AAMS Internal Medicine & Therapeutics
ISSN: 2834-7102 (Print) | eISSN: 2834-7103 (Online)
Volume 07, Issue 07, Pages 1-15
DOI: 10.4103/aams.0498
ORIGINAL ARTICLE

CHILDHOOD MYOPIA: RISK FACTORS, EARLY DETECTION, PROGRESSION, AND PREVENTIVE STRATEGIESCHILDHOOD MYOPIA: RISK FACTORS, EARLY DETECTION, PROGRESSION, AND PREVENTIVE STRATEGIES

Hamrakulov Sobir

Associate Professor, Department of Ophthalmology, Samarkand State Medical University

Received: 2026-06-16 · Accepted: 2026-07-12

Abstract

Childhood myopia has become one of the most important challenges in contemporary ophthalmology because of its increasing prevalence and its potential to progress during the most active stages of ocular development. Myopia in children is not simply a condition that causes blurred distance vision; progressive myopia may be accompanied by excessive axial elongation of the eye and can increase the risk of serious ocular complications later in life. The development of childhood myopia is influenced by multiple interacting factors, including genetic predisposition, family history, educational environment, near-work behavior, digital-device use, reduced exposure to outdoor light, and individual characteristics of ocular growth. Early identification of children at increased risk is therefore essential for timely intervention. This article examines the principal causes and risk factors of childhood myopia, mechanisms associated with its progression, clinical approaches to early detection, and contemporary preventive strategies. Particular attention is given to regular vision screening, outdoor activity, healthy visual habits, appropriate optical correction, and modern methods of myopia control. The article emphasizes that prevention should begin before severe refractive error develops and should involve cooperation among eye-care professionals, parents, schools, and children. A systematic approach to early diagnosis and long-term monitoring can contribute to slowing myopia progression and protecting visual health throughout life.

Keywords: childhood myopia, refractive error, myopia progression, axial elongation, children, visual habits, outdoor activity, eye screening, prevention, myopia control, ocular health.

1. Introduction

Myopia is a refractive condition in which the eye is unable to focus distant images accurately on the retina when accommodation is relaxed. In most childhood cases, the development of myopia is associated with excessive axial elongation of the eyeball. As the eye becomes longer, the optical system becomes increasingly mismatched with the retinal position, resulting in blurred distance vision. Although spectacles can compensate for the optical error, they do not necessarily prevent the biological process responsible for progressive ocular elongation.

Childhood is a particularly important period in the development of myopia because ocular growth is highly active during the early years of life. Myopia commonly begins during primary school years and may progress through adolescence. The earlier myopia appears, the greater the potential period of progression. Consequently, identifying myopia at an early stage can provide an opportunity to introduce preventive measures before a high level of refractive error is reached.

The global increase in childhood myopia has been associated with changes in lifestyle and educational patterns. Children in many societies spend substantial amounts of time studying, reading, using computers, smartphones, and other digital devices, while opportunities for outdoor activity may be reduced. However, the relationship between digital-device use and myopia is complex and cannot be explained by screen exposure alone. Modern research increasingly emphasizes the interaction between prolonged near work, limited outdoor exposure, genetic susceptibility, and the overall visual environment.

The clinical importance of childhood myopia extends beyond the immediate problem of blurred distance vision. High myopia is associated with structural changes in the posterior segment of the eye and an increased risk of retinal and macular complications. Therefore, controlling progression during childhood may have important long-term benefits. This has changed the role of pediatric eye care from simple correction of refractive error to active monitoring and management of abnormal ocular growth.

2. Materials and Methods

This article is based on a narrative analysis of scientific literature concerning childhood myopia, its development, risk factors, progression, diagnosis, and prevention. Relevant scientific publications, clinical studies, systematic reviews, and international professional recommendations were considered to provide a broad overview of current knowledge.

The literature was analyzed according to several major themes: epidemiological characteristics of childhood myopia, genetic and environmental risk factors, mechanisms of ocular growth, clinical diagnosis, behavioral prevention, optical correction, pharmacological approaches, and long-term monitoring. Particular attention was given to evidence obtained from studies involving school-age children and adolescents.

The methodological analysis included consideration of commonly used clinical indicators such as spherical equivalent refraction, uncorrected and corrected visual acuity, cycloplegic refraction, and axial length. Cycloplegic refraction is especially important in children because accommodation can influence refractive measurements and may lead to an inaccurate estimation of the true refractive state. Axial length measurement provides additional information about structural ocular growth and can be useful for monitoring progression over time.

