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RESEARCH ARTICLE **OPEN ACCESS**

The Impact of Electronic Device Use on Dry Eye Disease Symptoms based on Age and Gender: A Cross-sectional Study in Health Science University Students

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Abstract:

Background: Individuals with dry eye disease (DED) may experience ocular symptoms, affecting their quality of life. DED is multifactorial and is related to age, gender, and other factors. While a study may contain examination results of DED symptoms in elderly populations, where electronic device use has contributed to DED, disease occurrence in younger populations, such as university students, remains unclear.

Purpose: We evaluated DED frequency and risk factors for health science university students using electronic devices during online courses.

Methods: This study is a cross-sectional study using a previously validated DED questionnaire Computer Vision Syndrome Questionnaire (CVSQ), which contains three parts: student demographics, electronic device information, and DED symptoms. We conducted an observational cross-sectional study of 359 health science students (aged 18 and above) at King Saud Bin Abdulaziz University for Health Sciences, Jeddah, Saudi Arabia, between October 2022 and January 2023. We collected data on electronic device variables and DED symptoms in this cohort.

Results: We recruited 359 male (29.2%) and female (70.8%) health science students. Participant ages ranged from 18–20 (62.4%) to 21–27 (37.6%) years old. Participants were asked 24 questions, which gathered information on electronic device type, screen time in online classes, occupational characteristics (smoking status), and associated eye symptoms, such as pain, redness, itchiness, dryness, and heavy eyelids. Based on most responses, the Tablet was the most used and preferred device (85%), with continuous use of the device during university courses/ activities (85.8%). The correlation of the survey parameters was only significantly related to gender and study years with DED symptoms. The highest eye symptom intensity levels (always to severe) indicated burning (6.7%) and dryness (8.6%) sensations. Lastly, a significant association was identified between DED symptoms and screen time, gender, and smoking status.

Conclusion: DED symptoms were commonly reported in university students who used electronic devices. Our study provides valuable insights into electronic device usage duration impacted the ocular health of females and younger students, aiding in preventing dry eye disease risks and maintaining good eye health.

Keywords: Dry eye disease symptoms, Health science university students, Ocular health, Online classes, Electronic devices, Screen time.

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1. INTRODUCTION

Dry eye disease (DED) is a heterogeneous tear characterized by complex ocular surface symptoms, including dryness, discomfort, and blurred vision [1]. The prevalence of DED is ranging widely between 5% and 50% [2]. DED is one of the primary reasons patients visit ophthalmology clinics [3]. DED has multiple symptoms that have an impact on the patient's quality of life and their ability to function in their daily activities, including sleep quality, caffeine consumption, and use of electronic devices [4]. DED has many risk factors, such as systemic comorbidities, environmental factors, and activities such as using electronic devices for a long time [5]. This study investigates the impact of electronic device habits and DED symptoms.

Although epidemiological research assessing DED symptoms has expanded, and there is a rising global interest in DED, most studies have concentrated on very elderly populations. [6, 7, 8] As a result, the younger population, particularly university students, have little knowledge of DED and its symptoms [9]. The following recent studies investigated the use of electronic devices by young individuals, studies, and their potential link to DED symptoms. Starting with a study in 2016 shows the prevalence of DED among teenagers who spent an average of 9.7 hours/day using electronic devices were more susceptible to DED [10]. Tripathi *et al.* (2022) reported an observational study that using different electronic devices exerted possible side effects on the younger population, according to the OSDI questionnaire, the prevalence of DED is 41%, but the Schirmer's test shows it at 25% [11]. An additional observational study by Loebis *et al*. (2021) found that among senior high school students who used mobile devices heavily, DED was prevalent at 56% [12]. A recent study shows the female gender's prolonged use of electronic devices for more than six hours is significantly associated with symptomatic DED [4]. A previous study shows that prolonged use of electronic devices causes computer vision syndrome symptoms, including eye pain, redness, strain, blurred vision, double vision, and blink rates symptoms [13]. In a cross-sectional study in 2022 of university students during the COVID-19 pandemic, the study showed that increased electronic device use and DED symptoms were interrelated [14]. In 2022, a study reported that using visual display devices for extended periods each day (for study purposes) was linked to a higher risk of developing DED [15].

