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Electronic device exposure and dry eye symptoms among medical and nonmedical Palestinian university students: a multicenter cross-sectional study of associated factors

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Abstract

Background Dry eye disease (DED) is a prevalent ophthalmological health condition affecting university students. This study was conducted to assess the prevalence of DED among medical and nonmedical university students. In addition, another objective was to assess the impact of electronic device exposure on DED symptoms among medical and nonmedical Palestinian university students.

Methods This was a large multicenter cross-sectional study that was conducted among medical and nonmedical students in the largest five major universities across the West Bank of Palestine. The study was conducted in the period between May 2024 and October 2024. DED symptoms were assessed using the Arabic version of the ocular surface disease index.

Results A total of 426 students completed the questionnaire (response rate = 93.4%). Of the university students, 259 (60.8) were medical and 167 (39.2) were nonmedical students. The majority of the students ($n = 355$, 83.3%) used electronic devices. Of the students, 184 (43.2%) used more than one electronic device. The mean number of hours spent using electronic devices per day was 7.7 ± 2.7 h. The mean ocular surface disease index score was 28.9 ± 19.8. Of the students, 334 (78.4%) had DED symptoms of any severity, 77 (18.1%) had mild, 85 (20.0%) had moderate, and 172 (40.4%) had severe DED symptoms. Higher ocular surface disease index scores can be predicted by female sex (p-value = 0.001), consumption of alcohol (p-value = 0.001), having inadequate sleep (p-value < 0.001), using artificial tears (p-value < 0.001), and number of hours spent using electronic devices per day (p-value = 0.007).

Conclusion Increased exposure time was associated with higher prevalence and severe DED symptoms, indicating a need for preventive measures such as screen breaks and ergonomic solutions. Factors related to contact lens use, inadequate sleep, and family history underscore the multifactorial nature of this condition. Interventions targeting

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these factors, including educational awareness and accessible eye care, are crucial given the potential negative impact on academic performance and quality of life.

Keywords Dry eye disease, Prevalence, Risk factors, University students, Digital devices, Palestine

Background

Dry eye disease (DED) is a chronic ophthalmological health condition affecting the anterior surface of the eye—including both the cornea and the conjunctiva—characterized by persistent burning or irritation, and if left untreated, can result in inflammatory damage to the ocular surface [1]. DED symptoms include dryness, ocular pain, burning sensation, visual disturbance, ocular fatigue, grittiness, photophobia, soreness, irritation, and lacrimation [2–4]. In DED, ocular irritation often manifests as symptoms including stinging, burning, blurred vision, grittiness, and/or foreign body sensation [3]. These symptoms often considerably impair visual functioning and lead to difficulty concentrating on tasks that require persistent visual attention, including reading and viewing a screen like working on a computer. Increased sensitivity to light and reduction in visual acuity can negatively affect performing tasks and daily activities, academic performance, and overall quality of life of the affected individuals [3–8].

The global prevalence of DED, typically derived from population-based studies assessing symptoms, ranges between 5% and 50% [9]. Globally, the prevalence of DED was estimated at 11.59% and the prevalence of signs of DED was estimated at 35.2% [10]. The substantial variation in reported prevalence may be attributed to the diverse diagnostic criteria employed and the heterogeneity in population characteristics. It is important to note that the prevalence rates varied by geographical region, age, sex, and diagnostic criterion used [10–12]. Although several clinical tests are available to assist clinicians and optometrists in assessing and diagnosing DED, the majority of studies have used self-reported symptoms as a reliable means to diagnose DED [13–19]. In this context, the evaluation of DED symptoms is likely the most critical component in establishing a diagnosis, as it captures the patient's subjective experience and the variability of symptoms in everyday life. The ocular surface disease index has emerged as one of the most commonly used tools in assessing DED symptoms [20, 21]. The tool has been extensively tested for reliability and validity across diverse populations, providing an efficient and standardized method to assess the severity and impact of dry eye symptoms. Moreover, the tool's comprehensive format—including ocular symptoms, vision-related function, and environmental triggers—allows for a nuanced understanding of DED that other self-reported measures might not offer.

According to epidemiological studies, DED is more prevalent among older individuals and women, particularly those who have recently experienced menopause [4, 9]. Several risk factors have been associated with DED. These risk factors include, environmental factors such as extreme temperatures and low relative humidity [22, 23], the use of video display terminals [24, 25], tobacco use [20], laser eye surgery [26], contact lens wear, and the consumption of specific medications including antihistamines [27], beta-blockers [28], and oral contraceptives are among these identified factors [27, 29].

