INSIGHTS-JOURNAL OF
LIFE AND SOCIAL SCIENCES

INSIGHTS-JLSS
Insights-Journal of Life and Social Sciences

VISUAL SCREEN TIME EXPOSURE AND ITS ASSOCIATION WITH REFRACTIVE ERRORS IN SCHOOL-AGED CHILDREN: A CROSS-SECTIONAL STUDY

Original Article

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Conflict of Interest: None

Grant Support & Financial Support: None

Acknowledgment: The authors thank all participating schools and families for their cooperation.

ABSTRACT

Background: The increasing use of digital devices among children has raised global concerns about its impact on ocular health. Refractive errors, particularly myopia, have been observed to rise concurrently with screen time exposure, yet data from low- and middle-income countries remain limited.

Objective: To assess the relationship between daily screen time duration and the prevalence of refractive errors among school-aged children (6–12 years) in Islamabad, Pakistan.

Methods: This cross-sectional study was conducted over eight months in selected public and private schools in Islamabad. A total of 422 children aged 6–12 years were enrolled through stratified random sampling. Data on screen time were collected using parent-administered structured questionnaires, while comprehensive ophthalmologic assessments, including cycloplegic refraction, were performed to diagnose refractive errors. Statistical analyses included independent t-tests, Pearson's correlation, and binary logistic regression using SPSS version 26.

Results: The mean age of participants was 9.1 years (±1.7), with 50.9% male representation. Refractive errors were diagnosed in 173 children (41.0%). Prevalence of refractive errors increased with screen time: 17.0% (<2 hrs), 36.0% (2–4 hrs), 46.8% (4–6 hrs), and 68.9% (>6 hrs). Myopia was the most common refractive error (58.6%), followed by hyperopia (23.6%) and astigmatism (17.2%). Children with refractive errors had a significantly higher mean screen time (4.8 ± 1.5 hrs) compared to those without (2.6 ± 1.1 hrs, $p < 0.001$). Logistic regression showed children with >4 hours of screen time had 2.8 times higher odds of refractive error (95% CI: 1.9–4.2).

Conclusion: Prolonged screen time is strongly associated with an increased risk of refractive errors in children. These findings underscore the need for awareness, early screening, and lifestyle modifications to preserve pediatric visual health.

Keywords: Astigmatism, Child, Hyperopia, Myopia, Ocular Refraction, Pakistan, Prevalence, Risk Factors, Screen Time, Vision Screening.

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INTRODUCTION

In recent decades, the use of digital screens has become deeply ingrained in the daily lives of children, reshaping patterns of communication, education, and leisure. While technology offers undeniable benefits, the increasing duration of screen exposure among school-aged children has emerged as a growing public health concern, particularly due to its potential impact on visual health. Among the various ocular consequences associated with prolonged digital screen use, the development and progression of refractive errors have gained significant attention (1). Myopia, hyperopia, and astigmatism are increasingly diagnosed at younger ages, prompting both clinicians and researchers to investigate modifiable risk factors that may contribute to this trend. A growing body of literature suggests a correlation between environmental influences and ocular development in children (2). Studies have indicated that reduced outdoor activity, increased near work, and extended digital device usage may play a role in the onset and worsening of refractive errors, especially myopia. In a study conducted in East Asia, where digital learning and screen-based entertainment are highly prevalent, researchers reported a striking rise in childhood myopia, linking it to excessive near-vision tasks, including screen time (3,4). Similarly, Western countries have also observed a parallel trend in the increasing prevalence of visual impairments among children, aligning with changes in lifestyle and technology consumption (5,6). Despite regional differences in education systems and cultural habits, one common factor is the notable shift toward screen-based learning and recreation.