Another study demonstrated that a synchronous hybrid learning environment extended students' time on video display terminals and increased DED symptoms [16]. This questionnaire tested multiple risk factors, such as occupational and symptom parameters, for different subjects, such as students and participants [16]. Several DED questionnaires have been developed to examine multiple risk variables, including occupational and symptom criteria for patients and students. Using a DED questionnaire, Alhamiyani *et al.* examined DED risk factors and identified significant hypercholesterolemia and arthritis risks in patients with DED [17]. Based on the DED-related questionnaire, Mohan *et al*. also reported using the Computer Vision Syndrome Questionnaire (CVSQ) to evaluate whether digital device usage was related to the increased prevalence of vision symptoms in students during the COVID-19 pandemic [18]. Also, a previous study investigated the effect of reading using a smartphone and showed that CVSQ scores and the Ocular Surface Disease Index (OSDI) increased significantly [19].

Therefore, our study adopted a conducted questionnaire referred to CVSQ [14] in this study to evaluate DED frequency and related risk factors in health science students using electronic devices at King Saud Bin Abdulaziz University for Health Sciences (KSAU-HS) in Jeddah, Saudi Arabia.

2. METHODS

We used a questionnaire-based cross-sectional study design [18] to analyse relationships between common dry eye symptoms and electronic device use in health science students from King Saud Bin Abdulaziz University for Health Sciences (KSAU-HS), Jeddah, Saudi Arabia, between October 2022 and January 2023.

2.1. Study Population

The total number of KSAU-HS students was 1487, including students/ individuals of male and female gender. The estimated sample size was 150 based on the prevalence study (87%) [12] and by using the Raosoft website (http://www.raosoft.com/samplesize.html) with a confidence level of (95%) and an error rate of (5%). The electronic questionnaire was randomly distributed *via* university email to King Saud Bin Abdulaziz University for Health Sciences (KSAU-HS) students. We received 367 responses in total between October 2022 and January 2023. Of these, only 359 students indicated their

willingness to participate, while 8 expressed their unwillingness. Worth mentioned that students under 18 years old or those wearing contact lenses were excluded from the study.

2.2. Data Collection

Before recruitment, participants were informed about the study's purpose, length, and anonymity. Participants were informed that their data would be used for research purposes, with anonymity assured. The Declaration of Helsinki guidelines were followed throughout the study. Before the study commences, informed consent was requested from participants by checking the appropriate box. The institutional review board approved the study at King Abdullah International Medical Research Centre (IRB NRJ21J/296/12).

Using Microsoft Forms, the authors developed an online questionnaire with the required restrictions to be completed. The questionnaire was divided into three sections: student demographics, electronic device information, and DED symptoms. The demographic section gathered information on gender, age, and occupational information such as education levels and smoking status. The next section gathered information on electronic devices and time devoted to study and recreative activities. DED symptom questions were based on a previously developed and validated questionnaire [18]. Ten symptoms were identified as most common in students: blinking, blurring, burning, dryness, heaviness, itching, pain, redness, sensation, and watering. Symptoms frequency and intensity were categorized: Never, Occasionally Moderate, Occasionally Severe, Always Moderate, and Always Severe.

We excluded four questions related to eye strain symptoms, such as experiencing halos around objects, experiencing increased sensitivity to light, complaining of headaches, and worsening eyesight [18].

2.3. Statistical Analysis

Participant data were exported to Microsoft Excel from Microsoft Forms, and statistical analyses were performed using IBM SPSS Statistics software. Quantitative variables were presented as the mean ± standard deviation, while qualitative variables were presented as numbers and percentages. Parametric or nonparametric approaches were used to describe numerical data. Chi-square or Fisher exact tests were used to explore associations between categorical variables, and odds ratios were used to quantify potential associations. All data were categorical (qualitative) and presented as frequencies and percentages. Associated DED risk factors were analysed using multivariate logistic regression analyses on age, gender, electronic device, viewing distance, and screen time duration. We also performed multiple logistic regression analyses to identify independent DED risk factors. Correlations between gender, study year, duration, smoking status, and DED symptoms were examined using Spearman and Pearson correlation coefficient (r) tests. A P-value < 0.05 indicated statistical significance. The more information is in supplemental materials.

