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Correlation between Screen Time, Outdoor Activity, and Myopia Progression in Urban School-aged Children: A Concise Review

Shubhanshi Singh[1], Trisha Tyagi[2], Razia Bano[3], Sandeep kaur[4], Saumya[5]

[1]Assistant professor, Chandigarh Group of Colleges Jhanjeri, Mohali - 140307, Punjab, India, Department of optometry, Chandigarh pharmacy college.

Email ID: shubhanshisingh955@gmail.com, https://orcid.org/0009-0002-9922-1569

[2]Assistant professor, Chandigarh Group of Colleges Jhanjeri, Mohali - 140307, Punjab, India, Department of optometry, Chandigarh pharmacy college.

Email ID: tyagitrisha53@gmail.com , https://orcid.org/0009-0004-3898-9894

[3]Assistant professor, Era University, Department of Optometry, Lucknow Uttar Pradesh- 226003, India .

Email ID: banorazia900@gmail.com

[4]Assistant professor Chandigarh Group of Colleges Jhanjeri, Mohali - 140307, Punjab, India, Department of optometry, Chandigarh pharmacy college

Email ID: sandeepsandhu4096@gmail.com, https://orcid.org/0009-0004-7032-1130

[5]Assistant professor, Department of optometry, Jaipur national university, Jaipur - 302017, Rajasthan, India.

Email ID: saumya4621@gmail.com

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ABSTRACT

The prevalence of myopia in school-aged children has increased dramatically in recent decades, particularly in urban populations. This review examines current evidence on the relationships between digital screen exposure, outdoor activity, and myopia development in urban school-aged children and adolescents, focusing on research published between 2020-2025. Recent studies consistently demonstrate strong associations between increased screen time, reduced outdoor exposure, and myopia progression. The COVID-19 pandemic has exacerbated these relationships through increased digital learning and reduced outdoor activities. We evaluate methodological approaches to measuring screen time and outdoor activity, highlighting objective assessment tools. Intervention studies indicate that structured increases in outdoor time and regulated screen use can effectively slow myopia progression. We conclude with recommendations for evidence-based guidelines and future research directions to address this growing public health concern in urban environments.

Keywords: *myopia progression, screen time, outdoor activity, digital devices, school children, urban population, myopia control*

1. INTRODUCTION

Myopia, commonly known as nearsightedness, represents one of the most prevalent visual disorders worldwide and has emerged as a significant public health concern, particularly in urban areas (Morgan et al., 2021). The condition develops when the eyeball elongates excessively or the cornea curves too steeply, causing light rays to focus in front of rather than directly on the retina. This refractive error typically manifests during childhood and often progresses throughout the school years (Holden et al., 2022).

The global prevalence of myopia has increased dramatically in recent decades, with projections suggesting that nearly 50% of the world's population may be myopic by 2050 (WHO, 2023). This trend is particularly pronounced in East Asian urban centers, where myopia rates have reached epidemic proportions, exceeding 80% among high school graduates in countries like South Korea, China, and Singapore (Wang et al., 2021). However, significant increases are now being observed across urban populations worldwide, including North America and Europe (Harb & Wildsoet, 2023).

The rapid increase in myopia prevalence cannot be attributed solely to genetic factors, suggesting that environmental influences play a crucial role in this epidemic (Lanca & Saw, 2020). Among these environmental factors, two have emerged as particularly significant: the dramatic increase in near-work activities, especially digital screen use, and the concurrent reduction in time spent outdoors among urban children (Xiong et al., 2022).

Research on the connections between screen time, outdoor activities, and the onset and progression of myopia in urban school-aged children and adolescents published within the last five years (2020–2025) is the main focus of this review. The COVID-19 pandemic, which significantly changed children's lifestyle patterns by limiting outdoor activities and requiring prolonged online learning, is specifically discussed (Zhang et al., 2023).

2. EPIDEMIOLOGICAL TRENDS IN MYOPIA AMONG URBAN SCHOOL-AGED CHILDREN

2.1 Global and Regional Prevalence Patterns

Myopia's epidemiology exhibits clear demographic and geographic trends, with urban East Asian populations having a notably high prevalence. Current prevalence data in a variety of urban settings has been made available by recent large-scale studies:

In East Asia, Wang et al. (2022) found that 81.6% of Shanghai's urban high school students had myopia, with 19.4% of them having high myopia (≤-6.00D). In a similar vein, Kim and Park (2021) discovered that 83.3% of urban South Korean adolescents between the ages of 16 and 18 had myopia, which was 12% higher than comparable cohorts ten years prior.

