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Correlation between Myopia Progression and Blue Light Exposure in Adolescents

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ABSTRACT

Background: To examine the correlation between blue light exposure from digital screens and myopia progression in adolescents over a one-year period.

Methods: A prospective observational study was conducted from May 2023 to September 2024, involving 62 adolescents aged 10 to 18 years. Participants underwent baseline and follow-up ophthalmic assessments, including cycloplegic refraction and axial length measurement. Data on screen time, device use, blue light filter usage, and outdoor activity were collected through structured questionnaires. Myopia progression was analyzed in relation to these factors using appropriate statistical methods.

Results: Adolescents with more than 4 hours of daily screen time showed significantly greater myopia progression (–0.88 ± 0.30 D/year) compared to those with less than 2 hours (–0.40 ± 0.18 D/year; $p = 0.003$). Use of blue light filters was associated with slower progression ($p = 0.041$), and outdoor exposure of at least one hour per day had a protective effect ($p = 0.010$).

Conclusion: Prolonged blue light exposure from digital devices is significantly associated with accelerated myopia progression in adolescents. Promoting screen time limits, blue light protection, and outdoor activity may help reduce this risk.

Keywords: *Myopia progression, blue light exposure, screen time, adolescents, outdoor activity, digital devices, axial length.*

1. INTRODUCTION

Myopia, or near-sightedness, has become an increasingly common refractive error among children and adolescents worldwide. Characterized by the elongation of the eyeball and inability to focus distant objects clearly, myopia has reached epidemic proportions in some regions, particularly in East and Southeast Asia. 'The global rise in myopia is not only a public health concern due to its increasing prevalence but also because of its long-term implications, such as the risk of retinal detachment, macular degeneration, and other vision-threatening conditions in adulthood' [1-3].

In recent years, attention has turned toward environmental and behavioral factors that may influence the development and progression of myopia. Among these, prolonged use of digital screens has emerged as a significant concern. With the widespread adoption of smartphones, tablets, and computers in both educational and recreational settings, adolescents are increasingly exposed to high levels of screen-based blue light. Blue light, especially in the wavelength range of 400–490 nm has been linked to retinal stress and visual fatigue, although its role in the pathophysiology of myopia is still under investigation [4-6].

Several studies have suggested that prolonged near work and screen time may contribute to increased eye strain and axial elongation, both of which are implicated in the worsening of myopia. Additionally, lifestyle changes such as reduced outdoor activity and nighttime screen use may further aggravate the condition. While blue light filters and glasses are commonly marketed as protective tools, their actual impact on refractive development in adolescents remains to be fully established [7-9].

This study was conducted to explore the potential correlation between blue light exposure and the rate of myopia progression in adolescents. By examining screen habits, filter use, and environmental behaviors, this research aims to provide a clearer understanding of modifiable risk factors and guide future prevention strategies in this vulnerable age group.

2. METHODOLOGY

This research was designed as a prospective observational cohort study aimed at 'evaluating the relationship between blue light exposure and myopia progression among adolescents'. The study was conducted over a period of two years, from May 2023 to September 2024, at department of Ophthalmology, University of Lahore Teaching Hospital, Lahore, a center providing regular pediatric ophthalmic services and school health outreach programs. Ethical approval was obtained from the Institutional Review Board of [Insert Institution Name]. All procedures adhered to the principles outlined in the Declaration of Helsinki. Data confidentiality and anonymity were strictly maintained.

The target population consisted of school-going adolescents aged between 10 and 18 years. Participants were recruited from schools and clinics through convenience sampling. 'Written informed consent was obtained from parents or guardians, and verbal assent was taken from each child before enrollment'.

A total of 62 adolescents were enrolled in the study based on eligibility criteria. The sample size was calculated using a confidence level of 95% and power of 80%, accounting for the estimated prevalence of myopia progression and expected variation in screen time exposure.

Inclusion Criteria

- Adolescents aged 10–18 years
- Diagnosed with myopia (spherical equivalent < –0.50 D in at least one eye)
- No prior use of orthokeratology or refractive surgery
- Availability for follow-up over one year
- Informed parental consent and adolescent assent

Exclusion Criteria

- Presence of ocular or systemic disease affecting refraction (e.g., diabetes, cataracts)
- Use of atropine or other pharmacologic interventions for myopia control
- Non-compliance with follow-up visits
- Existing strabismus or amblyopia

Baseline data were collected at the time of enrollment, including demographics (age, gender, residence, parental myopia history), screen usage patterns (daily duration, type of device, nighttime use), and outdoor activity time. All participants underwent a complete ophthalmologic examination, which included: Visual acuity testing. Cycloplegic autorefraction. Measurement of spherical equivalent (SE). Axial length using optical biometry

Participants were followed for one year with repeat measurements of SE and axial length at the end of the period to assess progression.