The visual demands placed on young eyes by smartphones, tablets, laptops, and televisions are fundamentally different from those of traditional reading materials. Digital screens often involve prolonged focus, shorter viewing distances, and exposure to blue light, all of which can contribute to visual fatigue and accommodative stress. In children, whose visual systems are still developing, such strain may precipitate or exacerbate refractive anomalies (7). Furthermore, the COVID-19 pandemic accelerated the transition to online education, drastically increasing children's daily screen exposure and highlighting the urgency of evaluating the ocular consequences of this shift. Biologically, the eye grows and adapts in response to visual stimuli (8). Prolonged near work, such as reading or screen use at short distances, is hypothesized to alter the emmetropization process, the natural adjustment of the eye's refractive state during growth. Disruption of this process may predispose children to myopia or other visual issues. While genetic predisposition plays a significant role in refractive development, the interaction between environmental triggers and genetic susceptibility remains a critical area of research. It is becoming increasingly evident that modifiable lifestyle factors, including screen time, must be considered in strategies aimed at preserving pediatric eye health (9,10).

Although some studies have explored the association between screen time and refractive errors, findings remain inconclusive and often limited by methodological differences, regional variations, or inadequate sample sizes (11,12). Moreover, many studies fail to capture the nuances of screen time—such as device type, usage context, and total daily exposure—which may differentially impact visual health. This creates a compelling need for more standardized, population-specific research that not only quantifies screen exposure but also correlates it with clinically diagnosed refractive errors. In Pakistan and other low- to middle-income countries, where access to regular eye care is limited and awareness about pediatric vision screening is often lacking, understanding such associations is even more critical. The shift toward digital learning platforms in urban schools, coupled with unregulated recreational screen use, may place children at heightened risk of developing visual problems that go undiagnosed or untreated. These issues, if not addressed early, can have long-term consequences on academic performance, quality of life, and overall developmental outcomes. Given this context, the present cross-sectional study aims to investigate the relationship between daily screen time duration and the prevalence of refractive errors among school-aged children aged 6 to 12 years. By evaluating this association within a specific age group during a formative stage of ocular development, this research seeks to contribute to the evidence base needed to inform clinical guidelines, parental practices, and public health policies. The objective is not only to quantify the extent of the problem but also to encourage early preventive interventions that support healthy visual development in an increasingly digital world.

METHODS

This cross-sectional study was conducted over a duration of eight months, from March to October 2024, in selected primary and middle schools situated in urban areas of Islamabad, Pakistan. The study was designed to evaluate the association between daily visual screen time and the prevalence of refractive errors among children aged 6 to 12 years. Schools from both public and private sectors were approached to ensure socioeconomic diversity in the sample, and permission was obtained from school administrations prior to participant recruitment. A calculated sample size of 384 children was determined using OpenEpi sample size calculator, based on a confidence interval of 95%, an anticipated prevalence of refractive errors in children (estimated at 30% from previous regional studies),

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and a margin of error of 5%. To account for potential non-response or incomplete data, the sample size was increased by 10%, bringing the total to 422 participants (3,4). Children were recruited through stratified random sampling, where each school served as a stratum, and proportionate sampling ensured equal representation from different grades and age categories within the eligible range.

Inclusion criteria for the study consisted of children aged 6–12 years enrolled in the selected schools, who were available during school hours and whose parents or guardians provided informed written consent. Exclusion criteria included children with a history of ocular trauma, congenital eye diseases, systemic illnesses affecting vision (such as diabetes), or those already undergoing treatment for any ocular pathology other than refractive error. Children with developmental delays or learning disabilities that could interfere with accurate visual acuity testing were also excluded (13). Data collection was carried out through a two-part procedure. In the first phase, a structured, pre-validated questionnaire was administered to the parents or primary caregivers. This questionnaire collected demographic data including age, gender, and parental education, and focused on screen usage patterns—such as daily average screen time (in hours), device types used (smartphones, tablets, computers, televisions), usage purpose (educational or recreational), and screen viewing distance and posture. The questionnaire was pretested on a separate group of 30 children to ensure clarity and relevance, and adjustments were made accordingly.

