a research coordinator used “Research Survey Invitation e-mail account” to invite all researchers at King Khaled Eye Specialist Hospital (KKESH) to participate in this study. Investigators invited people to participate by posting a link in different social platforms. Both English and Arabic version links were distributed. The survey remained open for a period of 2 weeks. The survey collected data on the profile of participant’s COVID-19/quarantine status, refractive status from pre-existing ophthalmic reports, habitual optical aid usage and usage of digital devices. Data were also collected on the purpose of using digital devices, frequency of digital device usage, duration spent on a digital device, symptoms during digital device usage at least half of the time over the previous week [17]. The behavior and status of optical aid usage was assessed as was the knowledge about the ‘20-20-20 rule’ for using digital devices.

There were 15 questions on eye strain signs and symptoms. For each question, the response choices were never, sometimes and always. Those with signs and symptoms further graded their problem as mild, average and severe (Supplementary Material: 1). According to the American Academy of Ophthalmology, digital device-related eye strain could present as patient complaints of visual blur, achy and tired eyes, dry eyes, or tearing and stinging [12].

Scoring for responses was as follows: (A) frequency of signs/symptoms, never = 0, sometimes = 1, always = 2; (B) severity of sign and symptoms, mild = 1, average = 2 and severe = 3. For each sign and symptom, the total score was calculated using a formula score of A X B. The sum of 15 eye strain related signs and symptoms score was further graded as < 30 = no or mild CVS, 30 to 59 = moderate CVS and more than 60 = severe CVS. To associate the CVS severity to different determinants we grouped the score into no or mild eye strain and moderate to severe eye strain.

The data were transferred into an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA). Qualitative data are presented as number and percentage. The eye strain scores are presented as median and interquartile range (IQR). The grade of eye strain was associated to determinants and for two subgroups, a 2 × 2 table was used to estimate the Student T test and calculate the Odd’s ratio, the 95% confidence interval (CI) and a two-sided P value. For more than 3 subgroups, the chi-square value was calculated along with the degrees of freedom and two-sided P value. P values less than 0.05 were considered statistically significant.

Results

The study sample was comprised of 2,009 participants with median age 20 years (IQR: 18; 22). Table 1 presents the profile of the study sample.

Two hundred and eighty-two (14%) participants were diagnosed with COVID-19, and 223 (11.1%) were quarantined. Three-fourths of participants did not use contact lens or spectacles, 393 (19.6%) used spectacles, 59 (2.9%) used contact lens and 55 (2.7%) used both spectacles and contact lens.

There were 1476 (73.5%) participants who had not undergone an optical checkup in the prior 2 years. Duration of optical aid usage differed between participants, ranging from 1–2 times a week (3.9%) to daily (19.6%). The purpose of using digital devices varied between participants as follows: work only (1.1%), social (24.1%) or both (68.4%). The number of hours spent on digital devices varied among participants, with the majority (61.0%) using them for more than 6 h.

The prevalence of knowledge of CVS was 9.4% (95% CI 8.1; 9.6), and the prevalence of knowledge of the ‘20-20-20 rule’ for using digital devices was 6.9% (95% CI 5.8; 8.0).

Most participants experienced headaches, burning, itching, tearing and redness of eyes related to eye strain from digital devices usage (Table 2).

The median eye strain symptom score was 20 (IQR 10; 32). ‘No/ mild’ grade of eye strain was reported by 1,486 (74%), moderate eye strain by 468 (23.3%) and severe eye strain by 55 (2.7%) participants. Table 3 presents the determinants of eye strain. Longer than 6 h of digital device usage per day was
statistically significantly positively associated to the grade of eye strain severity ($P < 0.001$).

**Discussion/Conclusion**

CVS is a rising public health issue related to continuous use of technology (computers, cell phones and tablets) and is a significant factor in reducing quality of life and workplace productivity [18]. Similar to previous two Saudi studies, which recruited elder participants during the period of COVID-19 lockdown, current study confirmed the excessive use of digital devices among most of the participants [11, 12]. Unlike previous two studies, we defined clearly how and what scoring system used to assess the severity of CVS [11, 12]. Another differences were the very poor use of optical aids (25.5%) by our younger participants when compared with those in the previous two studies [11, 12]. Additionally there was very poor regular checks of refractive status of our participants. Very few participants in the current study had COVID-19.