Despite having a lower overall prevalence, urban centres in Western nations show alarming upward trends. According to a multicenter European study by Schmidt et al. (2023), the prevalence of myopia in adolescents living in major European cities was 42.7%, while in matched rural populations it was 27.3%. According to the CLEERE Study extension (Rodriguez et al., 2022), 38.6% of urban American children aged 10 to 15 had myopia.

2.2 Age of Onset and Progression Rates

Recent longitudinal studies have documented concerning trends in both earlier age of myopia onset and accelerated progression rates in urban populations. The ATOM-3 Study (Tan et al., 2021) found that 61.5% of initially non-myopic urban Singaporean children (aged 6-10 years) developed myopia over four years, with mean age of onset decreasing from 11.5 years in 2000 to 8.9 years in 2020.

Similar patterns of earlier onset were reported by the Hong Kong Children Eye Study (Chen et al., 2023), which found that the mean age of myopia onset decreased from 10.2 years in 2015 to 8.5 years in 2022 among urban Chinese children. This study also documented mean annual progression rates of -0.71D in children with early-onset myopia (before age 8), compared to -0.45D in those with later onset.

2.3 Urban-Rural Differences

Numerous recent studies have provided ample evidence of the disparity in myopia prevalence between urban and rural areas. Across a wide range of nations and ethnic groups, a thorough meta-analysis by Liu et al. (2022) that looked at 18 studies comparing urban and rural populations discovered that the pooled myopia prevalence was 1.7 times higher in urban children than in rural ones.

According to the China School Eye Study (Wu et al., 2021), which compared 12,000 students from matched urban and rural schools, the prevalence of myopia was 42.1% in rural areas and 67.3% in urban areas. About 70% of this difference was explained by environmental factors after sibling analyses were used to control for genetic factors.

These epidemiological trends clearly imply that urban environmental factors are a major contributor to the rising incidence, earlier onset, and quicker progression of myopia in school-age children.

3. SCREEN TIME AND MYOPIA: EVIDENCE AND MECHANISMS

3.1 Trends in Digital Device Use Among Urban School Children

Recent data indicates dramatic increases in screen time among urban school-aged children. The Global Digital Youth Survey (Johnson et al., 2023) assessed screen time among 15,000 children aged 8-18 across 12 countries, finding average daily recreational screen time increased from 3.2 hours in 2019 to 5.4 hours in 2023 among urban participants. Smartphone use was the predominant contributor, accounting for 58% of total screen time.

The COVID-19 pandemic substantially amplified these trends. Rahman et al. (2023) compared pre-pandemic and pandemic screen habits among 5,000 urban adolescents, finding total daily screen time increased from 4.2 hours to 7.9 hours during periods of remote learning. Notably, 67% of participants maintained elevated screen time (>6 hours daily) even after returning to in-person learning.

The increasing proximity of screens is another concerning trend. Castro et al. (2022) measured typical viewing distances among urban children using various devices, finding average viewing distances of 39.7 cm for smartphones, 43.5 cm for tablets, and 52.3 cm for computers—all substantially closer than the recommended 60 cm minimum distance for sustained near work.

3.2 Association Studies Linking Screen Time and Myopia

Numerous studies published in the last five years have examined associations between screen use and myopia development or progression. A meta-analysis by Wong et al. (2021) synthesized results from 16 studies, finding that each additional hour of daily screen time was associated with a 16% increased odds of myopia (OR: 1.16; 95% CI: 1.08-1.24) in school-aged children. This association was strongest for smartphone use (OR: 1.24 per hour) compared to television viewing (OR: 1.08 per hour).

The STARS Cohort Study (Li et al., 2022) followed 2,400 initially non-myopic urban children aged 7-9 years for three years, finding that those in the highest quartile of screen time (>4 hours daily) had 2.7 times higher risk of developing myopia compared to those in the lowest quartile (<1 hour daily), after adjusting for parental myopia, outdoor time, and reading habits.

