

Prolonged Smartphone Use and Tear Film Instability: A Narrative Review

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ABSTRACT

The widespread use of smartphones and other digital devices has become an integral part of modern life, particularly among children, adolescents, and young adults. Prolonged screen exposure has been increasingly associated with various ocular surface and visual disturbances, including digital eye strain and dry eye disease. This narrative review aims to synthesise existing evidence on the effects of prolonged smartphone and digital screen use on tear film stability, blink behaviour, and ocular surface health. The findings indicate that prolonged screen use leads to reduced blink rate, increased incomplete blink rate, tear film instability and meibomian gland dysfunction, contributing significantly to dry eye symptoms and visual discomfort. Preventive strategies such as regulated screen time, regular breaks, ergonomic optimisation, and early detection play a crucial role in minimising screen-related ocular complications. This review highlights the need for increased awareness and implementation of effective preventive and management strategies to protect ocular health in populations with high digital screen exposure.

Keywords: Digital screen use; Smartphone use; Digital eye strain; Dry eye disease; Tear film instability.

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INTRODUCTION

The rapid evolution of digital technology over recent decades has profoundly transformed contemporary human life, making digital display devices such as smartphones, tablets, laptops, desktops, and computers and virtual reality systems an integral component of daily activities worldwide¹. Digital platforms now dominate educational systems, professional workplaces, healthcare services, communication networks, and recreational activities, resulting in prolonged and often unavoidable exposure to electronic screens². This widespread digital integration has significantly altered the visual demands placed on the human eye, particularly due to protracted near-work tasks, sustained visual attention, and reduced opportunities for visual rest³.

Early exposure to smartphones and tablets, increased reliance on online learning platforms, and extensive engagement with social media and digital entertainment have collectively resulted in markedly increased cumulative screen time in the younger population⁴. Although digitalisation offers undeniable advantages, accumulating scientific evidence has highlighted its adverse effects on health, particularly visual and ocular well-being⁵. Among these, digital screen-related ocular complaints have gained increasing attention, prompting researchers and clinicians to examine the mechanisms and clinical manifestations associated with prolonged screen use⁶.

Digital eye strain, also referred to as computer vision syndrome, is a multifactorial condition characterised by a group of ocular and visual symptoms resulting from sustained digital screen

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viewing⁷. Commonly reported symptoms include ocular dryness, a burning sensation, redness, blurred vision, headaches, and ocular fatigue, all of which negatively impact productivity, academic performance, and quality of life⁸. A substantial body of research has demonstrated a strong association between increased daily screentime and a higher prevalence of dry eyediseases, particularly among smartphone users⁹.

Tear film instability resulting from reduced blink efficiency causes a decrease in tear breakup time and promotes ocular surface desiccation, epithelial microdamage, and inflammation¹⁰. These changes play a crucial role in the irritation and progression of dry eye symptoms among frequent digital device users¹¹. In addition to blink-related disturbances, prolonged screen exposure has been associated with dysfunction of the meibomian glands, which are essential for maintaining the lipid layer of the tear film¹². Structural and functional changes in these glands contribute to evaporative dry eye and further compromise tear film stability¹³.

Objective clinical tools such as Non-Invasive Tear Breakup Time (NIBUT), Ocular Surface Diseases Index (OSDI), tear osmolarity assessment, and meibography are widely used to evaluate these ocular surface changes and disease severity¹⁴. Findings from such assessments consistently demonstrate poorer ocular surface parameters among individuals with extended daily screen exposure¹⁵. Prolonged near work imposes continuous accommodative and convergence demands, leading to accommodative fatigue, convergence insufficiency, and reduced stereopsis¹⁶. In pediatric populations, excessive screen exposure has been linked to the development and progression of refractive errors, including astigmatism and other binocular vision anomalies¹⁷.

The COVID-19 pandemic led to a significant increase in daily screen time due to lockdowns, online education, and remote working conditions, which subsequently increased ocular and visual complaints among students and professionals¹⁸. In addition to ocular effects, prolonged digital device use- particularly smartphones- has been associated with sleep disturbances and disruption of circadian rhythm due to excessive exposure to screen luminance and blue light¹⁹.

AIM

This review aims to comprehensively synthesise current evidence on the ocular and visual consequences of digital screen use, with particular

emphasis on children, adolescents and young adults, and to provide a robust scientific foundation for effective prevention, early detection, and clinical management strategies.

OBJECTIVES

1. To evaluate the effect of prolonged smartphone and digital screen use on tear film stability, blink behaviour, and dry eye-related symptoms.
2. To summarise existing evidence on the ocular and visual consequences of increased screen time in children and adolescents and to highlight preventive and management strategies.