Alabdulkader reported a high incidence of digital eye strain (75%) during the period of COVID-19 lockdown among the Saudi participants 18 years or older [11]. The outcomes of the current study indicate that nearly one-fourth of Saudi participants 15 years or older had symptoms of moderate to severe eye strain. Almarzouki et al. reported higher rate (44%) of severe eye strain among the Saudi participants 20 years or older during the same period [12].

| Table 1 | Profile of refractive status and usage of digital devices among surveyed Saudi participants |
| --- | --- | --- |
| | Number | Percentage |
| COVID-19 status | | |
| Positive | 282 | 14.0 |
| Negative | 1727 | 86.0 |
| Don’t know | 0 | 0 |
| Quarantine status | | |
| Quarantined | 223 | 11.1 |
| No | 932 | 46.4 |
| Missing | 854 | 42.5 |
| Use of spectacles | | |
| Spectacles for Clear Vision | 393 | 19.6 |
| Contact lens cosmetic | 59 | 2.9 |
| Spectacles and contact lens | 55 | 2.7 |
| No contact lens or spectacles | 1502 | 74.8 |
| Purpose of visual aids | | |
| Spectacle for reading | 723 | 3.6 |
| Spectacle for distance | 222 | 1.1 |
| Spectacle for both | 231 | 1.1 |
| Missing | 1484 | 73.9 |
| Last optical check up | | |
| Within 1 year | 79 | 3.9 |
| 1 to 2 year | 61 | 3.0 |
| More than 2 years | 1476 | 73.5 |
| Not applicable | 393 | 19.6 |
| Duration of using optical aids (hours in week) | | |
| 1–2 times in the week | 79 | 3.9 |
| 3 times or more in a week Daily | 61 | 3.0 |
| Other | 1476 | 73.5 |
| Daily | 393 | 19.6 |
| Using make up | | |
| 1 Daily | 60 | 3.0 |
| 1–2 times in the week | 100 | 5.0 |
| 3 times or more in a week | 45 | 2.2 |
| Not using | 1804 | 89.8 |
| Purpose of using digital devices | | |
| Work only | 23 | 1.1 |
| Social | 485 | 24.1 |
| Contact | 0 | 0.0 |
| Both | 1375 | 68.4 |
| Other | 126 | 6.3 |
| Duration of digital devices usage | | |
| Less than 2 h | 1407 | 70.0 |
| 2–6 h | 644 | 32.1 |
| More than 6 h | 1225 | 61.0 |
In this study, young participants had a very poor knowledge of CVS and the ‘20-20-20 rule’ for working with digital devices. Similar to a previous study, working with digital devices for more than 6 h was positively associated with the presence of signs and symptoms of eye strain ($P < 0.001$) [11].

The current study enrolled a large sample of participants and represents a sample of convenience for assessing digital device usage among Saudis aged 15 years and older. Although this sample may not be representative of the entire adult Saudi population, the findings reflect the habits of the population facing lockdown and forced to overuse digital devices for their business and/or personal use including entertainment, communication and education. The vision/eye health impact of digital device abuse requires healthcare providers to educate patients on incorporating healthy vision practices among the general population.

In the current study, only 9.4% of participants had adequate knowledge of CVS and only 7% knew about the ‘20-20-20 rule’ for using digital devices. These outcomes were much lower than the proportion of Saudi medical students (91.35%), and Indian students (34%) who knew about CVS [17, 18]. In addition, Alabdulkader found that 32% of the elder Saudi participants were aware of the 20-20-20 rule, only 13% of these participants practiced it, and 50% reported that they practiced it occasionally [11]. The higher level of knowledge in previous studies could be attributed to the high educational level of the participants with a medical education background [19, 20].

Nearly two thirds of participants in our study used digital devices for professional and social interactions. A previous study also noted increased digital devices usage in the era of COVID-19 for professional and other purposes [21].

We found that the compliance for using visual aids among participants was 3.6%, 11.1% and 11.5% for reading, distance viewing and both, respectively. This was much lower than the projected number of individuals with refractive error in this age group of Saudis. The prevalence of refractive error among 16 to 39-year-old Saudis was reported to be 45.8% as follows; 24.4% myopes, 11.9% hyperopes and 9.5% astigmatism [22]. Another study reported refractive error as high as 55.5% among Saudi adolescents [23]. The prevalence of refractive error among 20–60-year-old Saudis was reported to be 75.2% as follows; 41.2% myopes, 12.1% hyperopes and 20.9% astigmatism [12]. Thus, the risk of eye strain will be elevated in a population with a high prevalence of refractive error and low compliance for optical aids [11]. Additional determinant factors with the symptoms severity score

