Biomedical and Biopharmaceutical Research
Abbreviation: Biomed. Biopharm. Res.
Volume: 22: Issue: 01 |Year: 2025
Page Number: 377-381

A Review of Current Knowledge and Approaches for Managing Myopia Control

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Article Received:15-02-2025

Article Accepted:10-04-2025

Abstract

Myopia, or nearsightedness, has emerged as one of the most prevalent visual disorders worldwide, with alarming increases in incidence among children and adolescents, particularly in East Asia (Holden et al., 2016). It is projected that nearly half of the global population will be affected by myopia by the year 2050, making it a significant public health concern. This review aims to consolidate current understanding regarding the etiology, risk factors, pathophysiological mechanisms, and effective intervention strategies to control the onset and progression of myopia. Key contributing factors include both genetic predisposition and environmental influences such as prolonged near work and insufficient outdoor activity (Zadnik et al., 2015; Rose et al., 2008). The underlying pathophysiology primarily involves axial elongation and retinal signal disruption (Flitcroft, 2012). Evidence-based control measures—ranging from low-dose atropine and optical interventions to behavioral modifications—are discussed, highlighting their benefits and limitations (Chia et al., 2012; Lam et al., 2020). The review also underscores the necessity for future research into long-term outcomes, personalized therapies, and global policy reforms to address disparities in access and treatment. A multidisciplinary, preventive approach remains essential to mitigate the global burden of myopia.

Keywords: Myopia, Refractive Error, Axial Elongation, Genetic Risk, Near Work, Outdoor Activity, Atropine, Orthokeratology, Myopia Control, Vision Public Health

INTRODUCTION

Definition and Classification of Myopia:

Myopia, commonly referred to as nearsightedness, is a refractive error where distant objects appear blurry while close ones remain clear. It is typically classified into three categories: simple myopia (up to -6.00 diopters), high myopia (greater than -6.00 diopters), and pathological or degenerative myopia, which involves structural changes in the eye leading to vision-threatening complications (Morgan et al., 2012).

Global Epidemiology and Public Health Impact:

The prevalence of myopia is rapidly increasing worldwide and is particularly alarming in East and Southeast Asia. It is projected that by 2050, nearly half of the global population will be myopic, with up to 10% experiencing high myopia (Holden et al., 2016).

Rising Prevalence in Children and Adolescents:

Myopia now affects children at younger ages than in previous decades, with studies reporting onset as early as six years of age in certain regions, which raises concerns about prolonged progression into high myopia (Wu et al., 2016).

Need for Early Detection and Control:

Given the lifelong risk of complications associated with progressive myopia, early screening, parental awareness, and timely interventions are critical to mitigate long-term visual impairment and related socioeconomic burdens.

Etiology and Risk Factors

Genetic Factors

Genetics play a significant role in myopia development. A child with one or both parents who are myopic has a considerably higher risk of developing the condition themselves, suggesting a strong heritable component (Zadnik et al., 2015).

Environmental Factors

Near Work Activities:

Engaging in activities that require prolonged close-up vision—such as reading, computer use, and smartphone usage—has been associated with increased myopia risk (He et al., 2015).

Time Spent Outdoors:

Outdoor activity has a protective effect against myopia development, likely due to brighter light exposure and distance-focused visual stimulation (Rose et al., 2008).

Urban vs. Rural Differences:

Myopia prevalence tends to be higher in urban populations than in rural ones, attributed to lifestyle differences, including education pressure and reduced outdoor exposure (Morgan et al., 2012).

Lifestyle and Behavioral Factors

Other modifiable factors include sleep duration, diet, and patterns of light exposure, all of which influence ocular growth during developmental years (Guo et al., 2017).

Pathophysiology of Myopia

Axial Elongation and Scleral Remodeling:

The primary structural change in myopia is the elongation of the eyeball's axial length, which leads to the focal point falling short of the retina (Flitcroft, 2012).

Retinal Signaling Pathways:

The retina plays a crucial role in signaling the rate of eye growth, particularly through pathways that respond to defocus and blur (Wallman & Winawer, 2004).

Dopamine and Light Exposure:

Dopamine release in the retina is stimulated by bright light and has an inhibitory effect on axial elongation, underscoring the importance of adequate daylight exposure (Smith et al., 2012).

Epidemiological Trends

Regional Prevalence:

East Asian countries such as China, Singapore, and South Korea have reported myopia rates exceeding 80% among adolescents, whereas lower rates are observed in European and North American populations (Holden et al., 2016).

Global Forecast:

By 2050, it is expected that 49.8% of the world's population will be myopic, and 9.8% will have high myopia, increasing the risk of blindness and visual disability (Holden et al., 2016).

Economic and Social Impact:

The economic burden includes healthcare costs, productivity loss, and the psychosocial impact of visual impairment, which is expected to grow with the increasing prevalence of myopia.

