# Optical Dynamics of Violet and Blue Light in Myopia Development: A Comparative and Historical Analysis

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## ABSTRACT

The rising prevalence of myopia in children has become a major concern due to its long-term effects on eye health and vision. This increase has prompted extensive research into the environmental and biological factors influencing eye development. Recent studies highlight the critical role of specific light wavelengths, particularly violet (360–400 nm) and blue (400–500 nm), in regulating eye growth. Violet light is thought to support choroidal health by activating photopigments in the retina, helping to maintain proper eye growth and reduce the risk of myopia. Conversely, the elimination of blue light through blue-blocking lenses has been linked to changes in the refractive dynamics of the eye, potentially contributing to excessive axial elongation—a key characteristic of myopia. Modern lighting systems, such as LED lights and the widespread use of blue-blocking lenses, have disrupted natural light exposure, reducing access to these critical wavelengths. One perspective emphasizes the importance of reintroducing violet light into children's environments through natural sunlight and specially designed lighting systems to stabilize eye growth. Another approach focuses on minimizing the prolonged use of blue-blocking lenses during critical periods of eye development, cautioning against unintended structural changes in the eye. Future research should evaluate the potential of artificial violet light for controlling myopia, and quantify the differences between indoor and outdoor light environments. A comprehensive understanding of these factors is essential for creating effective strategies, such as optimized lighting and lens designs, to address the growing challenge of myopia in children.

## Keywords

Myopia; Blue Light; Violet Light; Refractive Errors; Axial Length

## Introduction

The prevalence of myopia in children has sparked significant concerns about its potential long-term impact on ocular health and vision function. This increase in myopia has led to heightened attention from both clinicians and researchers as it may increase the risk of various ophthalmic conditions throughout adulthood. Recent studies have begun to focus on the role of specific light wavelengths, especially blue and violet light. These wavelengths modulate refractive development during childhood. As children are increasingly exposed to artificial light from screens, LED lighting, and other modern sources, there is a pressing need to understand how these wavelengths influence the underlying biological

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mechanisms driving myopia.

The retinoscleral pathway involves intricate biochemical and biomechanical signaling between the retina and the sclera. This signaling ultimately determines eye growth and refractive errors. Traditionally, myopia has been linked to environmental factors such as near work and genetic predisposition. Emerging evidence now highlights the significant influence of light exposure, particularly the differential effects of violet and blue wavelengths, on this pathway. In clinical practice, ophthalmologists and optometrists must consider these emerging findings in managing pediatric myopia, integrating knowledge of light physics and refractive development into treatment plans. Research is now trying to establish a theoretical foundation for optimizing environmental lighting design to combat the growing epidemic of childhood myopia [1]. In rhesus monkeys, narrow-band long-wavelength lighting promoted hyperopia and inhibited vision-induced myopia by reducing vitreous chamber elongation and increasing choroidal thickness [2,3]. This suggests that chromatic cues play a role in emmetropization in primates. The effects of light on myopia development involve wavelength, illuminance, and contrast [4]. Dr. Martin Moore-Ede, a renowned expert in circadian biology [5], along with a research team comprising physicians and physicists, offers compelling and unique insights into the connection between light exposure and myopia [6]. For example, certain LED lighting systems lack violet light, which may be linked to eye growth issues. This article compares their perspectives, highlighting the mechanisms they propose and the implications for interventions in children's eye care.

## Thinning of the Choroid and Destabilizing Eye Growth

### Violet Light's Role

Dr. Moore-Ede emphasizes the critical role of deep violet light (360–400 nm) in preventing myopia. He identifies Neuropsin (Opsin 5), a photopigment in retinal ganglion cells, as the key mediator. Neuropsin is activated by violet light, promoting the health and thickness of the choroid—the vascular layer behind the retina responsible for oxygen and nutrient supply. Neuropsin activation is thought to influence signaling pathways that regulate eye growth, such as scleral remodeling and vascular perfusion. According to Moore-Ede, the absence of violet light—often due to modern LED lighting and UV-blocking eyewear—leads to choroidal thinning and destabilized eye growth [5]. While the absence of violet light is a concern, other factors such as reduced time outdoors and increased near work should also be considered. To address this, he recommends reintroducing violet light in children's environments through natural sunlight exposure and designing eyewear and lighting systems that safely transmit violet light.

## Refraction and Growth-Based Theory

The most significant increase in ocular axial length occurs during the first 10 months of life. However, axial length growth does not cease at this stage; it continues at a slower pace throughout childhood, particularly during the early years. The first few years of life are generally considered a critical period for axial length development.

Using the Refraction and Growth-Based Theory approach, the research team examines the unintended consequences of eliminating blue light from the environment or utilizing blue-blocking lenses designed to filter short-wavelength blue light on eye development [6]. They investigate the physics of refraction and suggest that removing blue light shifts the focal point farther back in the eye due to its lower refractive index. This optical adjustment might stimulate axial elongation—a key characteristic of myopia—as the eye adapts to the changed focal dynamics (Figure 1).