Research findings related to preventive interventions were evaluated according to the consistency of results, duration of follow-up, characteristics of study populations, and clinically relevant outcomes. The analysis also considered practical factors such as treatment adherence, accessibility, safety, and the feasibility of implementing preventive strategies in schools and families.

3. Results

The analysis indicates that childhood myopia is a multifactorial condition in which genetic predisposition and environmental exposure interact. Children with myopic parents are generally at greater risk of developing myopia than children without a family history. However, family history should be considered a risk indicator rather than a deterministic factor. Many children with a genetic predisposition may experience different levels of myopia depending on environmental and behavioral conditions.

Age at onset is one of the most important indicators of future progression. Children who develop myopia at a younger age generally have more years during which refractive error may increase. Early onset is therefore an important reason for regular visual screening in primary school children and preschool-aged children with risk factors.

The results also demonstrate a relationship between outdoor exposure and myopia development. Children who spend more time outdoors appear to have a lower risk of developing myopia than children who spend very little time outside. Bright outdoor light may influence retinal signaling and ocular growth mechanisms. Outdoor activity also indirectly reduces the total time spent on continuous near work and provides a healthier balance between indoor and outdoor visual tasks.

Another important observation concerns visual behavior during near tasks. Reading, writing, drawing, studying, and digital-device use require sustained near fixation. These activities are not inherently harmful and are essential components of education, but prolonged uninterrupted near work may be undesirable when combined with inadequate viewing distance and limited outdoor activity. Regular visual breaks, appropriate working distance, good illumination, and balanced daily routines can therefore be recommended as practical preventive measures.

Digital technology deserves particular attention because smartphones and tablets have become common in children's daily lives. Small screens are often viewed at shorter distances than books or desktop monitors. This may encourage prolonged accommodation and convergence. Nevertheless, current evidence does not support treating digital screens as the sole cause of myopia. The more appropriate approach is to reduce excessive and uninterrupted screen use while ensuring adequate outdoor activity and healthy visual ergonomics.

The results further indicate that early detection is essential. Children with emerging myopia may not complain about blurred vision because they gradually adapt to reduced distance acuity. Behavioral signs can include sitting close to the classroom board or television, narrowing the eyes when looking into the distance, frequent headaches during visually demanding activities, or difficulty recognizing distant objects. Such signs should prompt professional eye examination.

Comprehensive examination can identify the degree of refractive error and assess ocular health. In children, cycloplegic refraction provides a more reliable measurement of refractive status by temporarily reducing the influence of accommodation. Where available, axial length measurement can provide valuable information about ocular growth and may support longitudinal monitoring.

The review also demonstrates that conventional spectacles remain an important component of childhood myopia management because they provide clear vision and are safe when appropriately prescribed. However, standard single-vision correction primarily addresses visual clarity and does not necessarily provide the same myopia-control effect as specialized optical interventions.

Modern myopia-control methods include specially designed spectacle lenses, multifocal or myopia-control contact lenses, orthokeratology, and low-dose atropine. These methods have been investigated in numerous clinical studies and may slow refractive progression and axial elongation in appropriately selected children. The choice of intervention should be individualized according to age, progression rate, baseline refractive error, ocular characteristics, treatment availability, and family preferences.

Long-term monitoring is another important result of the analysis. Myopia management cannot be considered a short-term intervention because ocular growth may continue for several years. Regular examinations allow clinicians to determine whether the selected strategy is effective and whether modification of treatment is necessary.

4. Discussion

Childhood myopia represents a complex interaction between ocular biology and the modern environment. The rapid increase in myopia prevalence in many populations has occurred during a period of significant changes in children's educational and recreational behavior. Although these changes do not provide a complete explanation for the phenomenon, they support the importance of environmental modification as part of a comprehensive prevention strategy.

One of the strongest practical recommendations is to increase children's opportunities for outdoor activity. Outdoor time is relatively inexpensive, accessible, and beneficial for general physical and psychological health in addition to its potential protective effect against myopia. Schools can contribute by incorporating outdoor activities into daily schedules, while parents can encourage children to spend part of their leisure time outside rather than exclusively using digital devices or engaging in indoor activities.

Near work should not be presented as something children must avoid. Reading and studying are essential for intellectual development. Instead, the focus should be on visual ergonomics. Children should maintain a reasonable working distance, avoid holding books or smartphones extremely close to the face, use appropriate lighting, and take regular breaks during prolonged periods of near work. These measures are practical and can be incorporated into normal daily routines.