3. RESULTS

3.1. Descriptive Analysis

In total, 359 students responded to questionnaires within the allocated time frame. Student ages were distributed as follows: 62.4% (n=224) of students were aged between 18–20 years, 36.8% (n=132) between 21–25 years and 0.8% (n=3) aged ≥ 26. Of the respondents, 70.8% (n=254) were female and 29.2% (n=105) were male, as shown in supplementary materials (Table **S1**).

Student distributions across study years were: 33.7% (n=121) in their first year, 19.2% (n=69) in their second year, 20.3% (n=73) in their third year, 14.8% (n=53) in their fourth year, 2.5% (n=9) in their fifth year, 4.7% (n=17) in their sixth year and 4.7% (n=17) in their seventh year. Additionally, 49.3% (n=177) of students sometimes attended online classes, while 39.6% (n=142) often attended online courses, as shown in supplementary materials (Table **S1**).

In Table **S1**, we observed that 85.8% (n=308) of students spent > 5 hours of screen time/day after online classes when compared with 61.3% (n=220) of students before online courses. The most common and preferred digital devices for online courses were tablets (85%, n=305), laptops (29%, n=104), smartphones (15.6%, n=56), and PCs (8.1%, n=29).

Table **S1** shows the distance between digital devices and the eyes: 49.3% (n=177) of students viewed devices at approximately 0.25 meters from the eyes during online classes, 41.8% (n=150) at 0.5 meters, 8.4% (n=30) at 1 meter and only 0.6% at > 1 meter.

Table **S1** shows smoking habits: 86.9% (n=312) responded that they never smoked, 6.4% (n=23) considered themselves as occasional smokers, 1.1% (n=4) were former smokers, 3.6% (n=13) were second-hand smokers and 1.9% (n=7) were heavy smokers.

3.2. Comparisons between DED Symptoms and Intensity Levels

The DED symptom based on frequency and intensity levels shown the most common disease symptoms associated with intensity were (always to severe) burning at 6.7% (n=24) and dryness at 8.6% (n=31). The least common disease symptoms associated with intensity (never) were excessive blinking at 44.3% (n=159) and heavy eyelids at 59.6% (n=214), as shown in Table **S2** in supplementary materials.

3.3. Correlation Analysis

3.3.1. Correlations between Gender, Study Year, and DED Symptoms

Table **S3** in supplementary materials shows Spearman correlation coefficient analyses to examine the linear correlation between two independent variables, gender and study year, with DED symptoms. Positive correlations

were identified between gender *versus* burning, foreign body sensation, pain in the eyes, and heavy eyelids, with coefficient values of r= 0.132, r= 0.118, r= 0.114, and r= 0.108, respectively (P<0.05). Negative correlations were also identified between the study year and pain in the eyes and vision blurring, with coefficient values of r=-0.127 and r=-0.129, respectively (P<0.05).

3.3.2. Correlations between Gender and Study Year with Electronic Device Usage Duration and Smoking

Table **S4** in supplementary materials shows Pearson correlation coefficient analyses to examine linear relationships between two independent variables: gender with study year, electronic device usage duration, and smoking. Positive correlations were identified between gender and electronic device usage hours during classes/day and between gender, study year and smoking, with coefficient values of r= 0.109 and r= 0.133, respectively (P=0.05).

3.4. Regression Analyses

3.4.1. DED Symptom associations with Regression Models

A linear regression analysis was conducted to understand the relationships between all independent variables and dry eye symptoms. In total, ten regression models were analysed for the ten DED symptoms. The models explained approximately 8% of variations in determining blinking and dry eye symptoms, with 99% confidence levels. Other adjusted R-squared (R^2) values ranged from 0.29–0.76 (P<0.05). Table **1** shows each DED symptom as the dependent variable (DV**)** for the regression model, along with R values, standard errors (SE), and the significance levels (P-value).

In linear regression analysis, explanatory of all independent variables of electronic device habits and DED symptoms which are relevant to the most fitted data were Blinking (P<0.0001, regression coefficient adjusted= 0.084, R^2=0.120), Dryness (P<0.0001, regression coefficient adjusted= 0.083, R^2=0.119) and Watering (P<0.0001, B=0.076, adjusted R^2=0.112) in the study subjects.

