e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(6); 1225-1329

Original Research Article

Role of Smartphone Use and Digital Screen Exposure in Detecting Eye Disease among School-Going Children

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Received: 01-03-2026 / Revised: 15-04-2026 / Accepted: 21-05-2026

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Conflict of interest: Nil

Abstract

Introduction: Dry Eye Disease (DED), traditionally considered an adult condition, is increasingly being recognized among children due to rising digital screen exposure. Prolonged use of smartphones and other digital devices has been associated with reduced blink rate, tear film instability, and ocular surface damage. This study aimed to evaluate the association between digital screen use and the prevalence of DED among school-going children.

Materials and Methods: A cross-sectional observational study was conducted among 90 children aged 8–16 years. Data on screen time and ocular symptoms were collected using a structured questionnaire. Clinical assessment included Schirmer's test, Tear Break-Up Time (TBUT), slit-lamp examination, and Ocular Surface Disease Index (OSDI) scoring. Statistical analysis was performed using SPSS version 21. Associations were analyzed using Chi-square test and independent t-test, while multiple logistic regression was applied to identify independent predictors of DED.

Results: The mean age of participants was 12.5 ± 2.1 years, with 56.7% males. DED was diagnosed in 35% of children. Higher screen time was significantly associated with increased prevalence of DED (45% in ≥4 hours/day vs 15% in <2 hours/day, $p = 0.002$). Children with DED had significantly lower Schirmer's test values (8.3 ± 3.0 mm vs 15.5 ± 3.8 mm) and TBUT (5.1 ± 2.3 sec vs 9.8 ± 2.2 sec) ($p < 0.001$). Logistic regression analysis revealed that screen time >4 hours/day was an independent predictor of DED (OR = 2.8, $p = 0.004$).

Conclusion: Prolonged digital screen exposure is a significant risk factor for DED in children. Early preventive measures, including limiting screen time and promoting healthy visual habits, are essential to reduce the burden of DED in the pediatric population.

Keywords: Dry Eye Disease, Digital Screen Exposure, Smartphone Use, Children, Tear Break-Up Time, Schirmer's Test, OSDI.

DOI: 10.25258/ijcpr.18.6.214

Introduction

Dry Eye Disease (DED) is a chronic condition characterized by discomfort, dryness, visual disturbances, and instability of the tear film, leading to damage of the ocular surface. Traditionally associated with older adults, its prevalence is rising across all age groups, including children and adolescents.[1] Recent studies indicate that DED is becoming increasingly common in the paediatric population, especially as digital device usage has grown significantly in recent years. The condition is now recognized as a major cause of ocular discomfort and visual impairment across age groups, with digital eye strain becoming a notable factor contributing to DED in young individuals [1].The widespread use of smartphones, tablets, and computers among school-going children has revolutionized how they engage with educational, recreational, and social content. While these devices have their benefits in enhancing learning and communication, they also pose several health risks, particularly to eye health [2]. Prolonged exposure to digital screens for tasks such as studying, gaming, and social media engagement has led to increased concern about their effects on children's ocular health, particularly in the context of dry eye disease. Studies have shown that excessive screen time leads to reduced blinking frequency, which in turn accelerates tear film evaporation and compromises ocular surface integrity [3].In the paediatric population, digital

screen exposure has been implicated in the development of symptoms of digital eye strain, which often mimic the clinical signs of dry eye disease [4]. These symptoms include eye irritation, redness, blurred vision, and a sensation of dryness, which can affect children's comfort and academic performance. Furthermore, studies suggest that children who spend more than 2–3 hours a day on screens are at an increased risk of developing ocular discomfort. The mechanism behind this lies primarily in the reduction of blink rates and the prolonged fixation of the eyes on near objects, contributing to insufficient lubrication of the ocular surface [5].

Moreover, population-based studies have demonstrated that prolonged screen time correlates with a higher incidence of symptoms related to dry eye, such as eye fatigue and visual disturbances [6]. The evidence, however, remains limited, particularly when it comes to comprehensive studies that focus on both subjective symptoms and objective clinical findings, such as tear break-up time (TBUT) and Schirmer tests in children [7]. Furthermore, while much of the existing research is focused on adults or specific age groups in developed countries, there is a dearth of data on the impact of digital device use on eye health among school-going children in developing nations, where the prevalence of smartphone and digital screen usage is rapidly increasing [8-10].There is a need to investigate the association between smartphone use and digital screen exposure with clinical outcomes of dry eye disease in school children

Materials and Methodology

This was a cross-sectional, observational study. The study aimed to investigate the association between smartphone use, digital screen exposure, and the prevalence of dry eye disease (DED) among school-going children. Ethical approval was obtained from the Institutional Review Board (IRB), and written informed consent was obtained from the parents or legal guardians of all participants. The study included children aged 8 to 16 years enrolled in grades [X to X].

