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ASSOCIATION BETWEEN DAILY SCREEN TIME AND DRY EYE DISEASE AMONG ADOLESCENTS: A CROSS-SECTIONAL STUDY

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ABSTRACT:
Background: Dry eye disease is a multifactorial ocular surface disorder characterized by tear film instability and inflammation. Rising digital device use among adolescents has increased concerns about its adverse effects on ocular surface health.
Aim: To determine the association between screen time and dry eye disease among adolescents aged 14–19 years.
Methods: This cross-sectional analytical study included 372 adolescents attending the ophthalmology outpatient department of a tertiary care hospital over 18 months. Daily screen time, device type, and spectacle use were recorded. Dry eye was assessed using the Ocular Surface Disease Index (OSDI) questionnaire and Schirmer's I test. Data were analyzed using SPSS version 29, with $p < 0.05$ considered statistically significant.
Results: The mean age of participants was 16.41 ± 1.89 years, with females comprising 52.96%. Average daily screen time was 4.36 ± 2.81 hours. Dry eye prevalence was 5.4% using OSDI and 3.8% using Schirmer's test. Increasing screen time was significantly associated with dry eye by both assessments ($p < 0.001$), and affected participants had significantly higher screen exposure. Older adolescents (17–19 years) demonstrated a higher prevalence than younger participants ($p < 0.01$). Laptop users showed greater dry eye prevalence than mobile phone or television users, whereas spectacle use was not significantly associated.
Conclusion: Prolonged screen exposure is significantly associated with dry eye disease in adolescents, especially older individuals and laptop users. Early detection, reduced screen time, and preventive measures may help minimize digital eye strain and ocular surface damage.

KEYWORDS: Dry eye disease; screen time; digital eye strain; adolescents; OSDI; Schirmer's test; visual display unit.

INTRODUCTION

Dry eye disease (DED) is a multifactorial disorder of the ocular surface characterized by loss of tear film homeostasis, accompanied by ocular symptoms in which tear film instability, hyperosmolarity, ocular surface inflammation, and neurosensory abnormalities play central pathogenic roles. The global prevalence of DED ranges from 5% to 50%, reflecting variations in geographic regions, study populations, and diagnostic criteria.[1,2] Common manifestations include ocular dryness, burning sensation, foreign body sensation, blurred vision, photophobia, and fluctuating visual acuity, which can adversely affect visual function, academic performance, and overall quality of life.[3-5]
The rapid expansion of digital technology has resulted in a substantial increase in cumulative daily screen exposure, particularly among adolescents. Smartphones, laptops, tablets, and other visual display units (VDUs) have become integral to education, communication, entertainment, gaming, and social networking. Prolonged digital device use reduces spontaneous blink rate, increases incomplete blinking, and accelerates tear film evaporation, leading to tear film instability and ocular surface dysfunction. In addition, prolonged visual concentration and reduced blinking during screen use may further compromise tear film homeostasis and contribute to the development of DED.[6,7]
Adolescents are especially vulnerable because of increasing dependence on digital devices for academic activities and recreational purposes. Emerging evidence suggests that both the duration of screen exposure and the type of digital device used may influence the risk of DED. Devices requiring prolonged uninterrupted visual attention, such as laptops, may induce greater blink suppression and accommodative stress than intermittent smartphone use, thereby increasing the likelihood of ocular surface disturbances.[7-9]
Recent studies have consistently demonstrated a positive association between prolonged digital device use and dry eye symptoms among children and adolescents, with cumulative daily screen exposure identified as an important modifiable risk factor.[7-9] However, evidence regarding the relationship between cumulative daily screen exposure, the primary visual display unit, and both subjective and objective measures of DED among Indian adolescents remains limited.
Therefore, the present study was undertaken to determine the association between cumulative daily screen exposure and DED among adolescents using the Ocular Surface Disease Index (OSDI) and Schirmer's I test. The study also evaluated the influence of the primary visual display unit, age, and spectacle use on the occurrence of DED.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted over 18 months in the Department of Ophthalmology at a tertiary care teaching hospital. The study protocol was approved by the Institutional Ethics Committee of Bharati Vidyapeeth (Deemed to be University) Medical College, Pune. Written informed consent was obtained from participants aged 18 years and above, while written parental/guardian consent, along with participant assent, was obtained for those below 18 years of age.