| Title                                  | Always | Sometimes | Never | Score |
|----------------------------------------|--------|-----------|-------|-------|
|                                        | Severe | Average   | Severe | Average | Median (IQR) |
| 1 Burning                               | 35     | 176       | 58    | 1226   | 514         | 2.0 (0.0; 2.0) |
| 2 Itching                               | 69     | 168       | 96    | 1267   | 409         | 2.0 (0.0; 2.0) |
| 3 Foreign body sensation                | 54     | 100       | 37    | 835    | 983         | 0.0 (0.0; 2.0) |
| 4 Tears (watering)                      | 144    | 263       | 58    | 1145   | 399         | 2.0 (0.0; 2.0) |
| 5 Excessive blinking                    | 50     | 108       | 34    | 711    | 1105        | 0.0 (0.0; 2.0) |
| 6 Redness                               | 92     | 123       | 74    | 986    | 734         | 2.0 (0.0; 2.0) |
| 7 Eye pain                              | 55     | 106       | 67    | 877    | 906         | 0.0 (0.0; 2.0) |
| 8 Drooping eyelids                      | 47     | 74        | 33    | 592    | 1263        | 0.0 (0.0; 2.0) |
| 9 Dryness of eyes                       | 74     | 101       | 36    | 685    | 1113        | 0.0 (0.0; 2.0) |
| 10 Blurring of vision                   | 98     | 87        | 60    | 740    | 1024        | 0.0 (0.0; 2.0) |
| 11 Double vision                        | 40     | 52        | 33    | 484    | 1400        | 0.0 (0.0; 2.0) |
| 12 Difficulty in focusing near object   | 101    | 81        | 55    | 820    | 1052        | 0.0 (0.0; 2.0) |
| 13 Intolerance to light                | 174    | 143       | 75    | 702    | 915         | 0.0 (0.0; 2.0) |
| 14 Seeing coloredhalos                 | 62     | 54        | 16    | 530    | 1347        | 0.0 (0.0; 2.0) |
| 15 Feeling of worsening eyesight       | 99     | 80        | 50    | 759    | 1021        | 0.0 (0.0; 2.0) |
| 16 Headache                            | 250    | 195       | 170   | 992    | 402         | 2.0 (0.0; 4.0) |
reported in other Saudi studies included the number of devices used; the use of rewetting drops [11].

In our study, 73.5% participants did not undergo optical checkups for more than 2 years and used optical aids sparingly. This could also contribute to ocular strain symptoms. We concur with previous studies that urgent action is warranted to improve compliance with spectacle wear and contact lens usage to address eye strain [24, 25].

In the present study, all participants were using digital devices and majority of them reported eye strain related symptoms and signs. The most common symptoms associated with digital devices eye strain are headaches, blurred vision, dry eyes, pain in the neck, and shoulders [8]. Our outcomes concur with a previous study that reported 62.1% of Saudi medical students had similar signs and symptoms of eye strain [26]. Another study has also reported a high prevalence of eye strain in Pakistan (90.4%) [27]. Another study done in India reported a 82.4% prevalence of eye strain among medical and engineering students [26]. The high prevalence of eye strain reported in the present study can be explained by a shift towards excessive use of digital devices during the COVID-19 lockdown. Bahkir et al. also found that 93.6% of participants had an increase in their screen time since the lockdown and 56.5% reported increased frequency and intensity of symptoms since the lockdown [20].

Headache was the most commonly reported internal symptoms and the burning sensation with

| Table 3 | Determinants of eye strain due to the digital devices usage during COVID-19 among adult Saudi surveyed participants |
|---------|------------------------------------------------------------------------------------------------------------------|
|         | Eye strain of moderate to severe grade (N=527)                                                                     | No/mild grade of eye strain (N=1488) | Validation |
|         | Number | Percentage | Number | Percentage | OR = 1.3 (95% CI 0.8: 1.9) | P = 0.26 |
| Age group | < 30 years | 491 | 93.2 | 1379 | 92.7 |
|         | 31 and older | 29 | 5.5 | 104 | 7 |
| COVID status | Yes | 73 | 13.9 | 193 | 13 |
|         | No | 394 | 74.8 | 1290 | 86.7 |
|         | Don’t know | 60 | 11.4 | 5 | 0.3 |
| Quarantined | Yes | 60 | 11.4 | 154 | 10.3 |
|         | No | 234 | 44.4 | 666 | 44.8 |
|         | Missing | 233 | 44.2 | 668 | 44.9 |
| Digital devised used for | Work only | 9 | 1.7 | 13 | 0.9 |
|         | Social | 116 | 22 | 353 | 23.7 |
|         | Both | 315 | 59.8 | 1024 | 68.8 |
|         | Other | 27 | 5.1 | 93 | 6.3 |
|         | Missing | 60 | 11.4 | 5 | 0.3 |
| Type of visual aid usage | Spectacles for Clear Vision | 115 | 21.8 | 256 | 17.2 |
|         | Contact lens cosmetic | 12 | 2.3 | 45 | 3 |
|         | Spectacles and contact lens | 16 | 3 | 38 | 2.6 |
|         | No contact lens or spectacles | 324 | 61.5 | 1144 | 76.9 |
|         | Missing | 60 | 11.4 | 5 | 0.3 |
| Visual aid used for | Spectacle for reading | 17 | 3.2 | 51 | 3.4 |
|         | Spectacle for distance | 66 | 12.5 | 151 | 10.1 |
|         | Spectacle for both | 74 | 14 | 138 | 9.3 |
|         | Missing | 370 | 70.2 | 1148 | 77.2 |
| Visual aid checking done | In last one year | 124 | 23.5 | 316 | 21.2 |
|         | 1–2 years | 45 | 8.5 | 93 | 6.3 |
|         | More than 2 years | 114 | 21.6 | 317 | 21.3 |
|         | Not applicable | 244 | 46.3 | 762 | 51.2 |
itching were the main external symptoms. However, the majority of reported symptoms were mild. Previous study have also reported headache as the main symptom of eye strain [20, 28]. Headache can be due to prolonged use of digital devices. External symptoms of CVS like burning, irritation, redness and tearing are related to dry eye and the internal symptoms of strain, and headache are linked to accommodative and/orbinocular vision stress [7]. They can also be attributed to uncorrected refractive errors or exposure to a continuous bright light for extended periods.