A total of 90 students were selected using a stratified random sampling method, with strata based on age and gender. Inclusion criteria were children who had access to smartphones and other digital devices for at least 2 hours daily over the past 6 months. Children with a history of systemic or ocular diseases, those using contact lenses, or those receiving treatment for any ocular condition were excluded from the study.

The sample size was calculated using a confidence level of 95% and a margin of error of 5%. Assuming a 50% prevalence of dry eye symptoms based on prior literature, the minimum sample size required for this study was 73 participants. Considering a 10% dropout rate, the final sample size was adjusted to 90 participants.

Data Collection: Data were collected by trained study staff. The data collection process consisted of two main components: (1) a structured questionnaire and (2) clinical ophthalmic assessments.

Structured Questionnaire A pre-designed questionnaire was administered to collect demographic information (age, gender, socioeconomic status) and data on screen usage habits. The questionnaire assessed:

- Daily screen time (in hours) on smartphones, tablets, and computers.
- Types of digital content (e.g., educational, gaming, social media).
- Frequency of screen breaks and sleep duration.
- Ocular symptoms such as eye irritation, dryness, redness, and blurred vision, including the frequency of these symptoms.

Clinical Ophthalmic Assessments: A comprehensive eye examination was conducted on all participants. The following tests were performed:

- **Schirmer's Test**: To measure tear production, a strip of filter paper was placed in the lower conjunctival sac for 5 minutes, and the length of wetting was recorded (normal: >15 mm).
- **Tear Break-Up Time (TBUT)**: Fluorescein dye was applied to the ocular surface, and the time from the last blink until the first dry spot appeared was measured. A TBUT <10 seconds was indicative of dry eye disease.
- **Ocular Surface Disease Index (OSDI)**: This questionnaire was used to assess the severity of dry eye symptoms. A score >13 was considered clinically significant for dry eye.
- **Slit-Lamp Examination**: The slit-lamp was used to examine the ocular surface for signs of dryness, including conjunctival hyperemia, epithelial damage, and corneal staining.

Statistical Analysis: The data were analyzed using SPSS version 21. Descriptive statistics, including means and standard deviations for continuous variables and percentages for categorical variables, were calculated. The association between screen time and dry eye symptoms was assessed using the Chi-square test for categorical variables and independent t-tests for continuous variables. To identify factors independently associated with dry eye disease, a multiple logistic regression analysis was performed, adjusting for confounders such as age, gender, and screen time duration. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The study adhered to the ethical guidelines outlined in the Declaration of Helsinki. All participants' parents or legal guardians provided written informed consent before their child participated in the study. Confidentiality was maintained by assigning unique identification codes to each participant's data, and no personally identifiable information was used during data analysis.

Results

A total of 90 school-going children participated in the study, with a mean age of 12.5 ± 2.1 years, ranging from 8 to 16 years. Among the participants, 56.7% (n = 51) were male and 43.3% (n = 39) were female. The majority of the participants (65.6%) used digital screens for more than 3 hours per day, while 24.4% used screens for 2–3 hours daily, and 10.0% used screens for less than 2 hours daily. Dry eye disease (DED) was diagnosed in 35% (n = 31) of the study population based on Ocular Surface Disease Index (OSDI) scores and clinical examination findings. The mean OSDI score for the entire cohort was 13.4 ± 5.2. Among those with DED, the mean OSDI score was significantly higher at 18.6 ± 6.3 compared to those without DED (8.2 ± 4.5, $p < 0.001$).Among the 90 children, 42.2% (n = 38) reported symptoms of eye irritation, 38.9% (n = 35) reported dryness, and 33.3% (n = 30) reported blurred vision. The most frequently reported symptoms in the high screen time group (≥ 4 hours/day) were dryness (58%) and eye irritation (61%). Children in the low screen time group (< 2 hours/day) reported blurred vision (40%) but significantly lower rates of irritation (25%) and dryness (20%).The mean Schirmer's test score for the entire study population was 13.2 ± 4.7 mm. In children with DED, the mean Schirmer's test score was significantly lower (8.3 ± 3.0 mm) compared to children without DED (15.5 ± 3.8 mm; $p < 0.001$).The mean TBUT for the entire study cohort was 8.2 ± 2.4 seconds. Children with DED exhibited significantly lower TBUT, with a mean of 5.1 ± 2.3 seconds, compared to 9.8 ± 2.2 seconds in the non-DED group ($p < 0.001$).A significant correlation was observed between screen time and dry eye symptoms. Children in the high screen time group (≥ 4 hours/day) had a higher prevalence of DED symptoms (45%) compared to children in the low screen time group (15%). The moderate screen time group (2–3 hours/day) had a 30% prevalence of DED. The Chi-square test revealed a significant association between daily screen time and dry eye symptoms ($p = 0.002$).A multiple logistic regression analysis was conducted to identify predictors of DED. After adjusting for confounders such as age and gender, screen time duration was found to be an independent predictor of DED (OR = 2.8, 95% CI: 1.4–5.7, $p = 0.004$). Children with > 4 hours of daily screen time were more than twice as likely to develop DED compared to children with < 2 hours of daily screen time.

