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Impact of Digital Screen Time on the Occurrence of Refractive Errors among School Children

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Abstract: *The rapid increase in the use of smartphones, tablets, computers, and other digital devices has transformed children's educational and recreational activities. While digital technology has enhanced learning opportunities, prolonged digital screen exposure has raised concerns regarding children's visual health, particularly the occurrence and progression of refractive errors such as myopia, hyperopia, and astigmatism. Numerous epidemiological studies conducted between 2010 and 2022 have reported an increasing prevalence of refractive errors among school-aged children, with excessive screen time identified as one of several contributing environmental factors alongside reduced outdoor activity and prolonged near work. This review paper summarizes current evidence regarding the relationship between digital screen time and refractive errors among school children. The review also discusses associated risk factors, mechanisms, preventive strategies, and recommendations for parents, teachers, and policymakers.*

Keywords: Digital Screen Time, Myopia, Refractive Error, School Children, Eye Health, Digital Eye Strain.

I. INTRODUCTION

The widespread adoption of digital technology has fundamentally changed children's daily routines. Educational activities increasingly rely on digital devices, and recreational screen use has also grown substantially. During the last decade, school children have experienced unprecedented exposure to smartphones, tablets, computers, and television.

Refractive errors remain the leading cause of visual impairment among children worldwide. Myopia has emerged as the fastest-growing refractive disorder, particularly in Asian countries. Research suggests that excessive screen exposure contributes indirectly through prolonged near work, reduced blinking, accommodative stress, and decreased outdoor activity. However, screen time acts alongside several environmental and genetic influences rather than being the sole cause.

II. LITERATURE REVIEW (2010–2022)

Several studies published between 2010 and 2022 have investigated the impact of digital device use on children's vision.

Lanca and Saw (2020) systematically reviewed available evidence and concluded that excessive digital screen time may contribute to myopia development, although outdoor activity and educational intensity remain important confounding variables.

Kaur et al. (2022) reviewed Digital Eye Strain (DES) and reported that prolonged digital device use among children causes symptoms including eye fatigue, blurred vision, dry eyes, headaches, and may coincide with accelerated myopia progression, particularly during periods of increased online learning.

Zhang et al. (2022) found that prolonged screen exposure in school-aged children was associated with several health outcomes, including visual problems, especially when accompanied by reduced physical activity and outdoor exposure.

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III. CAUSES OF INCREASED REFRACTIVE ERRORS

Major contributing factors include:

1. Prolonged smartphone use
2. Continuous online education
3. Reduced outdoor activities
4. Increased near-work duration
5. Genetic predisposition
6. Poor lighting conditions
7. Short viewing distance
8. Lack of visual breaks

Table 1. Major Risk Factors for Refractive Errors

Risk Factor	Effect on Vision
Screen time >2 hours/day	Increased accommodative stress
Reduced outdoor activity	Higher myopia progression
Continuous near work	Eye fatigue and blurred vision
Poor posture	Digital eye strain
Genetic history	Increased susceptibility
Improper lighting	Visual discomfort

IV. MECHANISM OF SCREEN-INDUCED VISUAL PROBLEMS

Excessive screen use affects ocular health through several pathways:

1. Continuous accommodation
2. Reduced blink rate
3. Tear film instability
4. Dry eye symptoms
5. Retinal image defocus
6. Eye muscle fatigue
7. Increased axial elongation (associated with myopia progression)

These mechanisms are thought to contribute to digital eye strain and may play a role in the development or progression of refractive errors, particularly when combined with limited outdoor exposure.

V. COMMON REFRACTIVE ERRORS AMONG SCHOOL CHILDREN

Refractive errors are among the most common ocular disorders affecting school-aged children and represent a significant public health concern worldwide. They occur when the eye is unable to focus incoming light accurately on the retina, resulting in blurred vision. These visual impairments can negatively influence a child's academic performance, cognitive development, social interaction, and overall quality of life if left undiagnosed or untreated. According to the World Health Organization (WHO), uncorrected refractive errors are one of the leading causes of visual impairment among children and adolescents globally.

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The prevalence of refractive errors has increased substantially over the past decade due to changing lifestyles characterized by prolonged near-work activities, increased digital screen exposure, reduced outdoor activities, and intensive educational demands. School children are particularly vulnerable because their visual systems continue to develop throughout childhood, making early diagnosis and appropriate correction essential for maintaining healthy vision and preventing long-term ocular complications (Morgan et al., 2012; Holden et al., 2016).

The major refractive errors observed among school children include myopia (nearsightedness), hyperopia (farsightedness), astigmatism, and anisometropia. Among these, myopia has become the most prevalent and rapidly increasing refractive disorder worldwide. Myopia occurs when the eyeball is excessively elongated or when the cornea possesses excessive curvature, causing light rays to focus in front of the retina rather than directly on it.

