

Original Research Article

Association between Digital Screen Exposure and Dry Eye Disease among Medical Students: A Cross-Sectional Observational Study

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ABSTRACT

Background: Medical students increasingly rely on digital displays for academic and recreational activities, creating sustained visual demand that may aggravate dry eye symptoms and tear film instability.

Objective: To evaluate the association between daily digital screen exposure and dry eye symptoms and ocular surface parameters among medical students.

Methods: A cross-sectional observational analysis included 40 medical students aged 20-24 years. Daily screen time, viewing distance, primary device type, Ocular Surface Disease Index (OSDI) score, Schirmer test, tear break-up time (TBUT), contact lens use, refractive error, and sleep quality were evaluated. OSDI scores were classified as normal (0-12), mild (13-22), moderate (23-32), and severe (33-100); OSDI ≥ 13 was treated as symptomatic dry eye. Participant-level ocular surface analyses used the mean of right- and left-eye Schirmer and TBUT measurements. Associations were assessed using Spearman correlation and non-parametric group comparisons.

Results: The mean age was 21.82 ± 1.32 years and mean daily screen exposure was 6.79 ± 1.44 hours. OSDI-defined symptomatic dry eye was present in 36/40 (90.0%), with severe symptoms in 19 (47.5%). Daily screen time correlated strongly with OSDI score (Spearman $\rho=0.988$, $p<0.001$) and inversely with mean Schirmer test ($\rho=-0.981$, $p<0.001$) and mean TBUT ($\rho=-0.983$, $p<0.001$). Shorter viewing distance was associated with higher OSDI scores ($\rho=-0.364$, $p=0.021$). Students reporting poor sleep had higher OSDI scores than those reporting good sleep (median 40.5 vs 17.0, $p<0.001$).

Conclusion: Greater daily screen exposure was associated with more severe dry eye symptoms and poorer tear film measures in this cohort. The findings support attention to screen-use duration, viewing ergonomics, and ocular surface symptoms among medical students, while the cross-sectional design prevents causal inference.

Keywords: Digital Screen Exposure, Dry Eye Disease, Medical Students, OSDI, Schirmer Test, Tear Break-Up Time.

INTRODUCTION

Dry eye disease (DED) is a multifactorial disorder in which loss of tear-film homeostasis is accompanied by ocular symptoms and may involve tear-film instability, hyperosmolarity, inflammation, ocular surface damage, and neurosensory abnormalities.^[1] Its reported prevalence varies substantially across populations because diagnostic definitions, age structures, environmental exposures, and ascertainment methods differ, while younger

screen-intensive populations remain of particular epidemiological interest.^[2]

Symptom assessment is central to identifying individuals who may have DED. The Ocular Surface Disease Index (OSDI) is a validated instrument that quantifies ocular discomfort, visual-function difficulties, and environmental triggers.^[3] Contemporary diagnostic guidance, however, emphasizes that symptoms should be interpreted together with objective evidence of tear-film or ocular-

surface dysfunction. Tear break-up time and tear-volume assessment therefore remain clinically useful companion measures even when symptom questionnaires are used for screening.^[4]

Digital display exposure has become almost continuous for many students. Prolonged screen viewing has been linked with ocular dryness, burning, irritation, blurred vision, and visual fatigue.^[5] Proposed mechanisms include altered blink behaviour, a higher proportion of incomplete blinks, increased evaporative stress, and changes in tear-film stability during sustained visual attention.^[6,7] Smartphones are especially relevant because they are used at relatively short working distances and often for long uninterrupted periods; systematic evidence supports an association between smartphone exposure and dry eye symptoms, although study definitions and measurements remain heterogeneous.^[8]

Medical students represent a practical high-exposure population. Academic reading, online learning, messaging, reference applications, and leisure use can occupy several hours each day, frequently extending into late evening. Yet symptom severity does not depend on duration alone. Viewing distance, refractive status, contact lens wear, and sleep may modify ocular discomfort. The present study therefore evaluated the relationship between daily digital screen exposure and OSDI-defined dry eye symptoms, Schirmer test values, and TBUT among medical students, while also exploring selected associated factors.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional observational study analysed 40 Medical Students at KVG Medical College Sullia, Dakshina Kannada for a period of 6 months. All included participants had complete observations for the variables used in the analysis.

