

IMI - The Role of Light in Refractive Error Development and Myopia

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Time spent outdoors has a consistent protective association with delayed myopia onset in children which may be associated with exposure to sunlight. Multiple countries have adopted outdoor time recommendations for children (such as two hours daily), and clinical trials as well as national programs (e.g., Singapore, Taiwan, China) have observed reductions in myopia incidence following these interventions. For progression, there is less definitive evidence, though possible seasonal variations and pandemic-related declines in outdoor activity (e.g., during COVID-19) have correlated with increased myopia incidence and progression rates. Regardless, there remains significant uncertainty regarding the mechanistic details and optimal characteristics of light exposure (intensity, spectrum, timing) needed to achieve maximal benefit.

Role of bright light exposure

Substantial evidence from animal models shows that light characteristics—including intensity, chromaticity, and photoperiod—can influence ocular development and refractive error regulation, possibly via modulation of retinal dopamine. Specifically, bright light exposure increases dopamine release and acts as a regulatory “brake” to slow excessive axial elongation, a key process in myopia development. In humans, epidemiological studies and objective assessments from light sensor wearables support that time outdoors (measured via proxies like ambient lighting >1000 lux) slows the onset of myopia in children, an effect that is integrated into large-scale prevention initiatives. Indirect evidence from human studies suggests that exposure to bright light may be associated with a less myopic refraction. However, current human data make it difficult to determine whether bright light directly influences refractive development or merely serves as a proxy for time spent outside, with protective effects potentially stemming from other outdoor-related factors (e.g. broader spectral composition, reduced peripheral defocus, spatial frequency content differences).

Spectral composition and modern light sources

Animal studies indicate that spectral composition of the lighting environment can also influence refractive development, and narrow-band or monochromatic lighting can drive refractive changes in experimental models of myopia, but there are varied results across species, likely due to physiological differences. There are some novel light-based myopia control therapies being investigated, but their efficacy and/or safety profiles are not robust. Differences in activation patterns of retinal photoreceptors between sunlight and artificial sources may also contribute to myopia risk, although “white light” is not a uniform entity—spectral outputs and effects on opsin activation vary. Modern environments dominated by artificial lighting (LEDs, screens) therefore represent another area needing further study for potential effects on human myopia risk.

Sleep and screen time

Normal eye growth is regulated by a circadian (day-night) pattern, and light is the primary external cue. Disruption of circadian rhythms (due to constant light/darkness or altered sleep patterns) leads to abnormal refractive

development in animal models. Poor sleep and altered sleep timing (potentially from excessive screen use or late-night light exposure) have an unclear but potentially contributory relationship to myopia development in children. The impact of electronic device use on myopia development and progression remains inconclusive based on current evidence.

Mechanisms and knowledge gaps

While animal research supports bright light exposure as a protective mechanism, translation to humans is challenging. Critical gaps exist in understanding the precise intensity thresholds, exposure duration, spectral composition, and temporal patterns of light that confer optimal protection for humans. Multifactorial environmental features also contribute e.g., natural outdoor scenes offer different visual stimuli to indoors (e.g. dioptric range, peripheral blur, and temporal vision cues).

Evidence-based clinical recommendations

The current clinical recommendation of encouraging children to spend at least two hours outdoors daily as a strategy to delay myopia onset remains. While gaps remain in defining optimal light parameters (intensity, spectrum, and timing), there is strong consensus supporting increased outdoor activity as an evidence-based strategy to delay myopia onset.

- Several light-based therapies—predominantly involving chromatic manipulation (e.g., red light therapy)—are under clinical investigation. While some early studies show potential benefits in terms of myopia control, these remain experimental, and there are concerns about safety and long-term effects. IMI continues to monitor and evaluate these approaches as evidence and safety data mature.
- Clinicians can reassure parents that outdoor exposure is beneficial under typical conditions—whether sunny or cloudy—and that wearing hats or sunglasses does not negate its protective effects.

Future Directions

Further randomized controlled trials employing rigorous methods, standardized measurements, and wearable technologies are needed to clarify the roles and mechanisms of light exposure—including intensity, spectrum, and timing—in myopia prevention and management. Building this evidence base will enable IMI and the wider clinical community to define more precise, evidence-based guidance on light exposure that extends beyond the current recommendation to increase outdoor time.

In closing, this summary synthesizes the 2025 IMI white paper’s guidance for clinicians: maximize time outdoors as a validated public health intervention to delay myopia onset in children, while acknowledging the need for nuanced future recommendations targeting specific light exposure parameters and expanding the focus to the broader visual environment.

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REFERENCE

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