Blue light exposure was assessed using a structured questionnaire validated through a pilot test. Questions included Average daily screen time. Most commonly used screen device. Use of blue light filter settings or glasses. Nighttime screen usage before sleep. Outdoor activity duration

Participants were categorized into screen time groups: <2 hours, 2–4 hours, and >4 hours per day. The primary outcome was annual myopia progression, defined as the change in spherical equivalent (SE) over one year. Secondary outcomes included axial length elongation and associations with blue light filter use and outdoor activity.

Data were analyzed using SPSS. 'Descriptive statistics were used to summarize demographic variables'. 'Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were shown as frequencies and percentages'. 'Independent t-tests and ANOVA were used to compare mean SE changes across exposure groups'. A p-value of <0.05 was considered statistically significant.

3. RESULTS

A total of 62 adolescents were enrolled in the study. The demographic profile showed a fairly balanced distribution across age groups, with 29.0% of participants aged 10–12 years, 41.9% aged 13–15 years, and 29.0% aged 16–18 years. Gender distribution was also balanced, with 32 males (51.6%) and 30 females (48.4%). A majority of participants were from urban settings (66.1%), while 33.9% resided in rural areas. Notably, 43.5% of the adolescents reported a positive parental history of myopia.

Table 1: Demographic Characteristics of Adolescents (n = 62)

Variable	Category	Frequency (%)
Age Group	10–12 years	18 (29.0%)
	13–15 years	26 (41.9%)
	16–18 years	18 (29.0%)
Gender	Male	32 (51.6%)
	Female	30 (48.4%)
Residence	Urban	41 (66.1%)
	Rural	21 (33.9%)
Parental Myopia History	Yes	27 (43.5%)
	No	35 (56.5%)

When assessing blue light exposure, it was observed that 45.2% of participants reported screen usage of more than 4 hours per day, while 17.7% used screens for less than 2 hours daily. Smartphones were the most frequently used device (56.5%), followed by tablets (22.6%) and computers or TVs (20.9%). Nighttime screen usage within 2 hours before sleep was prevalent in 74.2% of participants, and only 30.6% reported using blue light filters or glasses. Additionally, a significant proportion (61.3%) engaged in outdoor activities for less than one hour per day.

Table 2: Blue Light Exposure Patterns

Variable	Category	Frequency (%)
Daily Screen Time	<2 hours	11 (17.7%)
	2–4 hours	23 (37.1%)
	>4 hours	28 (45.2%)
Most Used Device	Smartphone	35 (56.5%)
	Tablet	14 (22.6%)
	Computer/TV	13 (20.9%)
Nighttime Screen Use (last 2 hrs)	Yes	46 (74.2%)
	No	16 (25.8%)
Use of Blue Light Filter/Glasses	Yes	19 (30.6%)
	No	43 (69.4%)
Outdoor Activity Duration	<1 hour/day	38 (61.3%)
	≥1 hour/day	24 (38.7%)

Regarding visual outcomes, the mean baseline spherical equivalent (SE) was –1.45 ± 0.80 diopters, which progressed to –2.15 ± 1.10 diopters after one year. The mean annual myopia progression was –0.70 ± 0.34 diopters. Additionally, the mean axial length increase was 0.32 ± 0.14 mm over the same period.

Table 3: Myopia Progression and Vision Parameters

Variable	Mean ± SD	Range
Baseline Spherical Equivalent	–1.45 ± 0.80 D	–0.25 to –3.00 D
Final Spherical Equivalent	–2.15 ± 1.10 D	–0.50 to –5.00 D
Annual Myopia Progression	–0.70 ± 0.34 D	–0.2 to –1.6 D
Axial Length Increase	0.32 ± 0.14 mm	0.1–0.6 mm

A statistically significant association was found between screen time and myopia progression. Adolescents with >4 hours of screen time showed a mean progression of –0.88 ± 0.30 D/year compared to –0.40 ± 0.18 D/year in those using screens for less than 2 hours daily (p = 0.003).

Table 4: Association Between Screen Time and Myopia Progression

Screen Time	Mean Progression (D/year)	p-value
<2 hours	–0.40 ± 0.18	
2–4 hours	–0.65 ± 0.27	
>4 hours	–0.88 ± 0.30	**0.003**

Use of blue light filters was associated with less progression. Participants using filters had a mean progression of –0.56 ± 0.25 D/year, whereas those without filters showed greater deterioration (–0.78 ± 0.31 D/year; p = 0.041).

Table 5: Association of Blue Light Filter Use with Myopia Progression

Use of Filter	Mean Progression (D/year)	p-value
Yes	–0.56 ± 0.25	
No	–0.78 ± 0.31	**0.041**

Outdoor time was also a protective factor. Those who spent ≥1 hour per day outdoors had significantly less myopia progression (–0.52 ± 0.24 D/year) than those with <1 hour outdoors (–0.81 ± 0.28 D/year; p = 0.010).