It has been argued that prolonged use of digital devices by university students, notably medical students who depend heavily on electronic study materials, is a considerable risk factor for DED [19]. The intense nature of medical education requires prolonged screen exposure for accessing and reviewing lecture notes, research articles, and digital resources [30, 31]. This can lead to decreased blink rates and increased tear evaporation. This, along with environmental conditions like air conditioning and low humidity, may intensify ocular surface dryness, thereby affecting students' academic performance and their quality of life. Consequently, examining the prevalence and related causes of DED in this group is essential for designing focused prevention and therapeutic measures. In Palestine, few studies were conducted to assess the prevalence of DED among the Palestinians [32–35]. Moreover, no studies focused on electronic device exposure and DED symptoms among medical and nonmedical Palestinian university students. Therefore, this study was conducted to assess the prevalence of DED among medical and nonmedical university students. In addition, another objective was to assess the impact of electronic device exposure on DED symptoms among medical and nonmedical Palestinian university students.

Methods

Study design and settings

This was a cross-sectional study that was conducted using a questionnaire among medical and nonmedical university students. The study was conducted in adherence to the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) statement. This study was conducted among students in the largest five major universities across the West Bank of Palestine. The study was conducted in the period between May 2024 and October 2024.

Participants and sample size

The university students who were at least 18 years old, enrolled in a medical or nonmedical degree program, willing to respond to items in a questionnaire, and willing to provide written informed consent were included in the study. On the other hand, the students who had past eye surgery, received laser therapy, were heavy smokers, or had a medical condition that is known to reduce tear film production (e.g., Sjögren's syndrome, rheumatoid arthritis, systemic lupus erythematosus, scleroderma, vitamin A deficiency, thyroid disorders, ocular rosacea, meibomian gland dysfunction, and/or blepharitis) were excluded from this study.

According to the Palestinian Central Bureau of Statistics, there were 133,513 students in universities in the West Bank of Palestine. The sample size was calculated for the largest population of university students using an online sample size calculator (www.raosoft.com). The calculator used Daniel's formula to calculate the sample size needed for this study at a 95% confidence interval, accepting a margin of error of 5%, and a response distribution of 50%. The sample size needed for this study was 385 students. To account for potential refusals, we decided to invite 500 students to participate in this study, and ultimately, 426 students completed the questionnaire.

Study tool and data collection

The study tool was a questionnaire that was developed based on previous related studies [12, 14, 16–19]. The questionnaire collected the demographic, academic, and background variables of the university students. These variables included sex, age, field of study, academic year, study approach (using traditional paper-based study materials, modern electronic devices, or a combination of both), types of electronic devices used, family history of DED, number of hours spent using electronic devices per day, past surgical history, using chronic medications, smoking status, consumption of alcohol, routinely practicing swimming, history of allergy, having inadequate sleep, using contact lenses, and using artificial tears.

In addition, the questionnaire also contained the Arabic version of the ocular surface disease index [20, 21]. The ocular surface disease index was developed in 1997 by Allergan Inc.'s Outcomes Research Group (Irvine, California). The index contains 12 items and was designed to provide a rapid assessment of symptoms associated with ocular irritation and DED over the preceding week. The index contains three subscales: ocular symptoms (5 items), vision-related function (4 items), and environmental triggers (3 items) [21]. The students had to answer each item using a Likert scale of 0–4, where 0 denoted never, 1 denoted some of the time, 2 denoted half of the time, 3 denoted most of the time, and 4 denoted all the time. The questionnaire is provided as supplementary Table S1.

Statistical analysis

The ocular surface disease index scores were calculated using the following formula [21]:

$$Score = \frac{(sum\ of\ scores)\ X\ 25}{(\#\ of\ questions\ answered)}$$

Scores could range from 0 to 100. The calculated scores were interpreted as follows: 0–12 = normal, 13–22 = mild DED, 23–32 = moderate DED, and ≥ 33 = severe DED [36, 37].

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS), version 29.0. Categorical data were expressed as frequencies and percentages and continuous data were expressed as means with standard deviations (SD). Differences in continuous scores were compared using independent t-tests or analysis of variance (ANOVA) and differences in the distribution of categorical variables were assessed using Chi-square tests. Correlations were assessed using Pearson's correlations. To control potentially confounding factors, the variables that were significantly associated in the independent t-tests, ANOVA, or Pearson's correlations were included in a multiple linear regression model. A p-value of less than 0.05 was considered statistically significant, indicating that any observed differences were unlikely to be attributable to chance.

Ethical approval

The study was conducted in adherence to the local and international ethical principles, including those in the Declaration of Helsinki. The study received approval from the Institutional Review Board (IRB) of An-Najah National University (Med. Dec.2023/48). Written informed consent was obtained from all university students before they participated in the study, ensuring voluntary participation and awareness of the aims and procedures of the study.

Results

Demographic and background characteristics of the university students

A total of 456 university students were approached and invited to participate in this study. Of those, 426 students completed the questionnaire, giving a high response rate of 93.4%. The participant selection is shown in Fig. 1.

Of the university students, 259 (60.8) were medical and 167 (39.2) were nonmedical students. The mean age of the university students was 20.4± 2.0 years. The majority of the students (n = 355, 83.3%) used electronic devices, and 21 (4.9%) used books/papers and electronic study materials.