School screening program

The Rural Education Action Programme (REAP)'s Seeing for Learning social enterprise programme
Orbis' new REACH (Refractive Error Among Children) programme(Catherine Jan,2017)

Strategies for Controlling Myopia Progression

Optical Interventions

DIMS Spectacle Lenses:

Defocus Incorporated Multiple Segments (DIMS) lenses have shown significant efficacy in slowing myopia progression in children (Lam et al., 2020).

Think of DIMS, H.A.L.T., DOT and CARE as like a single vision lens for myopia correction, with an overlaying 'treatment zone' for myopia control.Similar axial length progression at 12 months appears in the DIMS, HAL and DOT lens data.

Myopia control progression Glasses

Improved myopia control in executive bifocals compared to PALs suggests that progression is determined more by dioptric demand across the visual field and/or peripheral focus, than by accommodative strain.(Tim frickle,2019)

Multifocal Contact Lenses:
These lenses reduce hyperopic defocus and have been found to slow axial elongation (Walline et al., 2013).

Cylindrical Annular Refractive Element (CARE)

CARE spectacle lenses have demonstrated significant potential in slowing myopia progression and axial elongation in children. Clinical trials showed up to a 23% reduction in eye growth compared to single-vision lenses over one year. Additionally, children reported high visual satisfaction and adaptability, supporting CARE's practical use in pediatric myopia management.(Xiaoqine chen,2024)

Orthokeratology (Ortho-K):
Ortho-K lenses reshape the cornea overnight, providing clear daytime vision and simultaneously reducing myopia progression (Cho & Cheung, 2012).

Red light Therpy

Repeated low-level red light demonstrates stronger treatment efficacy among those with high myopia, with 53.3% experiencing substantial axial shortening. Repeated low-level red light provides an excellent solution for the management of high myopia progression, a significant challenge in ophthalmology practice.(Yan Xu PhD,2024)

Pharmacological Approaches
Low-Dose Atropine:
The ATOM studies demonstrated that 0.01% atropine is effective in slowing myopia progression with minimal side effects (Chia et al., 2012).

Young adult myopes experienced a significant but temporary impact on the ocular surface with 0.05% atropine administration, whereas 0.01% atropine had a minimal effect.(Yifan Luo,2024)

Pirenzepine and Others:
Pirenzepine, a selective muscarinic antagonist, has shown promising results in early trials, but broader clinical adoption is limited by side effect profiles and availability.

Environmental and Behavioral Interventions
Increased Outdoor Time:
Promoting outdoor activities for at least 2 hours per day has been correlated with a reduced incidence of myopia in school-aged children (Rose et al., 2008).

Educational Reform:

Reducing academic pressure and incorporating outdoor recess and visual breaks in schools can be effective preventive measures (Li et al., 2021).

Digital Screen Time Regulation:
Limiting screen use and encouraging healthy visual habits can mitigate near work-induced eye strain and myopia risk (Lanca & Saw, 2020).

20:20:20 Rule:

Only one-third of participants practice the 20/20/20 rule at least occasionally. More number of adult females being symptomatic and practicing in greater number could be due to higher prevalence of dry eye condition in females (Sourav Datta,2023)

Surgical and Experimental Therapies
Scleral Reinforcement:
Surgical methods like posterior scleral reinforcement are being explored to halt further axial elongation in pathological myopia.

Gene Therapy and Biochemical Targets:
Emerging research is investigating gene pathways and molecular targets involved in myopic eye growth, though clinical application remains in early stages.

Challenges and Limitations in Current Strategies
- **Side Effects and Compliance:** Adverse effects such as light sensitivity and near vision blur limit widespread use of pharmacological treatments like atropine.
- **Optical Limitations:** Effectiveness of lenses and Ortho-K may vary with compliance and age.
- **Long-Term Efficacy:** Many interventions lack long-term follow-up data, especially into adulthood.
- **Healthcare Disparities:** Access to advanced treatments remains limited in low-income or rural regions.
- **High cost of myopia controlling Glasses**
- **Low dose atropine :**Reflex increase in axial length

Future Directions
- **AI for Early Detection:** Machine learning tools can aid in predicting at-risk children through imaging and biometric data.
- **Personalized Interventions:** Genetic profiling and personalized optical solutions could enhance treatment outcomes.
- **Longitudinal Research:** More studies are needed to track the impact of early interventions over decades.
- **Global Policy Integration:** WHO and national health authorities must prioritize vision screening and preventive strategies globally.

CONCLUSION
Myopia has emerged as a significant global health challenge with rising prevalence and associated complications. Current understanding emphasizes the multifactorial etiology, involving both genetic and environmental contributions. While a range of interventions exists—from optical to pharmacological—no single strategy offers a cure. A multifaceted approach, integrating early screening, public health education, and research-driven innovations, is essential to control this emerging epidemic.

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