METHODOLOGY

Study Design

This study was designed as a **narrative review** to synthesise existing literature on the ocular surface and the visual effects of prolonged digital screen use, with particular emphasis on children and adolescents.

Literature Search Strategy

A comprehensive literature search was conducted using electronic databases including PubMed, Google Scholar, and Scopus. The search focused on peer-reviewed articles published in the English language, primarily within the last 10-15 years, to ensure clinical relevance and contemporary evidence.

Eligibility Criteria

Inclusion Criteria comprised original research articles, observational studies, and review papers that evaluated ocular surface parameters, visual function, or digital screen-related ocular symptoms. Studies involving children, adolescents, and young adults were prioritised.

Exclusion Criteria included case reports, editorials, letters to the editor, conference abstracts, non-peer-reviewed articles, studies unrelated to digital screen exposure, and articles published in a language other than English.

Study Selection

Initially, articles were screened based on their titles and abstracts for relevance to the review topic. Full-text articles of potentially eligible studies were subsequently reviewed to confirm suitability according to the predefined eligibility criteria.

Data Extraction

Relevant information was extracted from the selected studies, including author and year of publication, study design, participant age group, type and duration of digital device exposure, ocular surface assessment parameters (such as tear

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breakup time, OSDI scores, meibomian gland status) and key findings.

Data Synthesis

The extracted data were synthesised qualitatively and organised thematically to describe the effects of prolonged digital screen exposure on tear film stability, ocular surface health, and visual function. Emphasis was placed on identifying common patterns, mechanisms, and risk factors reported across studies, particularly in paediatric adolescent populations.

Ethical Considerations

As this review was based on previously published literature, ethical approval was not required.

EFFECT OF PROLONGED SCREENTIME ON BLINK RATE

Prolonged screentime has been consistently associated with a significant reduction in spontaneous blink rate. During smartphone and digital device use, individuals tend to maintain sustained visual attention, which suppresses normal blinking. Evidence suggests that blink frequency decreases significantly during prolonged screen viewing compared to baseline conditions²⁰.

In addition to reduced blink rate, prolonged screen use is also associated with an increased frequency of incomplete blinks. Incomplete blinking prevents the uniform distribution of the tear film across the ocular surface, resulting in increased tear evaporation and instability of the tear film. These blink-related alterations are considered a key mechanism linking prolonged screen exposure to the development of dry eye symptoms and digital eye strain²¹.

DIGITAL SCREEN USE AND DIGITAL EYE STRAIN

Digital screen use has increased substantially with the widespread adoption of smartphones, online learning platforms, and digital media. Prolonged screen viewing requires sustained near focus and continuous visual attention, which increases visual demand and contributes to the development of digital eye strain among frequent device users²².

Digital eye strain, also known as computer vision syndrome, is characterised by a range of ocular and visual symptoms, including eye fatigue, dryness, burning sensation, blurred vision, and headache. Previous research has reported a higher prevalence of these symptoms in individuals with prolonged daily screen exposure, particularly among students

and young adults, with symptom severity increasing as screen time increases²³.

TEAR FILM INSTABILITY AND DRY EYE DISEASE

Prolonged digital screen use has been strongly associated with tear film instability, which is a key factor in the development of dry eye disease. Reduced blink rate and increased incomplete blinking during screen viewing disrupt the normal distribution of the tear film, leading to decreased tear breakup time and increased tear evaporation²⁴.

Tear film instability results in ocular surface desiccation, inflammation, and increased susceptibility to dry eye symptoms such as dryness, irritation, and visual discomfort. Previous research has reported significantly lower tear film stability parameters among individuals with extended daily screen exposure, suggesting that prolonged screen exposure plays an important role in both the onset and progression of dry eye diseases²⁵.

MEIBOMIAN GLAND DYSFUNCTION AND EVAPORATIVE DRY EYE

Prolonged digital screen use has been associated with alterations in meibomian gland function, which plays a crucial role in maintaining the lipid layer of the tear film. Reduced blinking and increased incomplete blinks during screen viewing can impair meibum expression, leading to instability of the tear film and increased evaporation²⁶.

Meibomian gland dysfunction contributes significantly to evaporative dry eye and exacerbates ocular discomfort in frequent screen users. Previous research has reported structural and functional changes in the meibomian glands among individuals with prolonged screen exposure, highlighting their role in worsening dry eye symptoms and tear film instability²⁷.