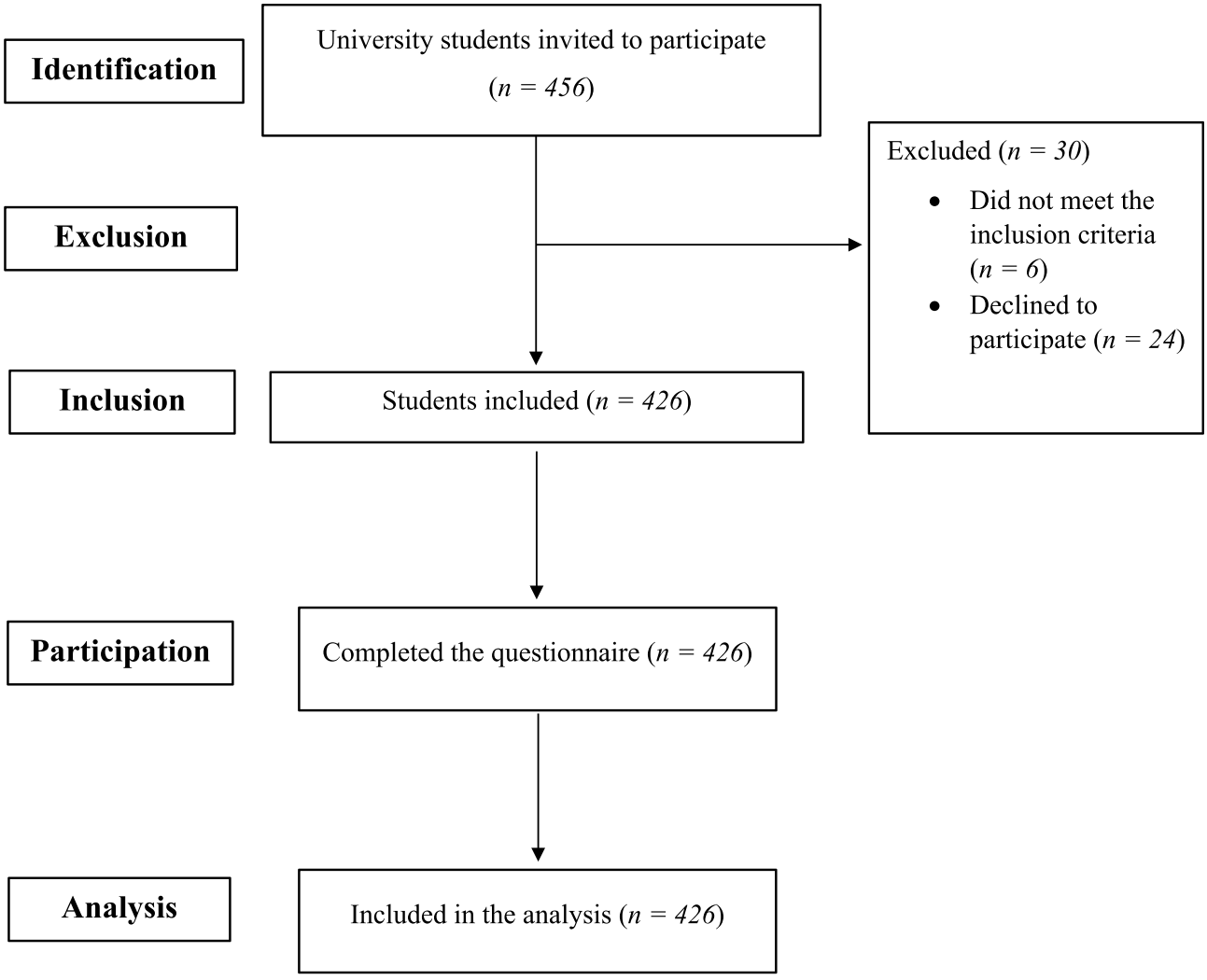

Fig. 1 Flow diagram of participant selection

Of the students, 184 (43.2%) used more than one electronic device. The mean number of hours spent using electronic devices per day was 7.7 ± 2.7 h. Of the students, 249 (58.5%) were females, 78 (18.3%) had a family history of DED, 70 (16.4%) had a past surgical history, and 33 (7.7%) used chronic medications. In addition, 42 (9.9%) students were smokers, 9 (2.1%) consumed alcohol, 100 (23.5%) routinely practiced swimming, 98 (23.0%) had a history of allergy, 188 (44.1%) reported having inadequate sleep, 34 (8.0%) used contact lenses, and 74 (17.4%) used artificial tears. The detailed demographic and health characteristics of the university students are shown in Table 1.

Responses of the students on the 12-item ocular surface disease index

In this study, a significant proportion of university students reported experiencing ocular symptoms and vision-related problems as indicated by "half of the time", "most of the time", and "all the time" answers. Of the students, 158 (37.1%) reported weakness in vision, 147 (34.6%) reported blurred vision, 139 (32.6%) reported painful or sore eyes, 116 (27.2%) reported sensitive eyes to light, and 55 (12.8%) reported sensation of having sand. The detailed responses of the students are shown in Table 2.

