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Research Article

The Myopia Epidemic in Children: Environmental Factors and Current Evidence

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Abstract:

The progression of refractive errors during childhood, particularly the increasing prevalence and severity of myopia, has emerged as a major global public health concern. The phenomenon commonly referred to as the "myopia epidemic" has accelerated over recent decades, with especially high prevalence rates reported in East Asian populations. Childhood myopia progression is primarily driven by axial elongation of the eye and is influenced by a complex interaction between genetic predisposition and environmental factors. This narrative review summarizes current evidence on the key mechanisms underlying the increase in spectacle prescription in children. Major contributing factors include genetic susceptibility, reduced time spent outdoors, increased near work activities, seasonal variation, environmental pollution, reduced ocular blood flow, lifestyle-related factors such as physical activity and sleep patterns, and socioeconomic influences. Emerging evidence also suggests potential associations with vitamin D levels, nutritional status, and exposure to second hand smoke, although causal relationships remain incompletely understood. Overall, while genetic factors provide a fundamental basis for myopia development, modifiable environmental and behavioral factors play a decisive role in determining disease progression. Early identification, regular follow-up, and the implementation of evidence based environmental interventions, particularly increased outdoor exposure, remain central strategies for controlling childhood myopia progression.

Key words: childhood myopia; myopia progression; outdoor activity; environmental factors; myopia epidemic; refractive errors

Introduction

The progression of refractive errors during childhood, particularly the increase in myopia, has emerged as a major public health concern worldwide [1,3]. In school-aged children, increasing spectacle prescription primarily reflects physiological ocular growth interacting with genetic susceptibility and environmental exposure [2,3]. This narrative review summarizes the main mechanisms underlying myopia progression in children and highlights current evidence from the literature. The phenomenon conceptualized as the "myopia epidemic" has become a significant ophthalmological and public health issue on a global scale over the past century [3]. The prevalence of myopia has accelerated markedly, reaching up to 80 to 90 percent among young adults in East Asian populations, while the prevalence of high myopia has risen to approximately 10–20%, raising concerns about future vision threatening complications. Although less pronounced, similar upward trends have also been reported in Europe and North America, underscoring the magnitude of this epidemiological problem [3]. This narrative review aims to summarize and critically evaluate current evidence on environmental and lifestyle factors associated with myopia progression in children. In addition, it seeks to identify gaps in the literature that warrant further investigation. The potential causes of the myopia epidemic are summarized below.

Methods

This narrative review was based on a comprehensive literature search of PubMed, Web of Science, and Scopus. Relevant articles published in English up to 2025 were identified using combinations of keywords related to childhood myopia, myopia progression, environmental factors, outdoor activity, near work, and lifestyle factors. Reference lists of selected articles were also screened to identify additional relevant studies. Original research articles, reviews, and meta-analyses focusing on children and adolescents were considered. Studies unrelated to myopia progression or not addressing environmental or lifestyle factors were excluded.

Pathophysiological Mechanisms

The fundamental biological basis of increasing childhood myopia is axial elongation of the eye. Infants are typically born hyperopic, and as the eye grows, this refractive state normally shifts toward emmetropia through the process of emmetropization. However, in myopic children, this process does not adequately halt. Longitudinal studies have shown that axial length increases more rapidly in myopic children than in emmetropic peers, with consistently greater annual axial elongation observed in children with progressive myopia. Numerous studies have demonstrated a direct relationship between myopia progression and increase in axial length [2,3].

Genetic Factors: Current Evidence

In recent years, advances in genomic technologies have profoundly transformed the understanding of the molecular mechanisms underlying myopia and refractive errors. Large-scale datasets generated by consortia such as the Consortium for Refractive Error and Myopia (CREAM) have produced the most comprehensive genome-wide association studies (GWAS) conducted to date in this field, establishing a new gold standard for genetic research on refractive errors [4]. Genetic predisposition plays a decisive role in both the age of onset and the rate of progression of childhood myopia. The influence of parental refractive status on children is commonly discussed within the framework of "myopic inheritance," with evidence suggesting that epigenetic factors and environmental interactions further modulate the course of myopia [5].

Outdoor Activity: Evidence and Proposed Mechanisms

Both cross sectional and longitudinal studies have shown a consistent association between increased time spent outdoors and a lower risk of myopia in children. The protective effect of outdoor exposure cannot be explained only by reduced near work. Higher ambient light levels are believed to stimulate retinal dopamine release, which may slow axial elongation of the eye. This biological mechanism has been supported by experimental animal models and clinical human studies. In addition, outdoor environments provide wider visual fields, longer viewing distances, and more dynamic visual stimuli, all of which may help maintain ocular growth signals within physiological limits. Consequently, regular and sufficient outdoor activity is widely accepted as an important environmental intervention capable of slowing myopia development and progression, even in genetically predisposed children [6,7].

Ocular Blood Flow: Clinical and Experimental Findings

Reduced ocular blood flow has been proposed as a potential pathophysiological mechanism underlying choroidal and retinal thinning, as well as the associated axial elongation observed in myopia. Supporting this hypothesis, multiple studies have shown significantly lower ocular blood flow in myopic eyes compared with emmetropic eyes. These hemodynamic alterations are thought to impair tissue perfusion in the retina and choroid, contributing to structural weakening and reduced mechanical resistance of the ocular wall. Consequently, decreased ocular blood flow is increasingly regarded as an important biological marker involved in the development and progression of myopia [8].