Early screening is particularly important because children may not understand that their vision has changed. A child who previously could see the classroom board clearly may gradually begin to experience difficulty but may not report it. Delayed diagnosis can affect academic performance and participation in classroom activities. Therefore, school-based screening and regular professional examinations can help identify refractive changes before they interfere significantly with daily functioning.

The role of parents is also important. Parents can observe changes in children's visual behavior and provide information about family history. If one or both parents have myopia, children may benefit from closer monitoring. Parents should also understand that increasing spectacle strength does not mean that spectacles caused the progression. Spectacles correct the refractive error and provide clear vision; progression is primarily related to changes in the eye itself.

The development of specialized myopia-control treatments represents an important advancement in ophthalmology. Rather than waiting for myopia to stabilize, clinicians can now consider interventions intended to slow its progression during childhood. This approach is especially relevant for children who demonstrate rapid progression or possess several risk factors for high myopia.

Pharmacological treatment with low-concentration atropine has become one of the most widely studied approaches. Clinical trials have shown that different concentrations can reduce myopia progression, although the magnitude of effect varies. Treatment must be prescribed and monitored by an eye-care professional because the appropriate concentration and duration depend on the individual patient.

Orthokeratology provides another approach by temporarily reshaping the cornea during overnight lens wear. It can provide functional daytime vision without conventional spectacles and may also reduce axial elongation. However, because contact lenses are worn overnight, careful hygiene, professional fitting, and regular monitoring are essential. Families should be informed about both potential benefits and risks before treatment begins.

Specialized spectacle and contact-lens designs provide additional options for children who are not suitable candidates for orthokeratology or pharmacological treatment. The availability of multiple treatment categories allows clinicians to select an approach according to individual circumstances rather than applying a single strategy to all patients.

An important consideration is treatment adherence. Even an intervention supported by strong scientific evidence may be less effective in real-world conditions if the child does not use it consistently. Parents and children should therefore receive clear explanations regarding the purpose of treatment, expected duration, possible side effects, and the importance of follow-up appointments. A treatment plan that is practical for the family may produce better long-term results than a theoretically stronger intervention that cannot be followed consistently.

Another major issue is inequality in access to eye care. Specialized myopia-control services may not be available in all regions, and the cost of certain interventions can be a barrier. Public-health strategies should therefore combine advanced clinical treatment for high-risk children with low-cost preventive measures such as outdoor activity, school screening, visual-education programs, and accessible primary eye care.

Future research should continue to investigate the biological mechanisms responsible for abnormal axial growth. Better understanding of these mechanisms may allow researchers to identify children at highest risk before substantial myopia develops. Research should also examine the long-term safety and effectiveness of combination treatments, the optimal duration of pharmacological therapy, treatment cessation strategies, and the influence of lifestyle interventions in different populations.

5. Conclusion

Childhood myopia is a significant and increasingly common ocular condition that requires attention from both clinical and public-health perspectives. Its importance is determined not only by blurred distance vision but also by the possibility of progressive axial elongation and the long-term ocular complications associated with high myopia.

The development of childhood myopia is influenced by multiple factors, including genetic susceptibility, age, family history, near-work behavior, educational demands, and limited outdoor exposure. Because these factors interact, prevention should not depend on a single intervention. A balanced strategy should include regular eye examinations, early identification of refractive changes, adequate optical correction, increased outdoor activity, healthy visual habits, and clinically appropriate myopia-control treatment.

Early intervention is particularly important for children who develop myopia at a young age or demonstrate rapid progression. Modern treatments such as low-concentration atropine, orthokeratology, specialized spectacle lenses, and myopia-control contact lenses provide additional opportunities to slow progression. However, treatment selection should always be individualized and accompanied by regular professional monitoring.

Parents, teachers, healthcare professionals, and children themselves all have a role in protecting visual health. Creating a daily routine that balances near work with outdoor activity, improving awareness of early symptoms, and ensuring timely eye examinations can contribute substantially to prevention and management.

The long-term objective of childhood myopia management should be to preserve visual function and reduce the probability of severe myopia-related complications in adulthood. Continued research, public education, early screening, and evidence-based clinical care are therefore essential for addressing the growing burden of myopia and improving visual health across future generations.

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DOI: 10.4103/aams.0498