The second phase involved a comprehensive ophthalmologic assessment conducted on-site by trained optometrists and ophthalmic technicians. Visual acuity was assessed using the Snellen chart for distance vision at 6 meters, and pinhole testing was used to differentiate refractive errors from other causes of decreased vision. Cycloplegic refraction using 1% cyclopentolate eye drops was performed on all children with subnormal visual acuity (<6/6 in either eye) to accurately identify and quantify refractive errors. Children were diagnosed as having refractive errors if spherical equivalent measurements indicated myopia (≤ −0.50 D), hyperopia (≥ +2.00 D), or astigmatism (cylinder ≥ 1.00 D). The final classification was documented in accordance with the American Academy of Ophthalmology's pediatric vision screening guidelines. All data were manually recorded and then entered into SPSS version 26 for analysis. Descriptive statistics were used to summarize demographic characteristics, screen time categories, and refractive error types. Mean and standard deviation were calculated for continuous variables, while categorical variables were expressed as frequencies and percentages. Since the data followed a normal distribution, inferential analysis was performed using independent t-tests to compare mean screen time between children with and without refractive errors. Furthermore, one-way ANOVA was used to assess differences in mean screen time across different types of refractive errors. Pearson's correlation coefficient was computed to examine the linear relationship between screen time duration and spherical equivalent refraction. A binary logistic regression model was constructed to evaluate the odds of having a refractive error based on screen time exposure, adjusting for age, gender, and parental education level as potential confounders. A p-value of less than 0.05 was considered statistically significant for all analyses.

Ethical approval for the study was obtained from the relevant Institutional Review Board (IRB). Informed consent forms, along with study information sheets in Urdu and English, were distributed to parents and guardians before data collection. Consent was confirmed prior to clinical examination, and verbal assent was taken from the children in age-appropriate language. All procedures adhered to the ethical principles outlined in the Declaration of Helsinki, ensuring participant privacy and data confidentiality throughout the study. Children found to have uncorrected refractive errors were referred to the pediatric ophthalmology unit at PIMS for appropriate treatment and follow-up care. This methodologically rigorous approach allowed for the careful examination of a potentially modifiable risk factor affecting pediatric visual health and ensured that the findings would be both generalizable and clinically relevant within the context of urban school children in Pakistan.

RESULTS

A total of 422 children aged 6–12 years participated in the study. The mean age of the participants was 9.1 years (±1.7 SD). Of these, 215 (50.9%) were male and 207 (49.1%) were female. The sample was nearly evenly split between public school students (50.2%) and private school students (49.8%). Among the total participants, 173 children (41.0%) were found to have refractive errors. Stratification of screen time showed that 88 children reported daily screen time less than 2 hours, while 136, 124, and 74 children reported screen time between 2–4 hours, 4–6 hours, and more than 6 hours respectively. The prevalence of refractive errors increased with screen time: 17.0% in those with <2 hours, 36.0% in 2–4 hours, 46.8% in 4–6 hours, and 68.9% in children exposed to more than 6 hours of screen time daily. Regarding the types of refractive errors diagnosed, myopia was the most prevalent, observed in 102 children (58.6% of those with refractive errors), followed by hyperopia in 41 children (23.6%) and astigmatism in 30 children (17.2%).

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A comparison of mean daily screen time revealed that children with refractive errors had a significantly higher average screen time of 4.8 hours (±1.5 SD), compared to 2.6 hours (±1.1 SD) in children without refractive errors. The difference in mean screen time between these two groups was statistically significant ($p < 0.001$), indicating a strong association. Pearson's correlation coefficient analysis showed a significant positive correlation ($r = 0.61$, $p < 0.001$) between screen time duration and the presence of refractive errors. Additionally, binary logistic regression indicated that children with daily screen time exceeding 4 hours were 2.8 times more likely (95% CI: 1.9–4.2, $p < 0.001$) to develop refractive errors compared to those with less than 2 hours of exposure, after adjusting for age, gender, and school type. These findings underscore a clear dose-response relationship between screen time and the prevalence of refractive errors in school-aged children. The data collectively highlight the impact of prolonged digital screen exposure on pediatric ocular health.