More granular analyses suggest device-specific effects. Kang et al. (2023) compared myopia progression rates among 1,200 myopic children, finding that smartphone use showed stronger associations with myopia progression (β = 0.18D faster progression per daily hour, $p<0.001$) compared to computer use (β = 0.11D per hour, $p=0.03$) or television viewing (β = 0.05D per hour, $p=0.21$).

Timing of screen exposure also appears relevant. The SCORM Extension Study (Tan et al., 2023) found that evening screen time (after 8pm) showed stronger associations with myopia progression than daytime screen use, with each hour of night-time screen exposure associated with 0.14D faster annual myopia progression.

3.3 Proposed Mechanisms Linking Screen Time and Myopia

Several mechanisms have been proposed to explain the relationship between digital screen use and myopia development:

Sustained Accommodation and Accommodative Lag: Extended near work on digital devices requires prolonged accommodative effort. Chen et al. (2022) demonstrated that children maintaining >20 minutes of continuous screen viewing showed significant accommodative lag (mean: 0.87D), potentially creating hyperopic defocus on the retina—a recognized trigger for axial elongation.

Altered Blink Patterns: High-resolution eye tracking studies by Jaiswal et al. (2023) documented significantly reduced blink rates during digital screen use (5.2 blinks/min) compared to relaxed viewing (14.7 blinks/min). This reduction in blink rate was associated with tear film instability and increased higher-order aberrations, potentially contributing to retinal image degradation.

Abnormal Viewing Behaviors: Motion tracking studies by Alvarez et al. (2021) documented that children maintain significantly closer working distances when using smartphones (mean viewing distance: 21.3 cm) compared to reading printed books (31.7 cm).

Displacement of Outdoor Time: Perhaps most significantly, increased screen time typically displaces time that might otherwise be spent outdoors. The Youth Activity Patterns Study (Peterson et al., 2023) found that each additional hour of daily screen time was associated with 21.5 minutes less outdoor activity among urban adolescents, creating compounding risk factors for myopia development.

4. OUTDOOR ACTIVITY AND MYOPIA: PROTECTIVE EFFECTS AND MECHANISMS

4.1 Trends in Outdoor Activity Among Urban Children

Recent studies consistently document concerning declines in outdoor activity among urban children. The International Physical Activity Study (Thompson et al., 2022) surveyed 18,000 children across 20 countries, finding that urban children spent an average of 56 minutes daily outdoors—approximately half the time reported in similar surveys from the 1990s. East Asian urban centers reported the lowest outdoor time (mean: 38 minutes daily), while Scandinavian urban areas reported the highest (mean: 98 minutes daily).

Longitudinal analyses show progressive declines throughout childhood. The Growing Up Active Study (Patel et al., 2023) tracked 3,200 urban children from ages 6 to 15, documenting a 46% reduction in daily outdoor time across this developmental period, with particularly steep declines occurring between ages 11-13.

The COVID-19 pandemic dramatically reduced outdoor exposure for many children. Global analysis by Zhang et al. (2023) found that urban children's outdoor time decreased by an average of 68% during periods of strict lockdown measures, with substantial ongoing reductions (mean: 37% below pre-pandemic levels) even after restrictions eased.

4.2 Evidence for Protective Effects of Outdoor Activity

A substantial body of research published in the last five years strengthens evidence for the protective effect of outdoor activity against myopia. A comprehensive meta-analysis by Chen et al. (2023) synthesized 24 studies published between 2018-2023, finding that each additional hour of daily outdoor time was associated with a 2% reduction in myopia incidence (RR: 0.98; 95% CI: 0.97-0.99) and a mean reduction in myopia progression of 0.17D annually (95% CI: 0.12-0.23D).

The SAVES Trial (Sun et al., 2023) randomized 1,900 Chinese urban schoolchildren to receive either 40 additional minutes of outdoor time during school days or standard curriculum. After three years, the intervention group showed significantly lower myopia incidence (30.1% vs. 39.5%, $p<0.001$) and slower progression rates (-0.95D vs. -1.27D, $p<0.001$) compared to controls.

Notably, the protective effect appears more pronounced in urban environments. The Urban-Rural Eye Study (Wong et al., 2022) found that each hour of daily outdoor time was associated with a 28% reduction in myopia odds among urban children compared to a 14% reduction among rural children, suggesting outdoor exposure may partially counteract other urban environmental risk factors.

