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The Global Rise of Myopia in Children: Pathophysiology, Early Detection Strategies, and Evidence-Based Interventions for Prevention

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Abstract: Myopia has become one of the most significant ocular public health concerns in children, with prevalence rising at an alarming rate worldwide. Modern lifestyle habits including excessive near work, reduced outdoor activity, prolonged digital screen exposure, and academic pressure are accelerating early-onset myopia and its progression. High myopia increases the risk for irreversible retinal complications such as myopic maculopathy, glaucoma, cataract, and retinal detachment. Early detection, effective screening strategies, and evidence-based interventions play a crucial role in mitigating long-term impacts. This comprehensive review summarises current knowledge on epidemiology, pathophysiology, risk factors, early detection, and management strategies, with an emphasis on low-dose atropine therapy, orthokeratology, multifocal lenses, and lifestyle modification. The review provides actionable guidance for paediatricians, family physicians, ophthalmologists, and public health practitioners to integrate preventive approaches into routine childhood care.

Keywords: *Myopia in Children, Progressive Myopia, Pediatric Ophthalmology, Axial Elongation, Atropine 0.01%, Orthokeratology, Digital Eye Strain, School Vision Screening, Outdoor Activity, Myopia Prevention.*

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I. INTRODUCTION

Myopia is emerging as a global epidemic and a critical public health concern. Current projections estimate that nearly 50% of the global population will be myopic by 2050, with 10% developing high myopia. Increased academic demands, urbanisation, and digital screen exposure are major contributors to early onset in children. India is witnessing a steady rise in prevalence, particularly in urban school children. Early detection and timely intervention are essential to minimise long-term vision-threatening complications.

II. EPIDEMIOLOGY AND GLOBAL TRENDS

➢ *Myopia Prevalence Varies Significantly Worldwide:*

- East Asia: 65%–90% in school-going children.
- South Asia (India):

✓ Urban: 13%–35%
✓ Rural: 4%–12%

- Global projection: By 2050, 4.9 billion people expected to be myopic.

The decline in outdoor exposure and increased indoor lifestyles contribute significantly to rising prevalence.

III. PATHOPHYSIOLOGY OF MYOPIA

➢ *Axial Elongation*

The most common mechanism involves elongation of the eyeball causing light rays to focus in front of the retina.

➢ *Genetic Predisposition*

Children with one myopic parent have 3× higher risk; with two parents, 6–7× higher.

➢ *Environmental Influence*

High near-work activity, prolonged screen exposure, reduced dopamine release in the retina due to insufficient bright light exposure, and decreased outdoor activity are major drivers of myopia progression.

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IV. RISK FACTORS FOR PEDIATRIC MYOPIA

➢ *Environmental Factors*

- Excessive screen time
- Reduced outdoor activity (<1–2 hours/day)
- High academic load
- Indoor-centric lifestyle

➢ *Child-Related Factors*

- Early onset (<6 years)
- Prematurity
- Low hyperopic reserve

➢ *Genetic Factors*

- Myopic parents
- Asian ethnicity

V. CLINICAL PRESENTATION AND RED FLAGS

➢ *Common Symptoms*

- Blurred distance vision
- Squinting
- Sitting close to screens
- Frequent eye rubbing
- Headaches

➢ *Red Flags for Progressive Myopia*

- Rapid progression > −0.5 D/year
- Axial length > 24 mm in early childhood
- Onset < 7 years
- Family history of high myopia

VI. EARLY DETECTION AND SCREENING

➢ *Screening Recommendations*

- 3–5 years: Preschool vision screening
- 5–18 years: Annual school screening
- High-risk children: Screening every 6 months

➢ *Diagnostic Evaluation*

- Visual acuity
- Cycloplegic refraction
- Axial length measurement
- Corneal topography (for Ortho-K)

VII. EVIDENCE-BASED INTERVENTIONS FOR MYOPIA CONTROL

A multimodal approach is recommended.