Table 1: Demographic Characteristics of Study Participants (n = 422)

Variable	Value
Total Participants	422
Mean Age (years ± SD)	9.1 ± 1.7
Gender	
Male	215 (50.9%)
Female	207 (49.1%)
Sector	
Public School	212 (50.2%)
Private School	210 (49.8%)

Table 2: Screen Time Categories and Prevalence of Refractive Errors

Screen Time (hrs/day)	Participants (n)	Refractive Errors (n)	Prevalence (%)
< 2 hours	88	15	17.0%
2–4 hours	136	49	36.0%
4–6 hours	124	58	46.8%
> 6 hours	74	51	68.9%

Table 3: Distribution of Refractive Error Types Among Diagnosed Children (n = 173)

Type of Refractive Error	Frequency (n)	Percentage (%)
Myopia	102	58.6%
Hyperopia	41	23.6%
Astigmatism	30	17.2%

Table 4: Mean Daily Screen Time by Refractive Error Status

Group	Mean Screen Time (hrs/day)	Standard Deviation
With Refractive Error	4.8	±1.5
Without Refractive Error	2.6	±1.1
p-value	< 0.001	

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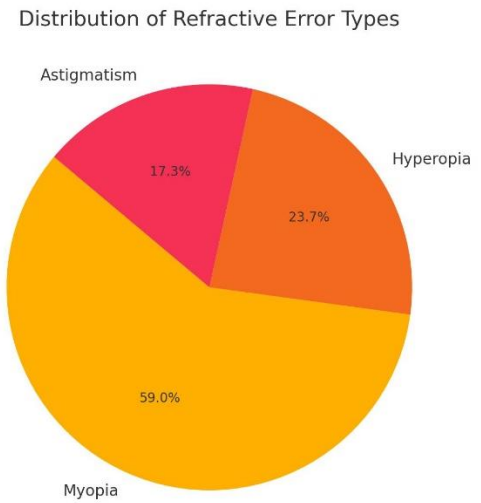