Variables and Ocular Surface Assessment

Recorded variables included age, sex, year of study, average daily digital screen time, primary digital device, habitual screen distance from the eyes, OSDI score, Schirmer test values for each eye, TBUT for each eye, contact lens use, presence of refractive error, and sleep quality (good or poor). Primary digital devices were categorized as smartphone, laptop, or tablet.

OSDI scores were interpreted using the conventional severity categories: 0-12 normal, 13-22 mild, 23-32 moderate, and 33-100 severe. For the primary symptom-based classification, an OSDI score of 13 or above was considered indicative of symptomatic dry eye. Schirmer test values below 10 mm of wetting at 5 minutes were considered abnormal, and TBUT below 10 seconds was considered abnormal. Right- and left-eye measurements were retained descriptively; for participant-level association analyses, bilateral means were calculated to avoid treating two eyes from the same participant as independent observations.

Data Quality and Statistical Analysis

Data were screened for completeness, range validity, duplicate participant identifiers, and internal consistency. OSDI severity and symptomatic dry eye status were derived from the recorded OSDI score using the prespecified cut-offs. Continuous measurements were retained as recorded. Continuous variables are reported as mean $\pm$ standard deviation when used descriptively and as median with interquartile range for non-parametric group comparisons. Categorical variables are presented as frequency and percentage. Spearman rank correlation was used to assess associations between screen exposure variables and OSDI, Schirmer, and TBUT measures. Mann-Whitney U testing was used for two-group exploratory comparisons, and Kruskal-Wallis testing for comparisons across OSDI severity categories. Statistical significance was set at $p < 0.05$. Analyses were performed using Python 3.13 with SciPy 1.17.0.

Ethical Considerations

The study was conducted after obtaining institutional ethical clearance and in accordance with accepted ethical principles for research involving human participants. Participation was voluntary, informed consent was obtained before enrolment, and confidentiality of participant information was maintained throughout the study. No experimental therapeutic intervention was administered as part of the study.

RESULTS

All 40 participant records were complete after consistency checking. Mean age was 21.82 ± 1.32 years (range 20-24 years); 22 (55.0%) were female and 18 (45.0%) were male. Mean

daily screen exposure was 6.79 ± 1.44 hours/day, with a range of 4.0-9.5 hours/day. Smartphones were the primary device for 20 (50.0%) students, followed by laptops in 16

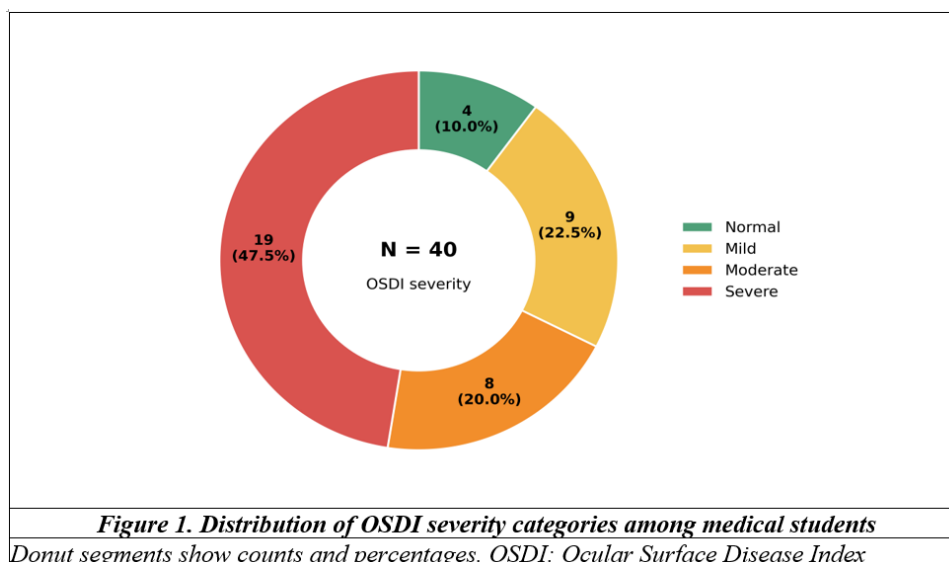
(40.0%) and tablets in 4 (10.0%). Baseline participant and exposure characteristics are summarized in Table 1.