As a result, distant objects appear blurred while nearby objects remain relatively clear. Numerous epidemiological studies conducted between 2010 and 2022 have documented a sharp increase in childhood myopia, particularly in East Asian countries, where prevalence rates exceed 70–80% among secondary school students. However, developing countries such as India have also experienced a steady rise in myopia due to urbanization, increased educational pressure, prolonged smartphone use, and reduced exposure to natural outdoor light.

Children with myopia often complain of difficulty seeing the classroom blackboard, squinting while reading distant text, frequent headaches, eye rubbing, and reduced participation in classroom activities. Early correction using spectacles, contact lenses, or myopia-control interventions is crucial to prevent progression to high myopia, which is associated with serious complications such as retinal detachment, glaucoma, cataract, and myopic macular degeneration (Holden et al., 2016; Morgan et al., 2012).

Hyperopia, commonly known as farsightedness, is another frequently encountered refractive error among school-aged children. Hyperopia occurs when the eyeball is shorter than normal or when the cornea has insufficient refractive power, causing light rays to focus behind the retina.

Mild hyperopia is relatively common during childhood and may remain asymptomatic because children's eyes possess strong accommodative abilities that compensate for the refractive defect. However, moderate to high hyperopia often results in blurred near vision, difficulty concentrating during reading, headaches, eye fatigue, and poor academic performance.

Children may avoid reading or writing activities because prolonged near work requires continuous accommodation, leading to visual discomfort. In severe untreated cases, hyperopia may contribute to accommodative esotropia and amblyopia (lazy eye), making early vision screening particularly important during preschool and primary school years. Appropriate optical correction using convex lenses effectively restores normal vision and prevents binocular vision disorders (American Academy of Ophthalmology, 2020).

Astigmatism represents another common refractive error observed among school children and frequently coexists with myopia or hyperopia. Astigmatism results from an irregular curvature of the cornea or, less commonly, the crystalline lens, causing incoming light rays to focus at multiple points instead of a single focal point on the retina. Consequently, both distant and near vision become distorted or blurred.

Children with astigmatism often experience symptoms such as eye strain, headaches, squinting, difficulty reading, reduced visual clarity, and frequent blinking. Since children may not recognize that their vision is abnormal, teachers and parents should observe behavioral signs such as sitting close to the television, holding books unusually close, tilting the head while reading, or losing concentration during classroom tasks. Modern cylindrical spectacle lenses effectively correct astigmatism, enabling children to achieve normal visual development and academic success. If left untreated, significant astigmatism during early childhood may interfere with normal visual maturation and increase the risk of amblyopia (Sheppard & Wolffsohn, 2018).

Anisometropia is a less common but clinically significant refractive condition in which the refractive power differs substantially between the two eyes. One eye may be more myopic, hyperopic, or astigmatic than the other. Because each eye produces images of different clarity, the brain may suppress the blurred image from one eye, eventually leading to amblyopia if the condition remains untreated.

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School children with anisometropia may not complain of visual problems because one eye often compensates for the poorer eye. Therefore, routine binocular vision assessment during school screening programs is essential for early identification. Treatment generally includes spectacle correction, contact lenses, and amblyopia therapy involving patching or penalization of the stronger eye to stimulate visual development in the weaker eye. Early intervention before the age of eight years significantly improves treatment outcomes.

The occurrence of refractive errors among school children is influenced by a complex interaction between genetic and environmental factors. Family history remains one of the strongest predictors of refractive errors, particularly myopia. Children with one or both myopic parents have a significantly greater likelihood of developing myopia compared with children whose parents have normal vision.

However, environmental influences have become increasingly important during the past decade. Rapid technological advancements have resulted in prolonged exposure to smartphones, tablets, laptops, desktop computers, and digital learning platforms. Extended periods of near work increase accommodative demand and may contribute to axial elongation of the eyeball, thereby promoting myopia progression.

Simultaneously, decreased participation in outdoor activities reduces exposure to natural sunlight, which plays an important role in regulating dopamine release within the retina and inhibiting excessive eye growth. Several longitudinal studies have demonstrated that children who spend at least two hours outdoors daily exhibit lower rates of myopia development than those spending most of their time indoors (Wu et al., 2013; Rose et al., 2018).

The COVID-19 pandemic further highlighted the relationship between digital learning and children's visual health. During prolonged school closures, online education dramatically increased children's daily screen exposure while simultaneously reducing outdoor play and physical activity. Several studies conducted between 2020 and 2022 reported accelerated myopia progression and increased symptoms of digital eye strain among school children during this period.