A total of 372 adolescents aged 14–19 years attending the ophthalmology outpatient department were enrolled using convenience sampling. Both male and female participants were included. Individuals with ocular conditions known to affect the ocular surface, including eyelid abnormalities (ectropion or entropion), allergic conjunctivitis, blepharitis, keratoconus, corneal opacity, or any previous ocular surgery, were excluded. Contact lens users and participants receiving topical or systemic medications known to affect tear film function, such as antiglaucoma medications and antihistamines, were also excluded.

A structured proforma was used to record demographic details, ocular history, spectacle use, and cumulative daily screen exposure, expressed as the average number of hours spent using digital devices per day. Participants also identified their primary VDU used for the majority of their daily screen exposure (mobile phone, laptop, or television). Information regarding spectacle use was recorded as a dichotomous variable (yes/no).

Subjective dry eye symptoms were assessed using the OSDI questionnaire. Based on the OSDI score, participants were categorized as having normal (0–12), mild (13–22), moderate (23–32), or severe (33–100) symptoms. Objective assessment of tear secretion was performed using Schirmer's I test without topical anaesthesia under standardized conditions. Filter paper strips were placed in the lower conjunctival fornix of both eyes, and the length of wetting was recorded after five minutes. A Schirmer's test value of ≤10 mm was considered indicative of reduced tear secretion.

Data were entered into Microsoft Excel 2016 and analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were summarized as frequencies and percentages. Associations between categorical variables were evaluated using the Chi-square test or Fisher's exact test, as appropriate. Differences in continuous variables between two groups were analysed using the independent samples t-test, whereas comparisons involving more than two groups were performed using one-way analysis of variance (ANOVA). A two-sided p-value of <0.05 was considered statistically significant

RESULTS

3.1 Demographic and Baseline Characteristics

A total of 372 adolescents aged 14–19 years were included in the study. The mean age was 16.41 ± 1.89 years. Participants aged 14–16 years constituted 53.76% (n = 200) of the study population, whereas 46.24% (n = 172) belonged to the 17–19-year age group. Females comprised 52.96% (n = 197) of the participants, while males accounted for 47.04% (n = 175). Nearly half of the participants (49.73%, n = 185) were spectacle users. Mobile phones were the most commonly used visual display unit (VDU), followed by laptops and television (Table 1).

Table 1. Baseline Characteristics of the Study Participants

Variable		Frequency (n)	Percentage (%)
Age group	14–16 years	200	53.76
	17–19 years	172	46.24
Gender	Male	175	47.04
	Female	197	52.96
Spectacle use	Yes	185	49.73
	No	187	50.27
Primary VDU	Mobile phone	227	61.02
	Laptop	83	22.31
	Television	62	16.67

3.2 Distribution of Cumulative Daily Screen Exposure

The mean cumulative daily screen exposure among study participants was 4.36 ± 2.81 hours/day. The majority (36.83%) reported screen exposure of 3–5 hours/day, followed by 31.72% with 1–2 hours/day. Approximately one-fourth of the participants reported screen exposure exceeding six hours/day (Table 2). Older adolescents (17–19 years) demonstrated significantly greater cumulative daily screen exposure (6.12 ± 2.63 hours) compared with those aged 14–16 years (2.85 ± 1.96 hours, p < 0.001).

Table 2. Distribution of Cumulative Daily Screen Exposure

Screen exposure (hours/day)	Frequency (n)	Percentage (%)
1–2	118	31.72
3–5	137	36.83
6–8	83	22.31
9–11	25	6.72
>11	9	2.42

Total	372	100

3.3 Prevalence and Severity of DED

Based on the OSDI, the prevalence of DED was 5.40% (n = 20). Most participants (94.62%) had normal OSDI scores. Mild, moderate, and severe DED were observed in 2.69%, 1.61%, and 1.08% of participants, respectively (Table 3).

Table 3. Severity of DED According to OSDI

OSDI Category	Frequency (n)	Percentage (%)
Normal	352	94.62
Mild	10	2.69
Moderate	6	1.61
Severe	4	1.08
Total	372	100

Based on Schirmer's test, the prevalence of DED was 3.80% (n = 14). Mild aqueous tear deficiency was observed in 2.42%, whereas 1.34% had moderate DED. None of the participants demonstrated severe dry eye according to Schirmer's test (Table 4).