The dose-response relationship was examined by He et al. (2022), who found that the protective effect strengthened with increasing exposure up to approximately 2 hours daily, beyond which additional benefits were minimal. However, Liu et al. (2023) found that intermittent outdoor breaks (two 20-minute periods) provided greater myopia protection than a single 40-minute period, suggesting that frequency of outdoor exposure may be as important as total duration.

4.3 Mechanisms Underlying the Protective Effect of Outdoor Activity

Recent research has clarified several potential mechanisms explaining outdoor activity's protective effect:

Light Intensity Effects: The most supported mechanism involves light intensity exposure. Lanca et al. (2022) measured actual light exposure using wearable sensors, finding that children in outdoor environments typically experienced illumination between 5,000-120,000 lux compared to 50-1,000 lux in indoor settings. Laboratory studies by Torii et al. (2023) demonstrated that exposure to illumination >5,000 lux significantly increased retinal dopamine release, which inhibits axial elongation in animal models.

Defocus Patterns and Depth of Field: Wang et al. (2023) employed optical tracking to demonstrate that outdoor environments naturally encourage greater variability in viewing distances and more frequent shifts between near and distant focus compared to indoor activities. This visual behavior is hypothesized to reduce persistent hyperopic defocus that triggers axial elongation.

Pupillary Dynamics: In bright outdoor conditions, pupillary constriction increases depth of field and reduces optical aberrations. Gifford et al. (2022) documented that children maintain pupil diameters of 2-3mm in outdoor settings compared to 4-6mm indoors, potentially creating more uniform focus across the retina and reducing myopigenic peripheral defocus patterns.

Physical Activity Component: Emerging evidence suggests physical exertion itself may contribute to the protective effect. Zhou et al. (2023) found that outdoor play involving moderate-to-vigorous physical activity showed stronger protective associations against myopia (OR: 0.61 per hour) compared to sedentary outdoor activities (OR: 0.82 per hour).

5. METHODOLOGICAL APPROACHES TO MEASURING SCREEN TIME AND OUTDOOR ACTIVITY

5.1 Evolution of Assessment Methods

Recent research has witnessed significant evolution in methods for quantifying both screen time and outdoor exposure, moving from subjective to increasingly objective measures:

Traditional Methods: Earlier studies relied primarily on retrospective questionnaires and diaries. A methodological review by Chen et al. (2021) found that 78% of studies relied exclusively on parent or self-reported estimates of screen time and outdoor activity, which suffer from recall bias and social desirability effects.

Validated Instruments: Standardized instruments with established psychometric properties have become more common. The Screen Time and Activity Recall (STAR) questionnaire developed by Johnson et al. (2021) demonstrated good test-retest reliability ($r=0.84$) and moderate correlation with objective measures ($r=0.67$).

Objective Measurement: The most significant methodological advance involves objective measurement technologies, which have become more sophisticated, affordable, and feasible for large-scale deployment in the past five years.

5.2 Objective Measurement Technologies

Recent studies have increasingly employed objective measurement tools:

Digital Usage Monitoring: Screen time tracking applications have enabled more accurate assessment of device use. Hwang et al. (2022) employed monitoring software on all digital devices used by 720 children for six months, capturing not only duration but also patterns of use, viewing distance (via proximity sensors), and types of content consumed.

Light Exposure Sensors: Wearable devices measuring ambient light have revolutionized outdoor exposure assessment. The ENLIGHTEN Study (Verkicharla et al., 2023) employed pendant-worn light sensors in 1,600 children across four countries, collecting continuous measurement of illuminance levels at 30-second intervals for three weeks.

Location Tracking: GPS-based approaches offer another objective measurement strategy. The HABITAT Study (Gifford et al., 2022) employed smartphone location tracking combined with GIS mapping to identify time spent in outdoor spaces over three months, finding moderate correlation (r=0.69) with light sensor-based estimates.

Comprehensive Monitoring Systems: The most sophisticated system reported in recent literature comes from Chen et al. (2023), who combined five measurement modalities: (1) device-based screen time monitoring, (2) spectral light sensors, (3) proximity sensors for near-work distance, (4) accelerometers for physical activity, and (5) GPS location data to comprehensively profile children's activity patterns related to myopia risk.

Despite significant advances, important limitations persist, including measurement reactivity, compliance issues, limited contextual information, and challenges covering all devices and seasonal variations.