IMPACT OF DIGITAL SCREEN USE ON CHILDREN AND ADOLESCENTS

Children and adolescents are a particularly vulnerable population due to early and prolonged exposure to digital screens for education, entertainment, and social interaction. Increased screen time at a young age has been associated with a higher prevalence of digital eye strain symptoms, including ocular discomfort, dryness, eye fatigue, and reduced visual performance²⁸.

Prolonged screen exposure in this age group may also affect tear film stability and visual development, as developing vision is more susceptible to environmental stressors. Previous

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research has highlighted the importance of early identification of screen-related ocular symptoms in children and adolescents and emphasised the need for preventive strategies such as regulated screen times, regular breaks, and awareness of healthy digital viewing habits²⁹

PREVENTIVE, EARLY DETECTION, AND MANAGEMENT STRATEGIES

Preventive strategies play a crucial role in reducing the ocular effects of prolonged digital screen use. Simple measures such as adherence to the 20-20-20 rule, regular screen breaks, conscious blinking, appropriate screen positioning, and adequate ambient lighting have been shown to reduce digital eye strain and associated symptoms. Promoting healthy digital habits is particularly important for children and adolescents, and young adults, who are increasingly exposed to screens for educational and recreational purposes³⁰.

Early detection of screen-related ocular problems is essential to prevent progression to chronic dry eye disease. Screening tools such as symptom questionnaires and basic tear film assessments can help identify individuals at risk at an early stage. Management strategies may include patient education, lifestyle modifications, optimisation of screen ergonomics, and use of lubricating eye drops when required. Increasing awareness among parents, educators, and healthcare professionals can significantly contribute to better ocular health outcomes in populations with high digital screen exposure³¹

DISCUSSION

Prolonged exposure to digital screen devices, including smartphones, tablets, and computers, has emerged as a significant contributor to the development and progression of dry eye diseases, particularly among children, students, and young adults. Evidence from multiple studies consistently demonstrates a positive association between increased screen time and both subjective dry eye symptoms and objective indicators of ocular surface dysfunction. Populations with extended daily digital device use exhibit a higher prevalence of dry eye-related complaints, underscoring the growing public health relevance of screen-associated ocular surface disorders^{32,33}.

The underlying pathophysiology of digital screen-related DED is largely attributed to the disruption of normal blinking patterns and subsequent tear film instability. Sustained visual concentration during digital tasks significantly reduces spontaneous

blink rate, thereby accelerating tear evaporation and impairing tear film homeostasis. Several investigations have reported notable reductions in tear breakup time following prolonged smartphone and tablet use, reflecting compromised tear film integrity. Additionally, prolonged screen exposure has been associated with increased oxidative stress within the tear film, which may contribute to ocular surface inflammation and epithelial damage, further exacerbating dry eye pathology^{34,35}.

Display technology and environmental viewing conditions also play an important modulatory role in the severity of dry eye manifestations. Light-emitting display technologies, such as OLED screens, have been shown to induce greater ocular surface stress and conjunctival redness compared to non-emissive alternatives such as E-Ink displays. Furthermore, suboptimal environmental factors, including inadequate ambient lighting, may intensify visual fatigue and ocular discomfort during extended digital devices³⁶.

In addition to objective tear film alterations, prolonged digital screen exposure is strongly associated with visual fatigue and a range of subjective symptoms. Frequently reported complaints include eye strain, burning sensation, blurred vision, and headache, with symptom severity increasing in relation to screen exposure duration. Subjective assessment tools, such as the Ocular Surface Disease Index, have consistently demonstrated elevated symptom scores following sustained digital activities, reinforcing the clinical significance of screen-induced ocular surface stress^{37,38,39}.

Overall, the findings of this narrative review indicate that prolonged digital screen use should be recognised not merely as a lifestyle behaviour but as a clinically relevant risk factor for dry eye disease. Implementation of preventive strategies, including limitation of uninterrupted screen exposure, optimisation of ergonomic and environmental conditions, selection of eye-friendly display technologies, and promotion of regular blinking and visual breaks, may play a crucial role in reducing the burden of digital eye strain and associated dry eye symptoms^{40,41}

CONCLUSION

Prolonged smartphone and digital screen use has emerged as a significant risk factor for tear film instability, digital eye strain, and dry eye diseases, particularly among children, adolescents, and young adults. Altered blink behaviour, reduced tear

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film stability, and meibomian gland dysfunction play a central role in the development of screen-related ocular surface disorders. Early identification of symptoms and adoption of preventive strategies such as regular breaks, conscious blinking, ergonomic optimisation, and healthy digital habits are essential to minimise long-term ocular complications. Increasing awareness among users, caregivers, educators, and healthcare professionals can contribute to improved ocular health outcomes in the digital era.

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