Table 4. Severity of DED According to Schirmer's Test

Schirmer's Category	Frequency (n)	Percentage (%)
Normal	358	96.24
Mild	9	2.42
Moderate	5	1.34
Total	372	100

3.4 Association Between Age and DED

Participants with DED had a significantly higher mean age than those without dry eye according to both OSDI (17.90 ± 1.61 vs. 16.33 ± 1.87 years, $p < 0.001$) and Schirmer's test (18.14 ± 1.46 vs. 16.35 ± 1.88 years, $p < 0.001$).

When analysed according to age group, adolescents aged 17–19 years had a significantly higher prevalence of dry eye than those aged 14–16 years, based on both OSDI (9.30% vs. 2.00%; $p = 0.002$) (Table 5) and Schirmer's test (7.00% vs. 1.00%; $p = 0.004$) (Table 6).

Table 5. Association Between Age Group and DED According to OSDI

Age group	Dry eye n (%)	No dry eye n (%)	Total	P value
14–16 years	4 (2.00)	196 (98.00)	200	0.002
17–19 years	16 (9.30)	156 (90.70)	172	
Total	20 (5.40)	352 (94.60)	372	

Table 6. Association Between Age Group and DED According to Schirmer's Test

Age group	Dry eye n (%)	No dry eye n (%)	Total	P value
14–16 years	2 (1.00)	198 (99.00)	200	0.004
17–19 years	12 (7.00)	160 (93.00)	172	
Total	14 (3.80)	358 (96.20)	372	

3.5 Association Between Cumulative Daily Screen Exposure and DED

Participants with DED had significantly greater cumulative daily screen exposure than those without dry eye, according to both OSDI (9.50 ± 2.48 vs. 4.07 ± 2.54 hours, $p < 0.001$) and Schirmer's test (10.57 ± 1.55 vs. 4.12 ± 2.56 hours, $p < 0.001$).

No participant with cumulative daily screen exposure below 3 hours/day developed DED. The prevalence increased progressively with longer exposure, with the highest prevalence observed among adolescents reporting >6 hours/day of cumulative screen exposure (Tables 7 and 8).

Table 7. Association Between Cumulative Daily Screen Exposure and DED According to OSDI

Screen exposure	Dry eye n (%)	No dry eye n (%)	Total	P value
<2 hrs	0	57	57	<0.001
2–3 hrs	0	127	127	
4–6 hrs	4 (4.10)	94 (95.90)	98	
>6 hrs	16 (17.80)	74 (82.20)	90	
Total	20 (5.40)	352 (94.60)	372	

Table 8. Association Between Cumulative Daily Screen Exposure and DED According to Schirmer's Test

Screen exposure	Dry eye n (%)	No dry eye n (%)	Total	P value
<2 hrs	0	57	57	<0.001
2–3 hrs	0	127	127	

4–6 hrs	0	98	98	
>6 hrs	14 (15.60)	76 (84.40)	90	
Total	14 (3.80)	358 (96.20)	372	

3.6 Association Between Primary VDU and DED

The prevalence of DED differed significantly according to the primary visual display unit used. Laptop users demonstrated the highest prevalence of DED according to both OSDI (10.80%) and Schirmer's test (8.40%), followed by mobile phone users (4.40% and 3.10%, respectively). The lowest prevalence was observed among television users. These associations were statistically significant (OSDI: p = 0.030; Schirmer's test: p = 0.021) (Tables 9 and 10).

Table 9. Association Between Primary VDU and DED According to OSDI

Primary VDU	Dry eye n (%)	No dry eye n (%)	Total	P value
Laptop	9 (10.80)	74 (89.20)	83	0.030
Mobile phone	10 (4.40)	217 (95.60)	227	
Television	1 (1.60)	61 (98.40)	62	
Total	20 (5.40)	352 (94.60)	372	

Table 10. Association Between Primary VDU and DED According to Schirmer's Test

Primary VDU	Dry eye n (%)	No dry eye n (%)	Total	P value
Laptop	7 (8.40)	76 (91.60)	83	0.021
Mobile phone	7 (3.10)	220 (96.90)	227	
Television	0	62 (100)	62	
Total	14 (3.80)	358 (96.20)	372	

3.7 Association Between Spectacle Use and DED

Although the prevalence of DED was marginally higher among spectacle users than non-users according to both OSDI (6.50% vs. 4.30%) and Schirmer's test (5.40% vs. 2.10%), these differences were not statistically significant (OSDI: p = 0.368; Schirmer's test: p = 0.110) (Tables 11 and 12).