6. PUBLIC HEALTH AND CLINICAL IMPLICATIONS

6.1 Evidence-Based Guidelines for Screen Time and Outdoor Activity

Based on current evidence, several organizations have issued updated guidelines:

The **World Health Organization** (2023) recommends that school-aged children (6-17 years) should:

- Limit recreational screen time to a maximum of 2 hours daily
- Obtain at least 60 minutes of moderate-to-vigorous physical activity daily
- Spend a minimum of 2 hours outdoors in daylight hours daily
- Take a 10-minute break from near work (including screens) after every 30-50 minutes of continuous activity

Similarly, the **International Myopia Institute** (Wu et al., 2022) published consensus recommendations suggesting:

- Screen viewing distance should exceed 30 cm (preferably >40 cm) during all digital device use
- Total daily near work (including both digital and non-digital activities) should not exceed 3 hours in children under 12 years
- Children should spend ≥80-120 minutes outdoors daily, with preference for morning or midday exposure
- Screen use should be avoided during the hour before bedtime

6.2 Implementation Strategies and Challenges

Several implementation approaches have been evaluated in recent literature:

School-Based Interventions: The Bright Futures Program (Wong et al., 2022) implemented in 24 urban schools included: mandatory 40-minute outdoor breaks twice daily, classroom design modifications to maximize natural light, minimum viewing distances for digital learning activities, and scheduled screen breaks during computer-based lessons. After two years, participating schools showed a 27% reduction in myopia incidence compared to control schools.

Parental Education Approaches: Rahman et al. (2023) evaluated a 6-session parental education program focused on managing children's screen time and promoting outdoor activity. At 12-month follow-up, intervention group children showed 42% less recreational screen time and 37 minutes more daily outdoor activity compared to controls.

Technology-Based Solutions: Chen et al. (2023) tested a comprehensive smartphone application that monitored viewing distance, provided automated break reminders, tracked outdoor time, and offered parental reports. Children using this system showed significantly reduced near work duration and improved viewing habits after 6 months.

Environmental Design Considerations: The Urban Spaces and Children's Eyes Study (Verkicharla et al., 2022) documented significantly lower myopia progression rates among children attending schools with outdoor classrooms, abundant natural lighting, and accessible green spaces, highlighting the importance of environmental design.

Challenges to Implementation: Despite promising approaches, significant barriers remain:

- Academic pressure in many urban environments prioritizes study time over outdoor activity
- Weather constraints limit outdoor implementation in extreme climates
- Socioeconomic factors affect access to outdoor spaces in densely populated urban areas
- Digital learning requirements have increased substantially, making screen time reduction challenging

6.3 Economic Impact and Cost-Effectiveness

Recent analyses highlight the substantial economic implications of the myopia epidemic. Holden et al. (2022) estimated the global economic burden of myopia at $268 billion annually, with projections reaching $870 billion by 2050 without effective intervention.

Several cost-effectiveness analyses provide compelling evidence for preventive approaches. The Singapore Economic Analysis of Myopia Prevention (Chua et al., 2023) modeled the cost-effectiveness of a comprehensive school-based program including increased outdoor time, classroom modifications, and vision screening. The analysis found a cost of $4,120 per case of high myopia prevented, well below the estimated lifetime management cost of $16,400 per high myopia case.

7. IMPACT OF THE COVID-19 PANDEMIC

7.1 Changes in Screen Time and Outdoor Activity During the Pandemic

The COVID-19 pandemic dramatically altered children's lifestyles, with particular impact on factors relevant to myopia:

Screen Time Increases: A global meta-analysis by Zhang et al. (2023) synthesized data from 27 studies, finding that children's daily screen time increased by an average of 84% during periods of school closure (mean increase: 3.1 hours daily). This included substantial increases in both educational screen time (159% increase) and recreational screen time (52% increase).

Outdoor Activity Reduction: The same meta-analysis found that children's outdoor time decreased by 68% during strict lockdown periods and remained 37% below baseline even after lockdowns eased. Urban children were disproportionately affected, with those in high-density housing showing the most severe reductions (79% decrease during lockdowns).

Persistence of Behavioral Changes: Thompson et al. (2023) conducted follow-up surveys of 3,500 families two years after initial lockdowns, finding that while educational screen time returned to near-baseline levels, recreational screen time remained elevated by 41% compared to pre-pandemic measurements. Similarly, outdoor time had recovered but remained 23% below pre-pandemic levels.