Their primary concerns include the possibility that blue-blocking lenses may cause lasting structural changes in the eye, when used during critical developmental periods, such as infancy. Moreover, there is insufficient data to support claims of their safety during these stages, high-

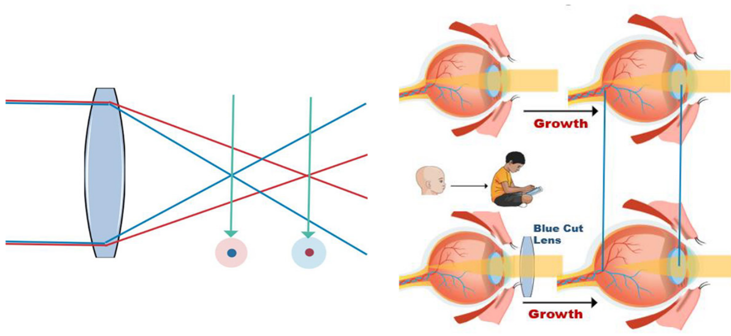


**Figure 1:** Reducing blue light shifts the focal point of the eye further back due to its lower refractive index. This optical change may trigger axial elongation, a primary feature of myopia, as the eye adapts to the modified focal dynamics.

lighting the need for longitudinal studies. Furthermore, prolonged use of these lenses without considering their impact on refractive adaptation could increase the risk of myopia [1]. To address these potential risks, they advocate limiting the use of blue-blocking lenses in young children and emphasize the need for further research to balance protective and developmental considerations in lens design [1].

## Comparison of Perspectives

Moore-Ede's model emphasizes biological processes, particularly the vascular health of the choroid, while the Refraction and Growth-Based Theory research team focuses on optical physics and how light wavelength affects refraction and axial elongation. Both perspectives highlight the disruption of natural light exposure by artificial means, such as modern lighting and lens technologies, and suggest that alterations in the light spectrum can significantly impact eye growth and development. However, Moore-Ede's approach underscores the importance of violet light for maintaining eye health, while the Refraction and Growth-Based Theory highlights potential risks of filtering specific wavelengths. To enhance clarity, Table 1 summarizes the key points of both perspectives.

## Directions for Future Studies

### Species-Specific Responses

Future studies should investigate how different species respond to varying light wavelengths. For example, while fish, chicks, and guinea pigs develop more myopic in long-wavelength light (red or green), tree shrews and rhesus monkeys show opposite results. Understanding these differences can inform species-specific models of light's impact on eye growth.

### Artificial Violet Light

Ongoing clinical trials should be expanded to evaluate the efficacy of artificial violet light in controlling myopia in humans. Establishing evidence-based guidelines for the therapeutic use of violet light could significantly advance myopia management.

### Indoor vs. Outdoor Light

Research should focus on quantifying the differences in light intensity and wavelength between indoor and outdoor environments and their effects on eye development. Addressing the lack of violet light in modern indoor lighting could help mitigate myopia prevalence in children.

### Far Red/Near-Infrared Light

Further investigation into the potential of far red/near-infrared (FR/NIR) light for improving choroidal blood perfusion and managing myopia is needed. This emerging area could provide innovative tools for combating myopia progression.

# Conclusion

The insights of Moore-Ede and the Refraction and Growth-Based Theory research team highlight a crucial takeaway: light exposure is not

**Table 1:** Key points of Moore-Ede's approach vs. Refraction and Growth-Based Theory.

| Aspect | Moore-Ede's Perspective [5] | Refraction and Growth-Based Theory [6] |
|---|---|---|
| Focus | Biological processes (vascular health of the choroid) | Optical physics (impact of light wavelength on refraction and growth) |
| Key Wavelength | Violet light (360–400 nm) | Blue light (400–500 nm) |
| Mechanisms | Neuropsin activation, scleral remodeling, and choroidal vascular health | Changes in refractive index and focal point dynamics |
| Impact of Modern Lighting | Reduced violet light exposure leads to choroidal thinning | Elimination of blue light shifts the focal point, promoting axial elongation |
| Proposed Interventions | Reintroduce violet light via natural sunlight, eyewear, and lighting | Limit blue-blocking lenses in children, especially during critical developmental periods |
| Potential Risks | Lack of violet light destabilizes eye growth | Prolonged use of blue-blocking lenses may lead to structural changes in the eye |

just a visual experience but also a developmental influence on the eye. Violet light supports choroidal health, while inappropriate blue-light filtering may disrupt refractive balance and promote myopia. Parents and educators can encourage outdoor activities to increase exposure to natural light, and policymakers can prioritize designing child-friendly lighting systems. Their findings call for a balanced approach to light exposure in children's environments. Key areas for further investigation include exploring species-specific responses to light wavelengths, evaluating the role of artificial violet light in myopia control, and understanding how indoor and outdoor lighting environments differ in impact. Future innovations in lighting and eyewear must consider both protective and developmental aspects to ensure healthy eye growth. Combining these perspectives can pave the way for more effective strategies to combat the global rise in myopia among children.

## Authors' Contribution

MH. Nowroozzadeh, M. Ostovari, SAR. Mortazavi, and SMJ. Mortazavi conceived the idea. J. Ong, K. Abri Aghdam, and E. Waisberg drafted the manuscript. All authors reviewed and approved the final version.

## Conflict of Interest

SMJ. Mortazavi, as the Editorial Board Member, was not involved in this manuscript's peer-review and decision-making processes.

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