Table 11. Association Between Spectacle Use and DED According to OSDI

Spectacle use	Dry eye n (%)	No dry eye n (%)	Total	P value
Yes	12 (6.50)	173 (93.50)	185	0.368
No	8 (4.30)	179 (95.70)	187	
Total	20 (5.40)	352 (94.60)	372	

Table 12. Association Between Spectacle Use and DED According to Schirmer's Test

Spectacle use	Dry eye n (%)	No dry eye n (%)	Total	P value
Yes	10 (5.40)	175 (94.60)	185	0.110
No	4 (2.10)	183 (97.90)	187	
Total	14 (3.80)	358 (96.20)	372	

DISCUSSION

The present study evaluated the association between cumulative daily screen exposure and DED among adolescents using both subjective (OSDI) and objective (Schirmer's test) assessment methods. The findings demonstrated a significant association between prolonged cumulative daily screen exposure and DED, with a higher prevalence observed among older adolescents and those using laptops as their primary VDU. These observations support the growing body of evidence indicating that excessive digital screen exposure adversely affects tear film homeostasis and ocular surface health in children and adolescents.[1,2,10,11]

The overall prevalence of DED in the present study was 5.40% according to the OSDI questionnaire and 3.80% according to Schirmer's test. The slightly higher prevalence identified by the OSDI compared with Schirmer's test is expected because symptom-based questionnaires are capable of detecting early functional disturbances of the ocular surface before measurable reductions in aqueous tear secretion become apparent. Previous studies have similarly reported only modest agreement between subjective symptom scores and objective tear function tests, emphasizing the multifactorial nature of dry eye disease and the importance of combining both assessment methods for accurate diagnosis.[5,11]

The prevalence observed in the present study was lower than that reported by Titiyal et al. [12], who found an OSDI-based prevalence of approximately 10% among Indian adolescents. Similarly, studies conducted in Saudi Arabia and China have reported substantially higher prevalence rates among students and young adults.[13,14] These differences may be attributed to variations in study populations, environmental conditions, climatic factors, diagnostic criteria, and patterns of digital device usage. Furthermore, adolescents generally possess healthier meibomian gland function, better tear film stability, and fewer systemic risk factors than adults, which may partly explain the comparatively lower prevalence observed in our study.

One of the most important findings of the present study was the significant dose-dependent relationship between cumulative daily screen exposure and DED. Participants with longer durations of digital screen exposure demonstrated a markedly higher prevalence of dry eye symptoms and abnormal Schirmer's test results, while no participant with cumulative daily screen exposure of less than three hours developed clinically significant DED. These findings are consistent with those reported by Uchino et al. [10], Moon et al. [15], Jadeja JN et al. [7], and Ghimire R et al. [9], all of whom demonstrated a significant positive association between prolonged digital device use and increasing dry eye symptoms among adolescents and young adults.

The pathophysiological mechanisms underlying this association are well established. During prolonged digital screen use, spontaneous blink frequency decreases by approximately 40–60%, while incomplete blinking becomes more frequent. Reduced blinking limits uniform redistribution of the tear film across the ocular surface, resulting in increased tear evaporation, tear hyperosmolarity, and instability of the lipid layer. Persistent tear film instability activates inflammatory pathways within the ocular surface, promoting epithelial damage and the development of dry eye symptoms.[16–18] Consequently, prolonged uninterrupted digital viewing represents an important modifiable risk factor for tear film dysfunction.