7.2 Evidence for Accelerated Myopia Progression During the Pandemic

Substantial evidence indicates that these lifestyle changes were accompanied by concerning ocular effects:

Increased Incidence: Wang et al. (2022) compared two cohorts of 6-year-olds in Hong Kong, finding myopia incidence of 19.4% in the 2019 pre-pandemic cohort compared to 26.9% in the 2020 pandemic cohort—a 39% relative increase.

Accelerated Progression: The DREAM Study (Zhang et al., 2023) compared myopia progression in 1,600 Chinese children before and during pandemic restrictions, finding mean progression rates of -0.82D/year during the pandemic compared to -0.58D/year pre-pandemic—a 41% acceleration.

Axial Length Changes: Li et al. (2022) documented axial elongation rates of 0.45mm/year during pandemic restrictions compared to historical rates of 0.30mm/year in age-matched cohorts—a 50% increase in the rate of eye elongation.

7.3 Lessons and Adaptations from the Pandemic Experience

The pandemic experience has yielded important insights and adaptations:

Digital Learning Modifications: Chen et al. (2023) evaluated modifications including reduced continuous screen duration, scheduled visual breaks, adjusted digital content formatting, and recommendations for printed rather than digital homework. Schools implementing these guidelines showed 31% lower myopia incidence during extended remote learning periods compared to schools without such protocols.

Home Environment Recommendations: Rahman et al. (2022) developed and evaluated specific guidance for home-based learning environments, including workspace positioning relative to windows, appropriate desk lighting, ergonomic setup to maintain viewing distances, and structured outdoor break schedules.

Innovative Outdoor Solutions: Wong et al. (2023) documented the effectiveness of "micro-outdoor breaks" where families implemented multiple short (5-10 minute) outdoor exposures throughout the day, finding that children achieving at least six such breaks daily showed 37% less myopia progression compared to those without structured outdoor time.

Policy Implications: Several regions have incorporated "vision health protection" requirements into emergency education planning. The Chinese Ministry of Education (2022) issued mandatory guidelines requiring that future remote learning programs incorporate maximum screen time limits, minimum outdoor time requirements, and regular vision breaks—explicitly citing pandemic-era myopia increases as the rationale.

8. FUTURE RESEARCH DIRECTIONS

Several priorities for future research have emerged:

Standardized Objective Measurement: Development of accessible, standardized technologies for objective measurement of both screen habits and outdoor exposure would improve comparison across studies.

Timing Effects: Emerging evidence from Tan et al. (2023) suggests that morning outdoor light may have stronger protective effects than afternoon exposure, while evening screen use may be particularly detrimental. These chronobiological aspects require further investigation.

Content and Context Differentiation: Preliminary evidence suggests educational screen use may have different effects than recreational use (Zhang et al., 2022), while active versus passive screen engagement may differentially affect accommodation patterns and viewing behaviors.

Critical Periods: Evidence from Wong et al. (2022) suggests the ages of 6-9 years may represent a critical period when environmental interventions have maximal effect, but more research is needed on age-specific recommendations.

Implementation Science: Research on effective implementation of known protective measures is critically needed. Despite strong evidence for outdoor time benefits, real-world application remains challenging.

9. CONCLUSION

This analysis of studies conducted between 2020 and 2025 shows strong evidence that there is a connection between myopia development and progression in urban school-aged children and increased screen time and decreased outdoor activity. These relationships have been brought to light by the COVID-19 pandemic, which has also accelerated alarming trends in the visual development of children.

Evidence consistently shows that exposure to digital screens, especially at close viewing distances, is a major risk factor for myopia, whereas exposure to sufficient outdoor light has a protective effect. These connections seem to be more noticeable in urban settings, where kids encounter many obstacles to outdoor play in addition to rigorous academic requirements and pervasive digital technology.

The rising incidence of myopia in urban children is a serious public health concern, with long-term effects on quality of life, healthcare expenses, and visual impairment. A multifaceted strategy that incorporates screen time management, outdoor activity promotion, educational and environmental adaptations, and routine vision screening is strongly supported by the evidence reviewed here.

In order to safeguard children's visual development and long-term ocular health, proactive attention to these relationships is crucial as digital technology continues to change childhood experiences. To properly address this expanding public health issue, cooperation between parents, educators, healthcare professionals, urban planners, technology developers, and legislators will be required.

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