Figure 1 Distribution of Refractive Error Types

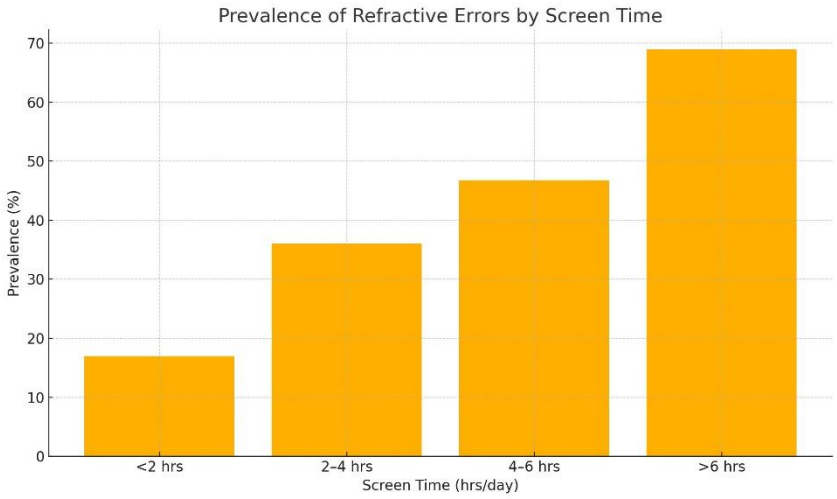

Figure 2 Prevalence of Refractive Errors by Screen Time

DISCUSSION

The findings of this cross-sectional study demonstrated a significant association between increased screen time and the prevalence of refractive errors among children aged 6 to 12 years. The data reflected a clear dose-response trend, wherein the prevalence of refractive errors escalated progressively with longer durations of daily digital screen exposure. These results are consistent with a growing body of global evidence indicating that prolonged near-work activities, especially those involving electronic screens, may play a substantial role in the early onset and worsening of refractive anomalies in the pediatric population. Myopia emerged as the most prevalent refractive error in the current study, accounting for over half of the diagnosed cases. This trend aligns with the rising global burden of pediatric myopia, particularly in urbanized settings where digital device usage is high. A multi-country analysis reported similar patterns, highlighting screen time as a modifiable risk factor for childhood myopia, especially in East and Southeast Asian populations (14). Furthermore, a longitudinal study concluded that near-work and digital screen exposure significantly increased the risk of incident myopia in school-aged children, echoing the findings observed in the present study (15).

The logistic regression analysis provided robust evidence that children with more than four hours of daily screen exposure were nearly three times more likely to develop refractive errors. This observation is consistent with the findings of a study which reported a strong correlation between higher screen time and increased risk of both myopia and asthenopic symptoms among Indian children during the COVID-19 lockdown (16). Similarly, another study found that home confinement and e-learning had significantly increased the incidence and progression of myopia, which was primarily attributed to increased screen time and reduced outdoor activity (17). While genetic predisposition cannot be overlooked in refractive development, the current study emphasizes the importance of environmental and behavioral modifiers, particularly in urban contexts like Islamabad where children may have limited access to outdoor play. Evidence from large-scale studies further supports this notion, as it demonstrated that lifestyle modifications, including reduced screen exposure and increased time spent outdoors, could significantly mitigate the risk of myopia progression (18-20).

One of the key strengths of this study lies in its focus on a well-defined pediatric age group using standardized refractive assessment techniques, including cycloplegic refraction, which is widely regarded as the gold standard in pediatric ophthalmology. The inclusion of both public and private school students improved the generalizability of the findings by representing children from diverse socioeconomic backgrounds. Additionally, the use of stratified random sampling and validated questionnaires enhanced the internal validity and reliability of the data collected. Nevertheless, several limitations should be acknowledged. Being a cross-sectional study, causality could not be established, and only associations could be inferred. The data on screen time were based on parental reporting, which may have introduced recall bias or social desirability bias, potentially affecting accuracy. Furthermore, other influencing factors such as time spent outdoors, lighting conditions, and the presence of parental myopia were not included in the scope of this study,

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limiting a more comprehensive understanding of all risk determinants. These factors are critical, as shown in the longitudinal research, which highlighted the protective role of daylight exposure in counteracting screen-related myopic shifts.

Future research should consider adopting prospective cohort designs with objective screen time tracking tools, such as digital usage logs or wearable eye-tracking sensors, to improve accuracy and causative inferences. Incorporating outdoor activity levels, sleep patterns, and dietary habits may also provide a more holistic understanding of pediatric ocular health. In addition, longitudinal studies assessing the effectiveness of educational interventions to reduce unnecessary screen exposure could offer actionable insights for school administrators and policymakers (21). The results of this study underscore the urgent need for public health strategies aimed at mitigating digital eye strain and refractive burden among school children. Interventions such as structured screen breaks, promoting outdoor activities, and routine school-based vision screening programs may help identify and manage refractive issues early. Collaborative efforts between healthcare providers, educators, and parents are essential to fostering healthy visual behaviors in the increasingly digital lives of children.

CONCLUSION

This study established a significant association between increased daily screen time and a higher prevalence of refractive errors among school-aged children. Myopia was the most common refractive issue observed, particularly in those with screen exposure exceeding four hours. These findings emphasize the need for parental awareness, routine vision screening, and public health strategies to mitigate the ocular risks linked to excessive digital device use in children.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Israr*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Taliah Hareem	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Usama Rahim	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Qasim Zia	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Mahnoor Tahir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Farhan Muhammad Qureshi	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Maryam Aslam	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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