Although screen time alone may not directly cause refractive errors, excessive near work combined with limited outdoor exposure appears to increase the likelihood of myopia onset and progression. These findings emphasize the importance of adopting healthy digital habits and maintaining visual hygiene during childhood (Lanca & Saw, 2020; Kaur et al., 2022).

Early detection of refractive errors is essential because many affected children remain asymptomatic or fail to recognize their visual impairment. Routine school vision screening programs provide an effective strategy for identifying children requiring comprehensive ophthalmic evaluation. Teachers and parents should remain vigilant for warning signs such as squinting, frequent eye rubbing, headaches, poor academic performance, reduced attention span, sitting very close to television screens, holding books close to the face, or complaints of blurred vision.

Comprehensive eye examinations should include visual acuity testing, objective and subjective refraction, binocular vision assessment, ocular alignment evaluation, and anterior and posterior segment examination. Timely prescription of appropriate corrective spectacles significantly improves educational outcomes, self-confidence, classroom participation, and overall quality of life.

Preventive strategies should focus on minimizing modifiable risk factors associated with refractive errors. Parents should encourage children to limit unnecessary recreational screen time, maintain an appropriate viewing distance of approximately 40–50 cm while using digital devices, ensure adequate room lighting, follow the 20–20–20 rule (every 20 minutes, look at an object 20 feet away for at least 20 seconds), and participate in at least two hours of outdoor activity each day. Schools should integrate regular eye health education into their curriculum, conduct annual vision screening programs, and educate teachers regarding early signs of visual impairment. Healthcare professionals should collaborate with educational institutions to promote awareness regarding childhood eye health and facilitate timely referral of children requiring specialist care.

Refractive errors constitute one of the most prevalent vision disorders among school children worldwide, with myopia, hyperopia, astigmatism, and anisometropia being the principal forms. Their prevalence has increased considerably over the past decade due to changing educational practices, increased digital device use, prolonged near-work activities, and declining outdoor exposure.

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If left untreated, refractive errors can impair academic achievement, psychological well-being, and visual development. However, most refractive errors can be effectively diagnosed through routine vision screening and corrected with appropriate optical interventions. Early detection, parental awareness, school-based screening programs, balanced digital device use, and promotion of outdoor activities remain the cornerstone strategies for reducing the burden of refractive errors among school children and preserving lifelong visual health.

Table 2. Types of Refractive Errors

Type	Characteristics	Common Symptoms
Myopia	Difficulty seeing distant objects	Squinting, blurred distance vision
Hyperopia	Difficulty focusing on near objects	Eye strain, headaches
Astigmatism	Irregular corneal curvature	Blurred vision at all distances
Presbyopia	Rare in children	Not applicable

Impact of Digital Screen Time

Research has consistently reported that children spending prolonged periods on digital devices experience:

1. Increased eye strain
2. Dry eyes
3. Headaches
4. Temporary blurred vision
5. Reduced blinking
6. Sleep disturbance
7. Increased likelihood of myopia progression when accompanied by prolonged near work and reduced outdoor time.

Table 3. Reported Effects of Excessive Screen Time

Screen Time	Common Effects
<1 hour/day	Minimal risk
1–2 hours/day	Mild eye fatigue
2–4 hours/day	Dry eyes, headaches
>4 hours/day	Higher risk of digital eye strain and myopia progression

Preventive Measures

Recommended interventions include:

1. Follow the 20-20-20 rule
2. Encourage at least two hours of outdoor activity daily
3. Maintain proper viewing distance
4. Reduce unnecessary smartphone use
5. Schedule annual eye examinations
6. Use appropriate room lighting
7. Encourage regular blinking
8. Limit recreational screen time

These measures are widely recommended to reduce digital eye strain and support healthy visual development.

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VI. DISCUSSION

Evidence from studies published between 2010 and 2022 indicates a positive association between prolonged digital screen exposure and visual complaints among school children. While the evidence linking screen time directly to refractive error development is mixed, many studies suggest that extended near work, increased screen use, and reduced outdoor activities together contribute to the onset and progression of myopia.

Children engaging in prolonged screen use without adequate breaks are more likely to experience digital eye strain, characterized by ocular discomfort, dryness, and blurred vision. Preventive strategies should therefore focus on balanced screen use, encouraging outdoor activities, ergonomic practices, and regular ophthalmic screening rather than attributing refractive errors solely to screen exposure.

VIICONCLUSION

Digital screen time has become an unavoidable component of modern education and recreation. The literature from 2010–2022 suggests that prolonged screen exposure is associated with increased digital eye strain and may contribute to the occurrence and progression of refractive errors, particularly myopia, when combined with reduced outdoor activity and prolonged near work. Schools, parents, and healthcare providers should work together to promote healthy digital habits, ensure regular eye examinations, and encourage outdoor play to protect children's visual health.

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