Similarly, 124 (29.1%) students reported problems with reading, 105 (24.6%) reported problems with working with a computer or bank machine, 92 (21.6%) reported problems with watching television, and 37 (8.7%) reported problems with driving at night (Table 2).

Regarding the environmental triggers, 153 (35.9%) students reported problems in windy conditions, 133 (31.2%) reported problems in air-conditioned areas, and 110 (25.8%) reported problems in places or areas with low humidity (Table 2).

Prevalence of DED

The mean ocular surface disease index score was 28.9 ± 19.8. Of the students, 33 (78.4%) had DED of any severity,

Table 1 Demographic and health characteristics of the university students ($n=426$)

Variable	*n* (%)
Field of study	
Medical	259 (60.8)
Nonmedical	167 (39.2)
Study approach	
Electronic devices	355 (83.3)
Books and papers	50 (11.7)
Both	21 (4.9)
Type of device	
Laptop	83 (19.5)
Tablet	94 (22.1)
Phone	15 (3.5)
More than one	184 (43.2)
Sex	
Male	177 (41.5)
Female	249 (58.5)
Family history of DED	
Yes	78 (18.3)
No	348 (81.7)
Past surgical history	
Yes	70 (16.4)
No	356 (83.6)
Chronic medications	
Yes	33 (7.7)
No	393 (92.3)
Smoking	
Yes	42 (9.9)
No	384 (90.1)
Alcohol	
Yes	9 (2.1)
No	417 (97.9)
Routine swimming	
Yes	100 (23.5)
No	326 (76.5)
History of allergy	
Yes	98 (23.0)
No	328 (77.0)
Having inadequate sleep	
Yes	188 (44.1)
No	238 (55.9)
Using contact lenses	
Yes	34 (8.0)
No	392 (92.0)
Using artificial tears	
Yes	74 (17.4)
No	352 (82.6)

DED dry eye disease

Table 2 Responses of the students on the 12-item ocular surface disease index

Domain/item	Never		Sometime		Half the time		Most of the time		All the time		Not applicable	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Ocular symptoms												
Sensitive eyes to light	125	29.3	185	43.4	46	10.8	56	13.1	14	3.3	-	-
A sensation of having sand	224	52.6	147	34.5	27	6.3	27	6.3	1	0.2	-	-
Painful or sore eyes	114	26.8	173	40.6	69	16.2	53	12.4	17	4.0	-	-
Blurred vision	124	29.1	155	36.4	66	15.5	39	9.2	42	9.9	-	-
Weakness in vision	142	33.3	126	29.6	49	11.5	36	8.5	73	17.1	-	-
Vision-related functions (Problems with)												
Reading	126	29.6	132	31.0	59	13.8	40	9.4	25	5.9	44	10.3
Driving at night	148	34.7	108	25.4	16	3.8	14	3.3	7	1.6	136	31.9
Working with a computer	133	31.2	118	27.7	49	11.5	41	9.6	15	3.5	70	16.4
Watching television	138	32.4	133	31.2	44	10.3	29	6.8	19	4.5	63	14.8
Environmental triggers												
Windy conditions	111	26.1	137	32.2	55	12.9	59	13.8	39	9.2	25	5.9
Places/areas with low humidity	148	34.7	122	28.6	47	11.0	40	9.4	23	5.4	46	10.8
Air-conditioned areas	137	32.2	128	30.0	51	12.0	49	11.5	33	7.7	28	6.6

Table 3 Prevalence of DED

DED category	*n* (%)
Normal	92 (21.6)
Mild	77 (18.1)
Moderate	85 (20.0)
Severe	172 (40.4)

DED dry eye disease

77 (18.1%) had mild DED, 85 (20.0%) had moderate DED, and 172 (40.4%) had severe DED. The prevalence of DED is shown in Table 3.

Associations between the demographic and health characteristics of the university students and DED

Chi-square tests showed that DED was significantly more prevalent among the students who were females (p-value < 0.001), had a family history of DED (p-value = 0.002), consumed alcohol (p-value = 0.014), had allergy (p-value = 0.010), had inadequate sleep (p-value < 0.001), used contact lenses (p-value = 0.018), and used artificial tears (p-value = 0.029). These associations are shown in Table 4.

Similarly, Pearson's correlations showed that there was a significant positive correlation between the ocular surface disease index scores with the number of hours spent using electronic devices per day (Pearson's r = 0.17, p-value = 0.001). Moreover, t-tests and ANOVA showed that the ocular surface disease index scores were significantly higher for the students who were females (p-value < 0.001), who had a family history of DED (p-value< 0.001), used chronic medications (p-value = 0.012), consumed alcohol (p-value= 0.012), had allergy (p-value = 0.007), had inadequate sleep (p-value < 0.001), used contact lenses (p-value < 0.001),

Table 4 Associations between the demographic and health characteristics of the university students with the prevalence and severity of DED