Variable	Category / Statistic	Value
Age (years)	Mean $\pm$ SD	21.82 $\pm$ 1.32
Age (years)	Range	20-24
Sex	Female	22 (55.0%)
Sex	Male	18 (45.0%)
Year of study	1st year	14 (35.0%)
Year of study	2nd year	13 (32.5%)
Year of study	3rd year	13 (32.5%)
Daily screen time (hours/day)	Mean $\pm$ SD	6.79 $\pm$ 1.44
Daily screen time (hours/day)	Range	4.0-9.5
Primary device	Smartphone	20 (50.0%)
Primary device	Laptop	16 (40.0%)
Primary device	Tablet	4 (10.0%)
Screen distance (cm)	Mean $\pm$ SD	31.00 $\pm$ 6.43
Contact lens use	Yes	5 (12.5%)
Refractive error	Yes	7 (17.5%)
Sleep quality	Poor	22 (55.0%)

Table 1. Participant characteristics and digital exposure profile (N=40)

The mean OSDI score was 31.25 ± 14.06 (range 10-58). OSDI-defined symptomatic dry eye (score ≥ 13) was present in 36/40 (90.0%). Four students (10.0%) were in the normal category, 9 (22.5%) had mild symptoms, 8 (20.0%) had moderate symptoms, and 19 (47.5%) had severe symptoms (Figure 1). Mean right- and

left-eye Schirmer values were 9.82 ± 3.86 mm and 8.90 ± 3.78 mm, respectively. Corresponding TBUT values were 5.97 ± 2.49 and 5.53 ± 2.35 seconds. At least one eye had a Schirmer value <10 mm in 24 (60.0%) students and a TBUT <10 seconds in 39 (97.5%) students. These ocular surface findings are detailed in Table 2.



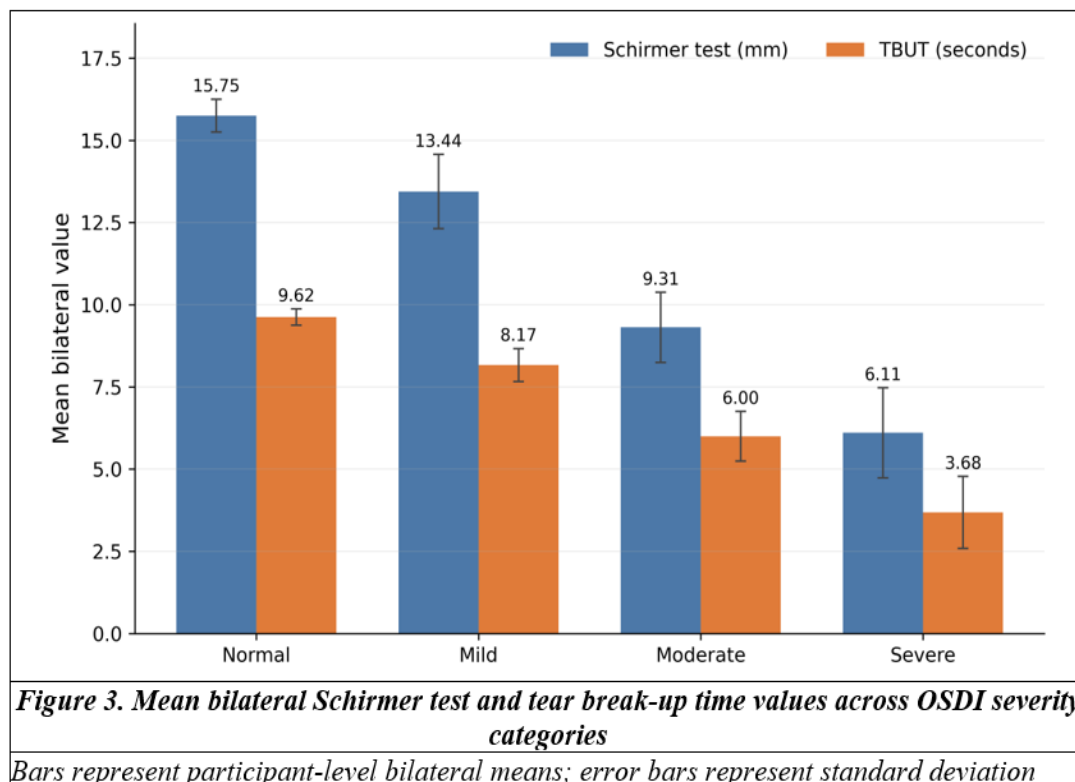
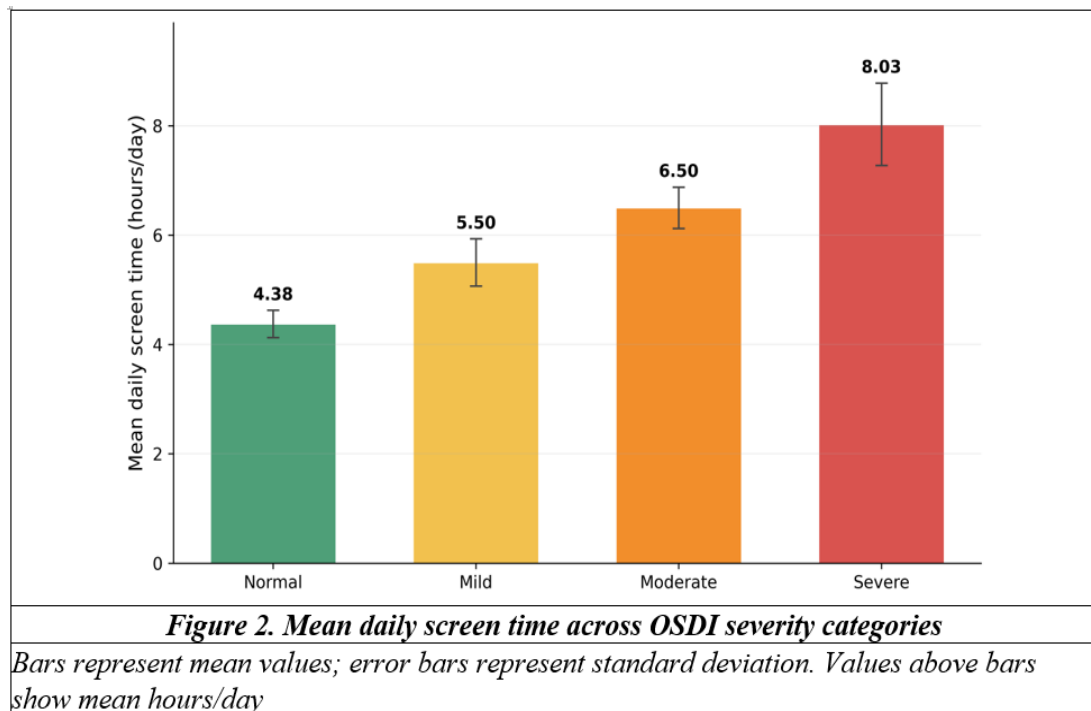
OSDI category	n (%)	Mean bilateral Schirmer (mm/5 min)	Mean bilateral TBUT (s)
Normal	4 (10.0%)	15.75 $\pm$ 0.50	9.62 $\pm$ 0.25
Mild	9 (22.5%)	13.44 $\pm$ 1.13	8.17 $\pm$ 0.50
Moderate	8 (20.0%)	9.31 $\pm$ 1.07	6.00 $\pm$ 0.76
Severe	19 (47.5%)	6.11 $\pm$ 1.37	3.68 $\pm$ 1.10