3.4.2. Associations between DED Symptoms, Electronic Device Usage Duration, Gender, and Smoking Status

Multivariate regression results between DED symptoms, electronic device use, and smoking status are shown in Table **2** and indicated that electronic device use duration during classes was significantly associated with all dry eye symptoms (P<0.05), except burning, foreign body, and blurring. Regarding gender, females were significantly associated with all dry eye symptoms (P<0.05) except for itching, redness, and heavy eyelids. Additionally, smoking status was significantly (P<0.05) associated only with blinking symptoms in former smokers.

Table 1. Regression model R values, standard errors, and significance levels.

Dry Eye Symptoms (Dependent Variables)	R^2	Standard Error (SE)	P-value
Blinking	0.120	0.976	**0.000**
Blurring	0.086	1.168	0.004
Burning	0.072	1.007	0.025
Dryness	**0.119**	**1.175**	**0.000**
Heaviness	0.081	0.916	0.008
Itching	0.082	1.038	0.008
Pain	0.091	0.953	0.003
Redness	0.083	0.983	0.007
Sensation	0.067	1.024	0.042
Watering	**0.112**	**1.130**	**0.000**

Table 2. Associations between DED symptoms, electronic device usage duration, gender, and smoking status.

Dry Eye Symptoms	How many hours do you use electronic devices during classes/day	Female	Occasional Smoker	Former Smoker	Second-hand Smoker	Heavy Smoker
	p-value					
Burning	0.243	*0.009	0.177	0.231	0.400	0.726
Itching	*0.048	0.566	0.118	0.716	0.794	0.335
Foreign body	0.240	*0.02	0.918	0.796	0.307	0.946
Watering	*0.032	*0.056	0.349	0.426	0.521	0.171
Blinking	*0.04	*0.00	0.490	*0.03	0.579	0.885
Redness	*0.025	0.835	0.856	0.547	0.911	0.798

(Table 2) contd.....

Dry Eye Symptoms	How many hours do you use electronic devices during classes/day	Female	Occasional Smoker	Former Smoker	Second-hand Smoker	Heavy Smoker
	p-value					
Pain	*0.034	*0.019	0.092	0.457	0.811	0.338
Heaviness	*0.013	0.066	0.578	0.228	0.302	0.571
Dryness	*0.037	*0.016	0.669	0.590	0.444	0.385
Blurring	0.748	*0.032	0.926	0.647	0.692	0.703

Note: * Correlation is significant ≤ 0.05 level 2-tailed.

4. DISCUSSION

The impact of this study is to increase health science students' knowledge of the risks of DED based on prolonged use of electronic devices by evaluating DED symptoms using a validated questionnaire. Our results identified three major independent variables (gender, study year, and electronic device usage duration) as potential DED risk factors in students.

Most participants were first-year college students, female, and between the ages of 18 and 20. This result is consistent with a recent cross-sectional questionnaire study that found the prevalence of symptomatic DED among medical students who, in their first year of college, were more likely to be female and to have a more extended experience with using electronic devices [4].

Our result shows that the percentage of students sometimes attending online classes was higher after the COVID-19 pandemic. In a recent study by Otifi *et al*., the virtual learning format persisted after the COVID-19 pandemic affected college academic outcomes, including simulation laboratories and educational systems [20].

Here, the percentage of non-smoking was high among health science students, in contrast to the earlier study conducted in western Saudi Arabia [21].

Also, the highest percentage type of electronic devices that were used by participants was tablets, which is consistent with the previous study [22]. Moreover, the screen time rate of electronic device use was high after the online classes were induced in the education system; this outcome is linked to another study that found that electronic device use for extended periods is highly common in young people [23].

This study thoroughly investigated the intensity and frequency of DED symptoms. Starting with the intensity, a comparison between DED symptoms and their intensity levels showed burning sensations and dryness symptoms with major severe intensity. This agreed with a previous study that identified common DED side effects in students who used digital devices [9]. A burning sensation is one of the visual problems associated with DED. This symptom was noted in a prior study, including schoolchildren who regularly (54.8%) used digital devices [24].

Following an investigation of the frequency of DED symptoms, this study found that most DED symptoms are always feeling dryness in the eyes. However, a previous study reported that the most frequent DED symptoms may also vary depending on DED severity [25].