Category	Subcategory	Presence of DED		*p*-value	DED category				*p*-value
		No	Yes		Normal	Mild	Moderate	Severe	
		n (%)	*n* (%)		*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Field of study	Medical	112 (26.3)	147 (34.5)	0.061	58 (13.6)	54 (12.7)	48 (11.3)	99 (23.2)	0.218
	Nonmedical	57 (13.4)	110 (25.8)		34 (8.0)	23 (5.4)	37 (8.7)	73 (17.1)	
Study approach	Electronic devices	136 (31.9)	219 (51.4)	0.435	75 (17.6)	61 (14.3)	72 (16.9)	147 (34.5)	0.751
	Books and papers	23 (5.4)	27 (6.3)		12 (2.8)	11 (2.6)	11 (2.6)	16 (3.8)	
	Both	10 (2.3)	11 (2.6)		5 (1.2)	5 (1.2)	2 (0.5)	9 (2.1)	
Type of electronic device	Laptop	29 (6.8)	54 (12.7)	0.158	18 (4.2)	11 (2.6)	23 (5.4)	31 (7.3)	0.084
	Tablet	46 (10.8)	48 (11.3)		29 (6.8)	17 (4.0)	14 (3.3)	34 (8.0)	
	Phone	5 (1.2)	10 (2.3)		4 (0.9)	1 (0.2)	2 (0.5)	8 (1.9)	
	More than one	67 (15.7)	117 (27.5)		30 (7.0)	37 (8.7)	34 (8.0)	83 (19.5)	
Sex	Male	96 (22.5)	81 (19.0)	**< 0.001**	57 (13.4)	39 (9.2)	32 (7.5)	49 (11.5)	**< 0.001**
	Female	73 (17.1)	176 (41.3)		35 (8.2)	38 (8.9)	53 (12.4)	123 (28.9)	
Family history of DED	Yes	19 (4.5)	59 (13.8)	**0.002**	7 (1.6)	12 (2.8)	12 (2.8)	47 (11.0)	**< 0.001**
	No	150 (35.2)	198 (46.5)		85 (20.0)	65 (15.3)	73 (17.1)	125 (29.3)	
Past surgical history	Yes	33 (7.7)	37 (8.7)	0.162	15 (3.5)	18 (4.2)	9 (2.1)	28 (6.6)	0.185
	No	136 (31.9)	220 (51.6)		77 (18.1)	59 (13.8)	76 (17.8)	144 (33.8)	
Chronic medications	Yes	9 (2.1)	24 (5.6)	0.130	4 (0.9)	5 (1.2)	5 (1.2)	19 (4.5)	0.196
	No	160 (37.6)	233 (54.7)		88 (20.7)	72 (16.9)	80 (18.8)	153 (35.9)	
Smoking	Yes	21 (4.9)	21 (4.9)	0.150	12 (2.8)	9 (2.1)	6 (1.4)	15 (3.5)	0.505
	No	148 (34.7)	236 (55.4)		80 (18.8)	68 (16.0)	79 (18.5)	157 (36.9)	
Alcohol	Yes	0 (0.0)	9 (2.1)	**0.014**	0 (0.0)	0 (0.0)	2 (0.5)	7 (1.6)	0.077
	No	169 (39.7)	248 (58.2)		92 (21.6)	77 (18.1)	83 (19.5)	165 (38.7)	
Swimming	Yes	46 (10.8)	54 (12.7)	0.139	26 (6.1)	20 (4.7)	20 (4.7)	34 (8.0)	0.431
	No	123 (28.9)	203 (47.7)		66 (15.5)	57 (13.4)	65 (15.3)	138 (32.4)	
History of allergy	Yes	28 (6.6)	70 (16.4)	**0.010**	13 (3.1)	15 (3.5)	24 (5.6)	46 (10.8)	0.063
	No	141 (33.1)	187 (43.9)		79 (18.5)	62 (14.6)	61 (14.3)	126 (29.6)	
Inadequate sleep	Yes	52 (12.2)	136 (31.9)	**< 0.001**	24 (5.6)	28 (6.6)	35 (8.2)	101 (23.7)	**< 0.001**
	No	117 (27.5)	121 (28.4)		68 (16.0)	49 (11.5)	50 (11.7)	71 (16.7)	
Contact lenses	Yes	7 (1.6)	27 (6.3)	**0.018**	5 (1.2)	2 (0.5)	1 (0.2)	26 (6.1)	**< 0.001**
	No	162 (38.0)	230 (54.0)		87 (20.4)	75 (17.6)	84 (19.7)	146 (34.3)	
Artificial tears	Yes	21 (4.9)	53 (12.4)	**0.029**	6 (1.4)	15 (3.5)	8 (1.9)	45 (10.6)	**< 0.001**
	No	148 (34.7)	204 (47.9)		86 (20.2)	62 (14.6)	77 (18.1)	127 (29.8)	

DED dry eye disease, *SD* standard deviation, statistically significant p-values are in boldface

Table 5 Associations between the demographic and health characteristics of the university students with the ocular surface disease index scores