Overall mean OSDI	31.25 ± 14.06	—	—
Schirmer <10 mm in at least one eye	24 (60.0%)	—	—
TBUT <10 s in at least one eye	39 (97.5%)	—	—

Table 2. OSDI severity and ocular surface measurements

Screen exposure increased progressively across the OSDI severity categories. Mean daily screen time was 4.38 ± 0.25 hours in the normal group, 5.50 ± 0.43 hours in mild, 6.50 ± 0.38 hours in moderate, and 8.03 ± 0.75

hours in severe symptom categories (Kruskal-Wallis $H=33.405$, $p<0.001$; Figure 2). In parallel, mean bilateral Schirmer and TBUT values declined across increasing symptom severity, as summarized in Figure 3.



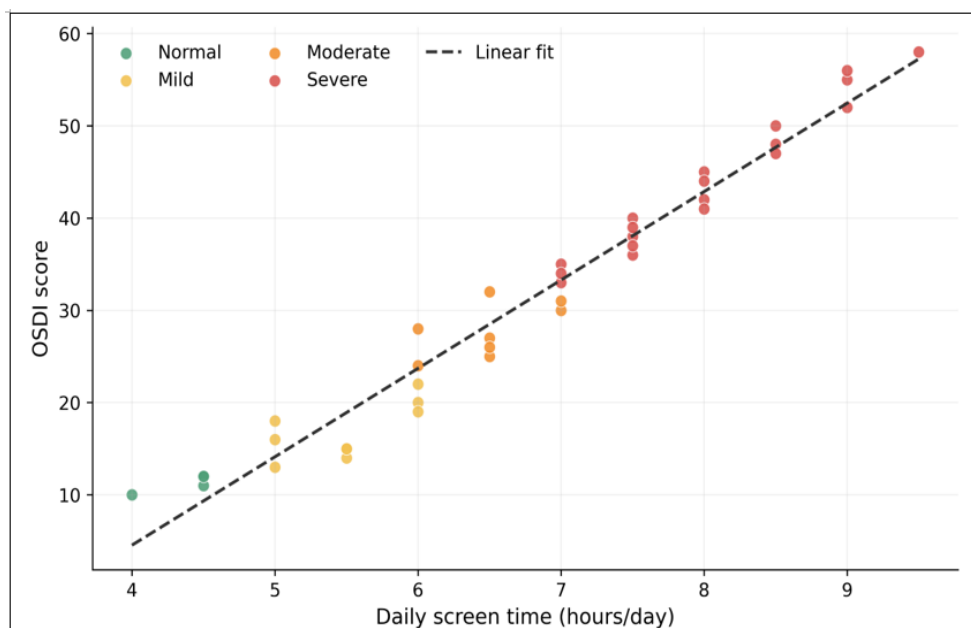


Figure 4. Relationship between daily digital screen time and OSDI score
Each point represents one participant; colours indicate OSDI severity categories. The dashed line shows the fitted linear trend

Spearman analysis demonstrated a very strong positive association between daily screen time and OSDI score ($\rho=0.988$, $p<0.001$), with the participant-level relationship illustrated in Figure 4. Longer daily screen exposure was also strongly associated with lower mean Schirmer values ($\rho=-0.981$,

$p<0.001$) and shorter mean TBUT ($\rho=-0.983$, $p<0.001$). Screen distance showed a weaker inverse association with OSDI score ($\rho=-0.364$, $p=0.021$), indicating greater symptom burden at shorter viewing distances. The correlation results are shown in Table 3.

Association	Spearman rho	p-value
Daily screen time vs OSDI score	0.988	<0.001
Daily screen time vs mean Schirmer test	-0.981	<0.001
Daily screen time vs mean TBUT	-0.983	<0.001
Screen distance vs OSDI score	-0.364	0.021

Table 3. Correlation of digital exposure with dry eye measures

Exploratory group comparisons identified higher OSDI scores among students reporting poor sleep, contact lens use, and refractive error, whereas the difference by sex was not statistically significant. Because

contact lens users and students with refractive error represented small subgroups, these findings should be regarded as exploratory rather than independent risk estimates (Table 4).

Factor	Group 1: median (IQR)	Group 2: median (IQR)	U statistic	p-value	Interpretation
Sleep quality	Good, n=18: 17.0 (13.2-23.5)	Poor, n=22: 40.5 (35.2-47.8)	0.0	<0.001	Significant
Contact lens use	No, n=35: 28.0 (17.0-37.5)	Yes, n=5: 55.0 (52.0-56.0)	5.0	<0.001	Significant
Refractive error	No, n=33: 28.0 (16.0-38.0)	Yes, n=7: 44.0 (37.0-46.5)	59.0	0.046	Significant
Sex	M, n=18: 25.5 (15.2-38.8)	F, n=22: 34.0 (24.8-44.2)	147.5	0.174	Not significant

Table 4. Exploratory comparison of OSDI scores across selected factors

IQR: interquartile range. Comparisons used the Mann-Whitney U test and were exploratory

DISCUSSION

The principal finding was a marked association between daily screen exposure and dry eye symptom burden among medical students. Nine in ten participants crossed the conventional OSDI threshold for symptomatic dry eye, and nearly half were in the severe OSDI category. Greater screen time was accompanied not only by higher symptom scores but also by progressively lower Schirmer and TBUT values. The concordant direction of these measures strengthens the clinical signal, although the unusually strong correlations in this small cohort warrant cautious interpretation and external replication.

The symptom prevalence observed here is higher than that reported in several Indian studies. Aberame et al. identified OSDI-defined dry eye in 46.1% of 310 medical students and found device use beyond six hours to be significantly associated with higher OSDI scores.^[9] Lulla et al. reported prevalence figures of 41.5% before the COVID-19 pandemic and 55.19% during the pandemic among medical students.^[10] Jakhar et al., studying university students in India, likewise found that greater screen exposure was associated with higher symptom scores and emphasized the ocular burden created by prolonged online learning.^[11] Differences in prevalence across studies are expected because screen habits, environmental exposure, assessment periods, and diagnostic definitions vary. The small sample in the present study also makes the prevalence estimate less stable than estimates from larger surveys.