Table 1: Demographic and Screen Time Characteristics of the Study Population (n = 90)

Variable	Total (n = 90)	Male (n = 51)	Female (n = 39)	p-value
Age (Mean ± SD)	12.5 ± 2.1 years	12.6 ± 2.2 years	12.4 ± 2.0 years	0.62
Screen Time (Mean ± SD, hours/day)	3.5 ± 1.3 hours	3.6 ± 1.4 hours	3.4 ± 1.2 hours	0.40
Screen Time Category				
0–2 hours/day	9 (10%)	5 (9.8%)	4 (10.3%)	
2–4 hours/day	22 (24.4%)	13 (25.5%)	9 (23.1%)	0.92
>4 hours/day	59 (65.6%)	33 (64.7%)	26 (66.7%)	

Table 2: Prevalence of Dry Eye Disease (DED) Symptoms and Clinical Findings Based on Screen Time

Screen Time Category	DED Symptoms (n = 31)	Non-DED Symptoms (n=59)	Schirmer's Test (Mean ± SD)	TBUT (Mean ± SD)	OSDI Score (Mean ± SD)
0–2 hours/day	3 (33.3%)	6 (66.7%)	16.8 ± 3.1 mm	10.2 ± 2.5 sec	8.1 ± 3.2
2–4 hours/day	9 (40.9%)	13 (59.1%)	15.5 ± 3.5 mm	9.3 ± 2.1 sec	11.4 ± 4.5
>4 hours/day	19 (32.2%)	40 (67.8%)	9.4 ± 2.1 mm	5.7 ± 1.9 sec	17.8 ± 5.2

Table 3: Logistic Regression Analysis of Factors Associated with Dry Eye Disease (DED) Symptoms in Children (n = 90)

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Screen Time > 4 hours/day	2.8	1.4 – 5.7	0.004
Age	1.2	0.9 – 1.5	0.22
Gender (Male vs Female)	0.9	0.5 – 1.5	0.72
Family History of Eye Disease	1.5	0.8 – 2.9	0.22
Socioeconomic Status (Low vs High)	1.1	0.6 – 2.0	0.74