Variable	*n* (%)	Mean (SD)	*p*-value
Field of study			
Medical	259 (60.8)	28.0 (19.6)	0.237
Nonmedical	167 (39.2)	30.3 (20.0)	
Study approach			
Electronic devices	355 (83.3)	29.5 (20.1)	0.308
Books and papers	50 (11.7)	25.2 (17.1)	
Both	21 (4.9)	26.5 (19.1)	
Type of device			
Laptop	83 (19.5)	29.8 (21.4)	0.124
Tablet	94 (22.1)	25.0 (19.0)	
Phone	15 (3.5)	30.5 (19.2)	
More than one	184 (43.2)	31.1 (20.0)	
Sex			
Male	177 (41.5)	22.9 (18.2)	**< 0.001**
Female	249 (58.5)	33.1 (19.8)	
Family history of DED			
Yes	78 (18.3)	36.3 (18.8)	**< 0.001**
No	348 (81.7)	27.2 (19.6)	
Past surgical history			
Yes	70 (16.4)	26.7 (17.1)	0.326
No	356 (83.6)	29.3 (20.2)	
Chronic medications			
Yes	33 (7.7)	37.2 (21.7)	**0.012**
No	393 (92.3)	28.2 (19.5)	
Smoking			
Yes	42 (9.9)	26.5 (21.5)	0.407
No	384 (90.1)	29.1 (19.6)	
Alcohol			
Yes	9 (2.1)	45.2 (18.8)	**0.012**
No	417 (97.9)	28.5 (19.7)	
Swimming			
Yes	100 (23.5)	26.8 (19.6)	0.223
No	326 (76.5)	29.5 (19.8)	
Allergy			
Yes	98 (23.0)	33.6 (19.8)	**0.007**
No	328 (77.0)	27.5 (19.6)	
Inadequate sleep			
Yes	188 (44.1)	35.1 (20.3)	**< 0.001**
No	238 (55.9)	23.9 (17.9)	
Contact lenses			
Yes	34 (8.0)	39.8 (20.9)	**< 0.001**
No	392 (92.0)	27.9 (19.4)	
Artificial tears			
Yes	74 (17.4)	37.7 (21.4)	**< 0.001**
No	352 (82.6)	27.0 (18.9)	

DED dry eye disease, statistically significant pp-values are in boldface

and used artificial tears (p-value < 0.001). These associations are shown in Table 5.

To control potentially confounding factors, the variables that were significantly associated in the t-tests, ANOVA, and Pearson's correlations were included in a multiple linear regression model. The model showed that higher ocular surface disease index scores can be predicted by female sex (p-value = 0.001), consumption of alcohol (p-value = 0.001), having inadequate sleep (p-value < 0.001), using artificial tears (p-value < 0.001), and number of hours spent using electronic devices per day (p-value = 0.007). These associations are shown in Table 6.

Discussion

Given the heavy reliance on digital devices, millions of university students around the world are at increased risk of DED [12, 14, 16–19]. Many studies have investigated the prevalence of DED, the majority of studies focused on relatively older populations, specifically those over 50 years of age [9]. There remains a paucity of current knowledge regarding DED among younger individuals, particularly medical and nonmedical university students [13, 17, 30]. One of the primary risk factors for DED is the prolonged use of visual display terminals, such as smartphones, tablets, or computers, which is highly prevalent among medical and nonmedical university students [12, 14, 16–19]. Consequently, DED among medical and nonmedical students warrants attention. This study aimed to evaluate the prevalence of DED symptoms among university students in Palestine.

In this study, the use of the ocular surface disease index showed that the majority (78.4%) of the university students had signs of DED of any severity and 40.4% had severe DED. These prevalence rates were considerably high and were consistent with the rates reported among university studies in other countries [12, 14, 16–19]. Regional variations in the prevalence of DED symptoms may also be attributed to local environmental and climatic factors. For instance, Thailand's tropical, high-humidity climate differs significantly from that of the Middle East, and such disparities in climate and humidity may play a crucial role in ocular moisture maintenance and reduction of tear evaporation [38]. Climatic conditions and humidity levels vary considerably across Middle Eastern countries. For example, studies from neighboring countries with similar climates further reinforce these findings. Research from Lebanon, Jordan, and Syria has reported a variable prevalence of symptomatic DED, underscoring the significant influence of shared environmental factors in the region [34, 39, 40]. In addition, investigations in Jordan and Syria indicate that arid conditions combined with low relative humidity may exacerbate tear film instability. By contrast, regions such as Saudi Arabia and the UAE—despite their high temperatures—often experience fluctuations in humidity that also contribute to higher DED rates [19, 41]. Moreover, one study reported that greater corneal fluorescein