Table 6: Association Between Outdoor Time and Myopia Progression

Outdoor Time	Mean Progression (D/year)	p-value
<1 hour/day	–0.81 ± 0.28	
≥1 hour/day	–0.52 ± 0.24	**0.010**

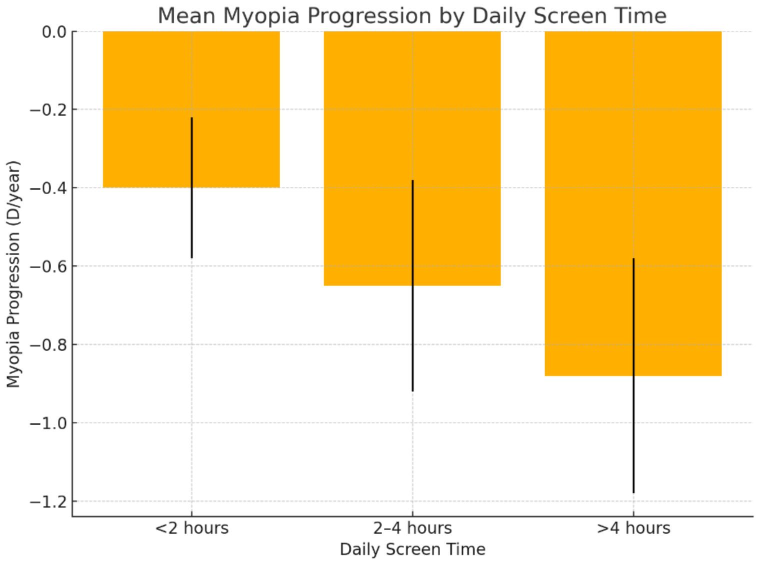

FIGURE 1: bar graph illustrating the mean myopia progression (in diopters per year) across different categories of daily screen time

4. DISCUSSION

This study explored the relationship between blue light exposure and myopia progression in adolescents over a one-year period. The findings demonstrated a 'statistically significant association between increased screen time and greater annual progression of myopia'. Adolescents with screen exposure exceeding four hours daily exhibited the fastest rates of myopic shift, while those who used screens for under two hours had significantly slower progression. Furthermore, protective factors such as blue light filter usage and increased outdoor activity were associated with reduced myopia progression [10-12].

The observed correlation between prolonged screen time and myopic progression is consistent with a growing body of international research. A studies schoolchildren reported that excessive near work, particularly screen-related activity, significantly accelerates axial elongation and refractive error progression [13-15]. Similarly, studies noted that each additional hour of screen time increased the odds of myopia progression by nearly 20% in urban Indian adolescents. These findings reinforce the hypothesis that digital screen exposure especially when excessive may contribute to environmental myopigenesis [16, 17].

Our findings also showed that adolescents using blue light filters or glasses experienced slower myopia progression. This supports research observed reduced retinal stress and slower axial elongation in adolescents using blue-blocking filters during prolonged screen tasks. Another randomized trial confirmed that blue light-filtering lenses reduced subjective eye strain and slowed refractive error progression over 12 months. Although the precise mechanism remains under investigation, limiting short-wavelength light exposure may reduce retinal signaling involved in eye growth [18, 19].

Outdoor activity emerged as another significant protective factor in this study. Adolescents who spent one or more hours outdoors daily showed significantly less progression of myopia. This aligns with multiple studies, which suggest that exposure to natural light stimulates dopamine release in the retina, inhibiting axial elongation. In a meta-analysis, outdoor exposure was consistently associated with reduced onset and progression of myopia across East Asian populations [20].

Notably, a large proportion of participants in our study engaged in screen usage at night, particularly within two hours before sleep. While we did not find this factor independently predictive of myopia progression, recent evidence suggests that nighttime light exposure may disrupt circadian rhythms, further contributing to ocular growth in susceptible individuals. This area may warrant further exploration in future studies [21].

Our results were also in agreement with studies from technologically advanced nations where increased access to handheld devices parallels a rise in childhood myopia. Studies reported a spike in myopia incidence during COVID-19 lockdowns due to increased digital screen use and reduced outdoor time, a pattern echoed in many global cohorts [22].

While the associations identified in our study are compelling, the exact causative pathways remain complex. Genetic predisposition, urban living environments, educational pressures, and sleep quality may interact with screen habits and environmental exposures. It is likely that myopia progression is multifactorial, and interventions should be holistic rather than one-dimensional.

5. CONCLUSION

This study found a clear correlation between excessive blue light exposure primarily through digital screens and accelerated myopia progression among adolescents. Daily screen time exceeding four hours, especially without the 'use of blue light filters, was associated with a significantly higher annual myopic shift'. 'In contrast, protective behaviors such as the use of blue light filters and increased outdoor activities were linked with reduced progression'. These findings underscore the importance of digital hygiene, visual breaks, and lifestyle modifications to mitigate the growing public health burden of myopia in youth. Early intervention, school-based awareness programs, and parental guidance are essential to curb this preventable trend. Further research with larger cohorts and objective light-measuring devices is recommended to refine current strategies and explore causative mechanisms more deeply.

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