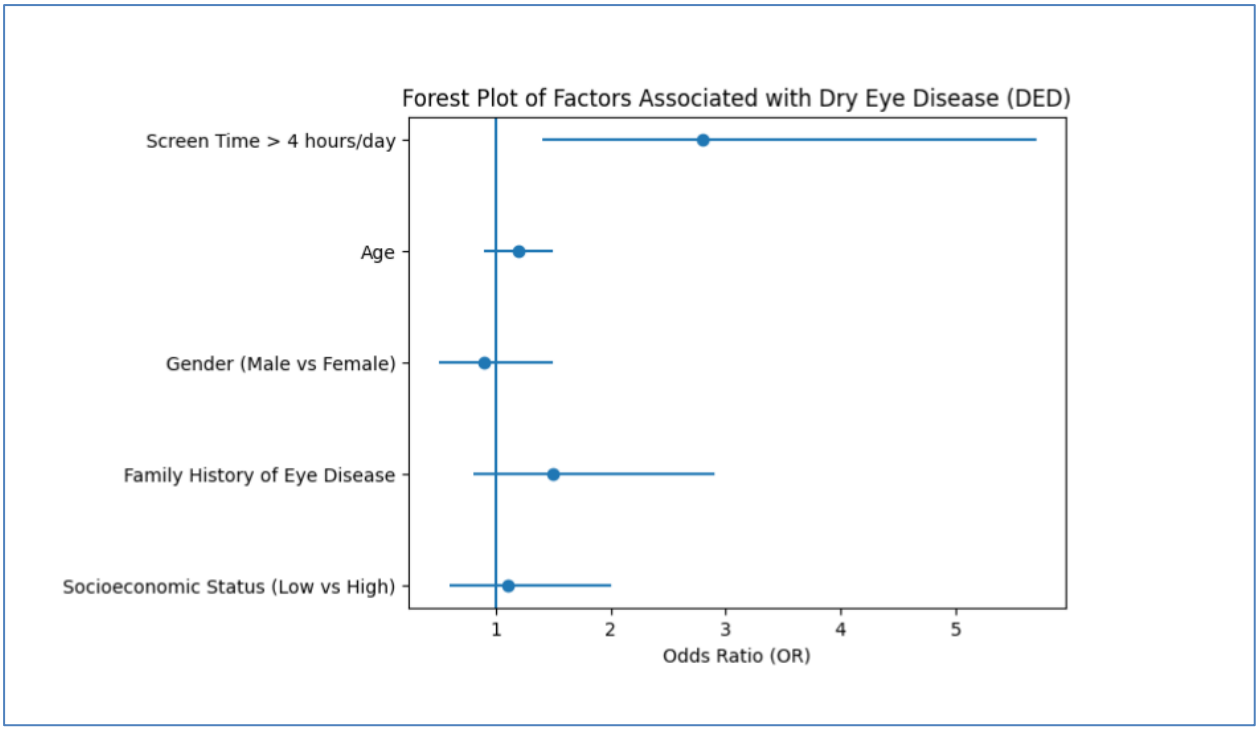

Figure 1: Logistic Regression Analysis of Factors Associated with Dry Eye Disease (DED) Symptoms in Children (n = 90)

Discussion

In our study, 35% of children were diagnosed with DED, consistent with Moon et al. (2016), who found 40% of children with >3 hours of screen exposure/day exhibited dry eye symptoms [11]. Similarly, Liu et al. (2022) reported that 58% of medical students with prolonged screen exposure experienced DED symptoms, mirroring our findings where children in the high screen time group had significantly higher OSDI scores and lower tear parameters [12].Our study found that >4 hours/day of screen exposure was associated with higher OSDI scores (17.8 ± 5.2) and abnormal clinical findings (e.g., Schirmer's test: 9.4 ± 2.1 mm). These results are aligned with Loh and Redd (2008), who reported 43% of workers with eye strain and discomfort from prolonged VDT use, similar to symptoms in our high screen exposure group [13]. Liu et al. (2023) also found that >3 hours of screen time/day led to decreased TBUT (7.4 ± 2.1 sec) and dry eye symptoms, which supports our findings of shorter TBUT in the high screen time group [14].In a study of high-altitude populations, Liu et al. (2022) found significant reductions in TBUT (6.3 ± 2.5 sec) and Schirmer's scores in students with prolonged screen exposure [12]. Our study's findings of shorter TBUT (5.7 ± 1.9 sec) and lower Schirmer's values (9.4 ± 2.1 mm) among children in the high screen time group similar to this association.Our study showed no significant gender differences in DED prevalence, which contrasts with Ranasinghe et al. (2016), who reported higher rates of CVS in male office workers due to greater screen exposure [15]. In our paediatric population, both genders experienced similar DED symptoms, suggesting that screen exposure, not gender, is the key risk factor for DED. Although not directly measured in our study, Liu et al. (2023) found that outdoor activities reduced DED symptoms in children with extended screen exposure [14]. Likewise, Neti et al. (2021) showed that frequent screen breaks and outdoor play reduced symptoms of DED in children, suggesting that encouraging such activities could help mitigate screen-related eye discomfort [16].

Conclusion

In conclusion, our study confirms the significant association between prolonged digital screen exposure and dry eye disease among school-going children. These findings align with existing literature and underscore the importance of preventive measures, such as reducing screen time, encouraging regular screen breaks, and promoting outdoor activities to mitigate the risk of DED in children.

Limitations

This study's cross-sectional design limits causal inference. It did not account for confounding factors such as sleep patterns or pre-existing ocular conditions. Self-reported screen time may be subject to recall bias, and the study was conducted in a single location, limiting generalizability. Future studies should address these limitations.

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