These data were compatible with the notion that increased digital screen usage for work, communications, and entertainment, particularly during the pandemic, increased ocular symptoms, such as burning, itching, and tearing, and potentially contributed to DED development [26]. On the other hand, the least frequency to intensity of DED symptoms was never for excessive blinking and heaviness in eyelids. Tsubota *et al*. reported that decreased blinking was associated with digital device use [27]. Additionally, our findings were supported by Vold *et al*., who found that the less frequent symptoms were eyelid heaviness as a sign of DED [28].

The correlation finding revealed significant positive correlations between genders if students experienced burning in their eyes, foreign body sensation in their eyes, pain in their eyes, and heaviness in their eyelids. According to previous epidemiological studies, being female was a DED risk factor, consistent with our findings [29-37]. In our study, negative correlations were identified between the study year and when students experienced pain in their eyes or vision blurring; this finding about the study year is aligned with the studies involving medical students [38, 39]. Therefore, the prevalence of DED symptoms increased among young university medical students. The correlation study shows that the study year and DED symptoms were negatively correlated with statistical significance. In contrast, Aćimović *et al*. compared the study year and DED symptoms and found differences were not statistically significant [15].

Another correlation finding showed a positive correlation between gender and usage duration in online classes. Thus, female students spent more hours using electronic devices than their male counterparts, consistent with previous studies [18, 40, 41]. It also found a positive correlation between smoking status and study year, consistent with studies from the western region of Saudi Arabia and Lebanon [21, 42].

In the regression analyses, our study found the following three DED symptoms, blinking, dryness, and watering, to be most well-fitted by the linear regression analysis of all independent variables of electronic device habits. This result is consistent with earlier research on the relationship DED symptoms and the use of digital devices [43-45].

This study results show that females were at greater risk of DED symptoms when compared with males, this was possibly due to several effects, such as sex and thyroid hormones, as well as systematic conditions related

to dry eye symptoms, including allergies and autoimmune diseases [9]. In our study, smoking was significantly associated with eye blinking frequency. Interestingly, a previous study examining DED symptoms related to occupational characteristics reported that higher prevalence rates were observed in smokers with dry eye symptoms such as blinking [46].

This observational study's limitation is that evaluating the DED risk factor due to prolonged use of electronic devices among college students exclude some DED questions in the questionnaire utilized in this study [18]. Future studies should incorporate all questions about DED symptoms, including double vision, near-focusing, halos around objects, light sensitivity, headaches, and worsening eyesight, to enhance the evaluation of DED further.

CONCLUSION

In this cross-sectional study, we used the questionnaire to investigate electronic device habits and the DED risk factors/symptoms in university health science students according to gender and study year. Female gender, study year, and prolonged screen time on electronic devices were associated with increased DED symptom severity and risk. This study will help health science students and other students become more aware of electronic device use in preventing DED symptoms. Future research must address these DED symptoms/risk factors. Clinical assessments should be performed to generate evidence-based data that may reduce DED symptoms/risks due to digital device overuse in society, including university students. In expansion to dry eye disease treatment, a lifestyle that includes the frequent use of electronic devices may be compelling for dry eye treatment. Further testing will be required to determine the effect of utilizing electronic devices in daily life in preventing dry eye disease.

AUTHORS' CONTRIBUTION

The authors confirm their contribution to the paper as follows: study conception and design: AA; data collection: JA, TA, RB,AA, MA,LA; data analysis and interpretation of results: MK. ZZ. Author; writing the paper: RA. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

DED	=	Dry eye disease
CVSQ	=	Computer Vision Syndrome Questionnaire
OSDI	=	Ocular Surface Disease Index
KSAU-HS	=	King Saud Bin Abdulaziz University for Health Sciences

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The institutional review board approved the study at King Abdullah International Medical Research Centre, Jeddah, Saudia Arabia (IRB NRJ21J/296/12).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of institutional and/or research committees and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from the participants.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data and materials used in this study were primarily obtained from self-reported questionnaires administered to participants. All data collected has been securely archived and is available upon request. For specific inquiries or to access the raw data, please contact the corresponding author [R.A.] at [lwihanr@ksau-hs.edu.sal].

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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Declared none.

SUPPLEMENTARY MATERIAL

Supplementary material is available on the publisher's website along with the published article.

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