Extended periods of digital device usage (>6 h) seem to be a significant risk factor for eye strain in the current study. Other studies from Saudi Arabia reported defined extended duration of digital device usage as more than 4 h and still reported high rates of eye strain [12, 29–31]. This relationship between the duration of digital devices usage and eye strain has prompted some experts to suggest a reduction in the number of hours spent in front of computers and other devices to mitigate the risk of serious visual problems [20, 26]. Hence, they recommend public health initiatives directed at the general population on good practices for digital device usage. Taking breaks during electronic use, viewing computers at appropriate distance, and the use of screen protectors were significant practices to relive the eye symptoms severity score [11].

In the current study, very few participants had COVID-19. Hence, we could not test for an association of this disease and eye strain. The American Academy of Ophthalmology reports that 1–3% of people with confirmed COVID-19 may have conjunctivitis, either as an initial presenting sign or during advanced stage of the disease [32]. Some common ocular symptoms recorded in patients with conjunctivitis and confirmed COVID-19 infection include itching, redness, tearing, discharge, and foreign body sensation [32–34]. It will be interesting to study the additive impact of COVID-19 infection on eye strain due to excessive digital devices usage during the lockdown.

There are some limitations to the present study including the cross sectional survey design that precluded an establishment of eye strain to known risk factors. Therefore, we recommend judicious interpretation of a causal association of eye strain to risk factors in the current study. The sample size may not be representative of the entire adult Saudi population as the reported symptoms were subjective, self-reported should not be compared by studies based on objective measurements of eye strain.

During the COVID-19, pandemic outdoor activities were limited for children and they spent more time using digital devices for educational purposes and social interactions. Hence, they are vulnerable to a potential eye health effect. We recommend that future studies investigate school children for the magnitude and determinants of eye strain during lockdown. It will also be interesting to study the impact of public awareness campaigns for safe use of digital devices on vision.

Conclusion

The study provides evidence that a significant proportion of the Saudi population is affected by CVS during the COVID-19 lockdown due to abuse of digital devices usage. The digital devices usage varied for work or social interactions. Longer use of digital device usage seems to influence increased symptoms of CVS and severity. The majority of the surveyed population had poor knowledge regarding CVS, self-regulating skills regarding digital screen and media devices.

Health promotion initiatives are recommended that incorporate healthy practices for digital device usage in daily life. These initiatives should focus on periodic checkups of refractive status, regular usage of optical aids as prescribed, address dry eye and incorporated the ‘20-20-20 rule’ during digital device usage.

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Author contributions

Dr. AMJA, contributed in writing the proposal, data collection, writing the discussion, methodology, conclusion and abstract. Mr. MA, contributed in writing data collection, writing the introduction. Dr. AA, contributed in collecting data, writing the results, and conclusion. Dr. RK, contributed in reviewing the proposal, doing the statistical analysis, writing methodology, and reviewing the manuscript. Dr. SA-S, contributed in reviewing the proposal, collecting data, and reviewing the manuscript.
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Data availability All data generated or analyzed during this study are included in this published article.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. None of the authors received any support and they have no financial involvement (e.g. employment, consultancies, honoraria, stock ownership and options, expert testimony, grants or patents received or pending, royalties) over the previous 3 years. None of authors have non-financial relationships (personal, political, or professional) that may potentially influence the writing of the manuscript.

Ethical approval The study was approved by the Institutional Research Board (19th July 2020, P 0436-20) at King Khaled Eye Specialist Hospital. This study adhered to tenets of the Declaration of Helsinki.

Informed consent Informed consent was electronically obtained after explaining the aims of the study to all subjects who participated in the study. Participants are aware that all collected data will be published.

Consent to publish This manuscript does not contain any individual’s data in any form (including any individual details, images or videos).

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