Another noteworthy finding of the present study was that laptop users demonstrated the highest prevalence of DED, despite smartphones being the most commonly used digital devices among participants. This observation may be explained by differences in the nature of device usage rather than the device itself. Laptop use among adolescents is predominantly associated with prolonged academic activities, including online classes, assignment preparation, project work, digital reading, and competitive examination preparation. These activities require sustained visual concentration for extended periods, leading to prolonged blink suppression, increased accommodative demand, and greater ocular surface exposure. In contrast, smartphone use generally consists of shorter and more intermittent activities, such as messaging, social networking, or brief internet browsing, which allow more frequent gaze shifts and spontaneous blinking. Television viewing is usually performed at a greater viewing distance and requires relatively less accommodative effort, thereby imposing less stress on the ocular surface. Similar observations have been reported by Portello et al. and Rosenfield, who demonstrated greater ocular discomfort and digital eye strain during prolonged near work compared with distant viewing tasks.[6,15]

The purpose of digital screen use also appears to influence ocular surface health. Academic activities require continuous reading, sustained attention, and prolonged near work, all of which substantially suppress blink frequency. Likewise, prolonged video gaming demands intense visual concentration, rapid eye movements, and sustained fixation, thereby increasing ocular surface exposure and tear evaporation. Although social media use often consists of shorter but repeated interactions, excessive cumulative daily use may still contribute significantly to digital eye strain and dry eye symptoms.[5,19,20] Therefore, both the duration and the type of digital activity should be considered when evaluating the risk of DED among adolescents.

The OSDI questionnaire evaluates multiple dimensions of dry eye disease, including ocular discomfort, visual function, and environmental triggers. Common symptoms include burning sensation, foreign-body sensation, ocular dryness, redness, blurred vision, photophobia, excessive watering, and eye fatigue. These symptoms frequently precede measurable abnormalities in tear secretion, explaining why the OSDI identified a greater proportion of affected participants than Schirmer's test in the present study.[3] The combined use of subjective and objective assessment methods therefore provides a more comprehensive evaluation of ocular surface disease.

The present study also demonstrated that older adolescents (17–19 years) had significantly greater cumulative daily screen exposure and a higher prevalence of DED than younger participants. This finding is likely attributable to increased educational demands, online learning, competitive examination preparation, and greater use of digital devices for both academic and recreational purposes in this age group. Similar age-related trends have been reported among adolescents in Korea and China, where increasing educational commitments were associated with longer daily screen exposure and a higher prevalence of dry eye disease.[15,21]

No statistically significant association was observed between spectacle use and DED in the present study. This finding is consistent with the observations of Alabdulkader, who also reported that spectacle wear alone has minimal influence on tear film stability.[22] Unlike contact lenses, spectacles do not directly interact with the ocular surface or alter tear film physiology and, therefore, are unlikely to constitute an independent risk factor for dry eye disease.

Overall, the findings of the present study emphasize the importance of limiting prolonged uninterrupted digital screen exposure among adolescents. Increasing awareness regarding appropriate digital device use, encouraging conscious blinking, maintaining proper viewing distance and ergonomics, ensuring adequate ambient lighting, and promoting regular visual breaks using strategies such as the 20–20–20 rule may help reduce the risk of digital eye strain and dry eye disease. As digital technology continues to play an integral role in education and recreation, preventive interventions targeting healthy screen-use behaviour are essential to preserve ocular surface health in this vulnerable population.

However, the present study has certain limitations. Its cross-sectional design precludes establishing a causal relationship between screen exposure and dry eye disease. Being a single-centre study with self-reported screen exposure, the findings may be subject to recall bias and have limited generalizability. Additionally, advanced ocular surface assessments such as tear film break-up time, fluorescein staining, meibography, and blink rate analysis were not performed. Future multicentre longitudinal studies with objective assessment of screen exposure and comprehensive ocular surface evaluation are recommended.

CONCLUSION

Prolonged screen exposure was significantly associated with dry eye diseasein adolescents, with a clear dose-response relationship demonstrated for screen time exceeding 6 hours per day. Laptop use and older adolescent age are associated with higher dry eye prevalence. Spectacle use does not appear to modify this risk. As adolescents become increasingly reliant on digital platforms for education and social interaction, ophthalmologists and public health practitioners should prioritise early screening for DED in high-screen-time individuals and promote evidence-based protective behaviours, including the 20-20-20 rule, conscious blinking exercises, and periodic screen breaks. Longitudinal and mechanistic studies are needed to clarify the causal pathway and identify the most effective preventive interventions.

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MM: study concept and design, data collection, statistical analysis, and manuscript drafting.
KS: study supervision, critical revision of intellectual content, manuscript review.
TK: data collection & study supervision.
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