Vitamin D: Observational Evidence

Lower serum vitamin D levels have been reported in individuals with myopia compared with non-myopic individuals. This finding is thought to reflect reduced outdoor exposure rather than a direct causal effect of vitamin D itself [9]. Nevertheless, given the potential biological effects of vitamin D on the retina and choroid, its role in myopia pathogenesis remains uncertain and warrants further investigation.

Near Work: Epidemiological Evidence and Visual Demand

The indoor visual environment differs markedly from outdoor settings and places greater optical demands on the visual system. The impact of this environment on ocular development can be explained through the concept of "dioptric variation." Increased time spent indoors and prolonged near work activities, such as reading at close distances, have been associated with an elevated risk of myopia onset and progression in school-aged children. Near work performed under inadequate lighting conditions and at short viewing distances may induce sustained accommodative demand, thereby promoting axial elongation of the eye. These findings underscore the importance of visual habits as a key environmental determinant of myopia risk during childhood [7,10].

Air Pollution: Emerging Evidence

Air pollutants such as carbon monoxide, nitrogen oxides, and ozone are hypothesized to exert toxic effects on ocular tissues by reducing retinal dopamine release and inducing systemic inflammation, oxidative stress, and retinal ischemia. These pathophysiological processes may facilitate axial elongation and contribute to the development and progression of myopia. Accordingly, air pollution is increasingly recognized as a potential environmental risk factor for myopia, particularly among children living in urban areas [11].

Seasonal Variation

Research has demonstrated a direct association between seasonal cycles and both myopia progression and axial elongation rates. According to these findings, myopia progression tends to slow during the summer months and accelerate during the winter months [12].

Exposure to Tobacco Smoke

A recent large-scale cross-sectional study conducted among Hong Kong children aged 6–8 years revealed a significant association between exposure to second hand smoke and both the onset and progression of myopia. This finding suggests that environmental tobacco smoke may represent a modifiable environmental risk factor for childhood myopia [13].

Physical Activity

Given the protective effect of outdoor exposure on myopia progression, promoting sports and physical activity may be a beneficial strategy by encouraging children to spend more time outdoors. While not a direct treatment for myopia, such activities serve as supportive measures that help modify environmental risk factors associated with myopia development [7,14].

Sleep and Circadian Rhythms

Current evidence examining the relationship between sleep, circadian rhythms, and myopia remains limited and inconclusive. To strengthen the reliability of findings in this area and to better define causal relationships, well-designed longitudinal studies using universally accepted definitions of sleep quality and myopia are required [15].

Socioeconomic Status

Educational level is closely associated with socioeconomic status and may play an important role in childhood myopia development. In societies undergoing economic growth, increased educational expectations often result in earlier academic engagement, longer study hours, and higher near work demands. These changes are frequently accompanied by reduced outdoor activity. Together, these factors may indirectly contribute to a higher prevalence and faster progression of myopia in children [3,16].

Nutritional Status

Although the relationship between dietary habits and myopia development remains controversial, recent studies have provided important insights into the effects of systemic health on ocular structure. In particular, components of Western-style diets have been proposed to influence ocular biomechanics and axial growth [17].

Optical Correction

Under correction of myopia, defined as deliberately prescribing spectacles with lower power than required, has long been debated in ophthalmology. Although previously believed to reduce progression by preventing "ocular dependency," current scientific evidence indicates the opposite effect [18].

Discussion and Conclusion

While genetic predisposition constitutes an undeniable foundation for myopia development, environmental visual and non-visual factors play a critical role in determining disease progression. Among these, "time spent outdoors" and "near work activities" are widely regarded as the two strongest and most independent variables influencing myopia, exerting opposing effects: outdoor activity acts as a protective factor, whereas intensive near work aggravates progression. Despite growing interest in environmental and lifestyle influences on childhood myopia, the strength and consistency of evidence vary across specific factors. In particular, findings related to vitamin D status, sleep patterns, and dietary habits remain inconsistent across studies. These discrepancies likely reflect differences in study design, exposure assessment, and residual confounding, especially by time spent outdoors. As a result, causal relationships for several proposed risk factors remain uncertain. However, the complex interactions between the physical properties of light, spatial visual environments, and myopia pathophysiology remain incompletely understood and require further investigation. Similarly, the roles of lifestyle factors such as sleep patterns and dietary habits continue to be debated within the academic community. Current literature emphasizes the importance of early diagnosis, regular follow-up, and environmental modifications in slowing myopia progression. From the authors' perspective, the available evidence indicates that not all proposed environmental factors contribute equally to childhood myopia progression. While several associations have been reported, interventions targeting outdoor exposure and near work behavior remain the most consistent, practical, and immediately applicable strategies. This focused interpretation represents the authors' critical synthesis of current evidence. In conclusion, although the need for more advanced predictive models persists, the primary focus in addressing the ongoing "myopia epidemic" should be the widespread implementation of evidence-based strategies (such as increasing time spent outdoors), the establishment of early detection mechanisms, and the timely optimization of treatment for affected individuals.

Conflict of Interest

The author declares no conflict of interest related to this manuscript.

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Ethical Approval

As this study is a review article, approval from an ethics committee was not required.

Author Contributions

All sections of the manuscript were prepared by the author.

Informed Consent

Informed consent was not required, as this study did not involve human or animal participants.

Data Availability Statement

Data sharing is not applicable to this article as no new data were generated or analyzed in this narrative revie

During the preparation of this work, ChatGPT 5 was employed solely to enhance grammar and readability. All text generated was carefully reviewed and edited by the authors, who take full responsibility for the accuracy, integrity, and final content of the published article.

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