Table 6 Factors predicting higher ocular surface disease index scores

Variable	Unstandardized coefficients		Standardized coefficients	t	*p*-value	Collinearity statistics	
	B	SE	β			Tolerance	VIF
Sex	6.50	2.02	0.16	3.22	**0.001**	0.85	1.18
Family history of DED	−4.69	2.51	−0.09	−1.87	0.062	0.92	1.09
Chronic medications	−2.05	3.62	−0.03	−0.56	0.573	0.94	1.06
Alcohol	−20.97	6.52	−0.15	−3.21	**0.001**	0.96	1.04
Allergy	−2.17	2.32	−0.05	−0.94	0.349	0.91	1.10
Inadequate sleep	−9.38	1.98	−0.23	−4.75	**< 0.001**	0.89	1.13
Contact lenses	−4.41	3.55	−0.06	−1.24	0.215	0.95	1.05
Artificial tears	−9.14	2.47	−0.17	−3.70	**< 0.001**	0.95	1.05
Number of hours spent using electronic devices per day	0.95	0.35	0.13	2.71	**0.007**	0.97	1.03

DED dry eye disease, *SE* standard error, *t* t-statistics, *VIF* variance inflation factor, statistically significant pp-values are in boldface

staining was associated with lower humidity levels (p-value < 0.0038) and that tear break-up time measurements positively correlated with humidity, indicating that higher humidity is associated with reduced signs of DED [42]. This suggests that even subtle variations in local climates within the Middle East may influence the extent of dry eye symptoms.

In this study, DED was more prevalent among female university students compared to male university students. These findings were consistent with those reported in previous studies in which female sex was identified as an independent risk factor for DED [10, 30]. It has been proposed that sex hormones, hypothalamic-pituitary hormones, thyroid hormones, glucocorticoids, insulin, insulin-like growth factor 1, sex-chromosomal complement, sex-specific autosomal variables, and epigenetics can contribute to a higher prevalence of DED among females [43]. Moreover, university students who wore contact lenses were more likely to develop DED symptoms. These findings align with previous studies indicating contact lenses as a significant risk factor for DED [9, 44, 45]. Wearing contact lenses disrupts the tear film through instability and increased evaporation, which damages the ocular surface and leads to the development of DED symptoms [46]. Additionally, mechanical irritation arising from the contact lens wear-ocular surface interaction can cause dysfunction of the Meibomian glands, further exacerbating the condition of DED [47]. In addition, the university students who had DED symptoms were more likely to use artificial tears. Artificial tears are marketed with a claim to provide symptomatic relief of DED symptoms. The use of artificial tears is hypothesized to stabilize the tear film as well as replenish tear volume and enhance the hydration to the ocular surface, which may provide some alleviation from discomfort caused by DED [48].

In this study, the majority (83.3%) of the university students reported that the use of electronic devices was an integral part of their studying routine. The findings of this study showed that prolonged exposure to digital display terminals was associated with higher prevalence and severe DED symptoms. These findings were consistent with numerous previous studies that have shown an increased prevalence and severe DED symptoms with increased exposure to digital display terminals [13, 49, 50]. Digital display terminal application induces abnormal blinking patterns and consequently the disturbed distribution of meibum and decreased exposure of the eye surface to tear film, which subsequently damages the ocular surface [49]. In addition, the students who suffered from DED symptoms spent more time interacting with electronic devices compared to those who did not report DED symptoms. These findings support the conclusion that prolonged exposure to screens is a risk factor for developing DED symptoms. Recent studies have reported an association between prolonged screen time and the prevalence of DED symptoms [49]. Given the increased dependence on digital devices for everyday life, consideration should be given to potential protective measures such as maintaining regular screen breaks, adjusting screen brightness, or wearing protective eyewear to mitigate the adverse effects of prolonged screen time on ocular health. Although blue-light filtering eyewear has been proposed as a strategy to reduce glare and digital eye strain by selectively blocking high-energy visible blue light [51, 52], a recent systematic review and meta-analysis evaluated three randomized controlled trials and found that blue-blocking spectacles did not significantly reduce the symptoms of digital eye strain [53]. Therefore, while blue-light filtering lenses may offer some benefits, they should be considered only as one component of a multifaceted intervention rather than a standalone solution. These combined strategies appear to be promising in preserving ocular surface integrity and reducing the risk or severity of dry eye symptoms among heavy digital device users.

In this study, the presence of a family history of DED was also associated with the prevalence of DED

symptoms. This finding aligns with previous studies that have indicated a genetic predisposition as an important contributor to the development of DED. Genetic factors may influence tear production or the integrity of the ocular surface, thus predisposing individuals to this condition [54]. In addition, the prevalence of DED was associated with inadequate sleep. Poor sleep quality may lead to inflammation and reduced tear secretion, both of which are essential processes in the development of DED symptoms [55]. Having allergies, consumption of alcohol, and chronic medications were also reported to be associated with the prevalence of DED. Antihistamines, diuretics, and antidepressants have been known to reduce tear secretion and exacerbate DED symptoms [56–58]. Moreover, the consumption of alcohol contributes to dehydration and inflammation, which exacerbate DED symptoms by reducing tear production and ocular surface irritation [59]. Allergies may result in the development of ocular inflammation, leading to dryness and irritation. Evidence from the literature suggests that the severity of DED is increased by allergic conjunctivitis [60, 61].