The graded increase in screen time from normal through severe OSDI categories closely parallels observations from Utlu et al., who reported a positive relationship between daily digital display duration and OSDI scores in medical students and also noted greater symptom scores at shorter viewing distances.^[12] In the present cohort, screen distance showed a statistically significant but substantially weaker association with OSDI than daily duration. This distinction is clinically plausible: distance is one ergonomic component, whereas total exposure time integrates repeated periods of reduced blinking, sustained accommodation, and environmental evaporative stress across the day.

Young adults are not uniformly protected from dry eye. In a large study of Brazilian undergraduates, Yang et al. identified prolonged screen use, contact lens wear, and short sleep duration among factors associated with dry eye.^[13] Our exploratory analyses showed the same direction for contact lens use and refractive error, but subgroup sizes were small. Five contact lens users had markedly higher OSDI scores than non-users. This finding should not be interpreted as an independent effect because lens wear may cluster with longer screen use, refractive correction needs, and individual ocular-surface susceptibility.

Sleep quality also emerged as a relevant clinical correlate. Students reporting poor sleep had substantially higher OSDI scores than those with good sleep. Abu-Ismael et al. similarly found a high burden of symptomatic DED among medical students and linked poorer sleep patterns with greater dry eye risk.^[14] A recent meta-analysis involving more than 400,000 participants further supports a bidirectional association between dry eye and impaired sleep quality.^[15] For medical students, this relationship has practical relevance because late-night study, smartphone use before sleep, irregular schedules, and academic stress often coexist. These cross-sectional findings cannot disentangle whether poor sleep contributes to ocular symptoms, whether ocular discomfort disrupts sleep, or whether both reflect high screen exposure.

The objective tear-film findings provide an additional perspective. TBUT below 10 seconds in at least one eye was present in almost all participants, and the mean TBUT fell substantially across increasing OSDI severity. Schirmer values showed a similar but less universal pattern. Digital viewing may alter blink completeness and interblink interval, creating longer periods during which the exposed ocular surface is vulnerable to evaporation. Portello et al. demonstrated that incomplete blinking is associated with computer-related visual symptoms, supporting blink quality as one mechanistic link between sustained visual display use and ocular discomfort.^[16] Reviews of screen-associated dry eye likewise describe tear-film instability and blink abnormalities as recurring biological pathways.^[5-7]

The findings have practical implications for medical colleges. Screening does not need to begin with complex instrumentation. A brief symptom questionnaire, followed by targeted ocular surface examination in symptomatic students, can identify those who may benefit from ergonomic counselling or clinical evaluation. Behavioural advice should focus on reducing uninterrupted viewing periods, consciously completing blinks, maintaining a comfortable viewing distance, and addressing contact lens or refractive issues when symptoms persist. These measures are low-cost and feasible within student health services, but the present study did not test an intervention and therefore cannot establish that any specific behavioural modification will reduce symptoms.

Strengths and Limitations

A strength of this study is the combined assessment of symptom severity and bilateral tear-film measures rather than reliance on a questionnaire alone. Participant-level averaging of paired-eye measurements also avoided pseudo-replication in the correlation analyses. Several limitations remain. The sample was small and restricted to a narrow age range, limiting precision and generalizability. The cross-sectional design cannot establish temporality or causation. Screen exposure was represented by reported daily duration and viewing distance rather than objective device-use logs, and sleep quality was recorded only as a binary variable. The OSDI threshold was used for the primary symptom-based classification, whereas comprehensive DED diagnosis ordinarily requires integration of symptoms with objective signs. Finally, the small numbers of contact lens users and students with refractive error make those subgroup findings exploratory.

CONCLUSION

Medical students in this cohort had a high burden of OSDI-defined dry eye symptoms. Longer daily digital screen exposure was strongly associated with higher OSDI scores, lower Schirmer values, and shorter TBUT, while shorter viewing distance and poor sleep were also associated with greater symptom burden. These findings support routine attention to digital viewing habits and ocular surface symptoms in screen-intensive student populations. Larger, prospectively designed

studies using objective screen-use measures and standardized DED diagnostic criteria are needed before causal or preventive conclusions can be drawn.

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Nil.

Conflict of Interest

None declared.

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