Another point of comparison between our study and those from surrounding regions involves the associated risk factors for DED. While several studies from the region have identified smoking as a risk factor for DED, our study did not find a significant association between smoking and DED severity. For instance, studies from neighboring countries have reported that chronic or heavy smoking is linked to increased tear evaporation and ocular surface damage, thereby aggravating DED symptoms [34]. One possible explanation for this discrepancy is that the prevalence of smoking in our study sample was relatively low, or that other confounding factors (such as prolonged screen time and inadequate sleep) may have exerted a more pronounced effect on DED among our university students. Additionally, methodological differences, such as the specific screening tools and population characteristics, might contribute to variations in the detection of smoking-related risk. This nuanced difference underscores the importance of considering local demographic and lifestyle factors when comparing risk profiles across different studies [35, 40, 50].

Although we initially speculated that medical students might experience prolonged digital exposure due to the rigorous demands of their education, our analysis revealed no statistically or clinically significant differences in DED prevalence or severity between medical and non-medical students. Several factors may explain this finding. First, electronic devices are used ubiquitously by all university students—for accessing educational resources, communication, and social networking—thereby minimizing any possible disciplinary differences in screen time exposure [62, 63]. Second, lifestyle factors such as inadequate sleep, contact lens use, and varying environmental exposures appear to have a stronger influence on DED symptoms than the field of study per se [61]. Finally, modern educational practices have increasingly adopted digital platforms across both medical and non-medical programs, leading to a more homogeneous exposure among students [62, 63]. These observations suggest that future research should investigate additional personal and environmental variables that may overshadow the expected discipline-based differences in DED risk.

Strengths and limitations of the study

This study had several strengths that enhance its validity and relevance. First, this was the first large-scale, multicenter study that was conducted to assess the prevalence of DED and its associated variables among medical and nonmedical university students in Palestine. The inclusion of students from several universities ensured a broad and representative sample, hence enhancing the generalizability of the findings. Second, a validated screening tool, the ocular surface disease index, was used to assess the prevalence of DED symptoms. The use of this validated tool ensured the reliability of the measurements and allowed the comparison of the findings of this study to those reported elsewhere. Third, the risk factors that potentially were associated with DED symptoms including demographic, health, academic, lifestyle, and environmental exposures were accounted for in this study. Therefore, this study could have allowed a more thorough understanding of the factors contributing to DED among university students by examining a wide array of variables. Fourth, appropriate statistical tests were used to analyze the data, including multiple regression that accounted for potentially confounding factors. This should have improved the validity of the reported associations and ensured that the detected risk factors were not confused by extraneous variables. Fifth, the findings of this study highlighted an important public health issue associated with the heavy use of digital devices by university students. The findings also highlighted the ocular health hazards linked to extended screen exposure, emphasizing the need for preventative measures and awareness initiatives due to the growing dependence on electronic learning tools. Finally, the sample size was relatively large and the response rate was also relatively high. This should have reduced the impact of selection bias and ensured adequate representativeness of the entire population of university students in Palestine.

On the other hand, the study had also some limitations that warrant acknowledgment. First, the use of self-administered questionnaires for data collection may be subject to recall bias and reporting bias. This might have over- or under-estimated the length of screen exposure

or DED symptoms. Second, this was a cross-sectional study. This study design constrained the capacity to determine causality between electronic device exposure and DED symptoms since it just offers a snapshot of relationships rather than long-term consequences. Finally, although several potential risk variables were examined, other unmeasured confounders, including particular environmental circumstances (e.g., air quality, humidity) and academic stress levels, may have impacted the findings.

Conclusion

The study revealed a notably high prevalence of DED symptoms among Palestinian medical and nonmedical university students, with lifestyle, gender, and health-related factors contributing to this condition. Although the modes of studying themselves did not exhibit direct correlations with DED symptoms, increased exposure time was associated with higher prevalence and severe DED symptoms, indicating a need for preventive measures such as screen breaks and ergonomic solutions. Factors related to contact lens use, inadequate sleep, and family history underscore the multifactorial nature of this condition. Interventions targeting these factors, including educational awareness and accessible eye care, are crucial given the potential negative impact on academic performance and quality of life.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

Ramzi Shawahna and Abdul Raheem Abu Shanab were involved in the conception and design of the work, analysis, and interpretation of data, and drafting and final approval of the manuscript. Mohammad Alashqar, Shahed Taqatqa, and Abdalrahman Ayaseha were involved in the data acquisition, analysis, drafting of the work, and final approval of the version to be published. All authors approved the final manuscript.

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Data availability

All data analyzed in this study were included in the manuscript. The datasets used in the analysis or entered into statistical software can be obtained from the corresponding author upon making a reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted in adherence to the local and international ethical principles, including those in the Declaration of Helsinki. The study received approval from the Institutional Review Board (IRB) of An-Najah National University (Med. Dec.2023/48). Written informed consent was obtained from all university students before they participated in the study, ensuring voluntary participation and awareness of the aims and procedures of the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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