A. Low-Dose Atropine

Low-dose atropine (0.01–0.05%) is currently one of the most effective pharmacological treatments.

➢ *Benefits*

- Reduces progression by 30–60%
- Minimal side effects at low concentrations
- Superior efficacy at 0.05% (LAMP Trial)

➢ *Ideal for*

- Early-onset myopia
- Rapid progression
- Family history of high myopia

B. Orthokeratology (Ortho-K)

Spherical or toric rigid contact lenses worn overnight reshape the cornea.

➢ *Evidence*

- Reduces axial elongation by 40–60%
- Improves uncorrected daytime vision

➢ *Limitations*

- Higher cost
- Risk of keratitis

C. Multifocal Spectacles and Soft Contact Lenses

Examples include MiSight lenses and DIMS (Defocus Incorporated Multiple Segments) spectacles.

➢ *Benefits*

- Reduces progression by 50–60%

D. Increased Outdoor Activity

Outdoor light (10,000–30,000 lux) stimulates dopamine release, reducing axial elongation.

➢ *Recommendations*

- Minimum 120–180 minutes' daily
- Proven to reduce incidence of myopia onset by up to 50%

E. Screen Time and Near-Work Management

➢ *Guidelines*

- Follow the 20–20–20 rule
- Maintain reading distance >30–40 cm
- Avoid prolonged near work (>30 minutes without break)
- Limit recreational screen time:

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✓ <1 hour/day (younger children)

✓ <2 hours/day (older children)

VIII. RISK STRATIFICATION TOOLS

➢ *Hyperopic Reserve*

- < +0.75 D at age 6 suggests higher risk

➢ *Axial Length Growth Charts*

- Useful for monitoring fast progressors.

➢ *Parental Myopia Score*

- Risk increases significantly if both parents are myopic.

IX. SCHOOL-BASED PREVENTION PROGRAMMES

➢ *Countries Like China and Singapore have Implemented:*

- Mandatory outdoor activity
- Reduced school workload
- Vision screening policies
- Digital screen restriction guidelines

India can adopt similar interventions for effective early prevention.

X. ROLE OF PAEDIATRICIANS

➢ *Paediatricians Play a Vital Role in:*

- Early identification
- Screening
- Parental counselling
- Reinforcing lifestyle modifications
- Referring high-risk cases early
- Monitoring treatment compliance

XI. FUTURE DIRECTIONS

➢ *Emerging Research Areas:*

- AI-based myopia prediction
- Dopamine agonist eye drops
- Personalised myopia risk calculators
- Improved spectacle design
- Community-level preventive strategies

XII. CONCLUSION

Childhood myopia is no longer a benign refractive error but a global public health concern. Rising prevalence demands early detection, prevention, and effective intervention strategies. Low-dose atropine, orthokeratology, multifocal optical devices, lifestyle modification, and school-based programs significantly reduce progression. Paediatricians are crucial in identifying high-risk children, implementing screening practices, and providing parental counselling. A comprehensive, preventive approach can substantially reduce the burden of high myopia and its long-term complications in future generations.

➢ *Tables*

Table 1 Key Risk Factors for Childhood Myopia

Category	Risk Factors
Environmental	Screen time, indoor lifestyle, near work, reduced outdoor time
Genetic	One or two myopic parents, Asian ethnicity
Child-specific	Early onset, low hyperopic reserve, prematurity

Table 2 Evidence-Based Interventions

Intervention	Effectiveness	Notes
Atropine 0.01–0.05%	30–60% reduction	Most effective, minimal side effects
Ortho-K lenses	40–60% reduction	Requires strict hygiene
Multifocal lenses	50–60% reduction	FDA-approved MiSight
Outdoor activity	Up to 50% reduction	2–3 hours/day required
Screen control	Reduces onset/progression	Essential lifestyle measure

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➢ *Flowchart: Clinical Approach to a Child with Myopia*

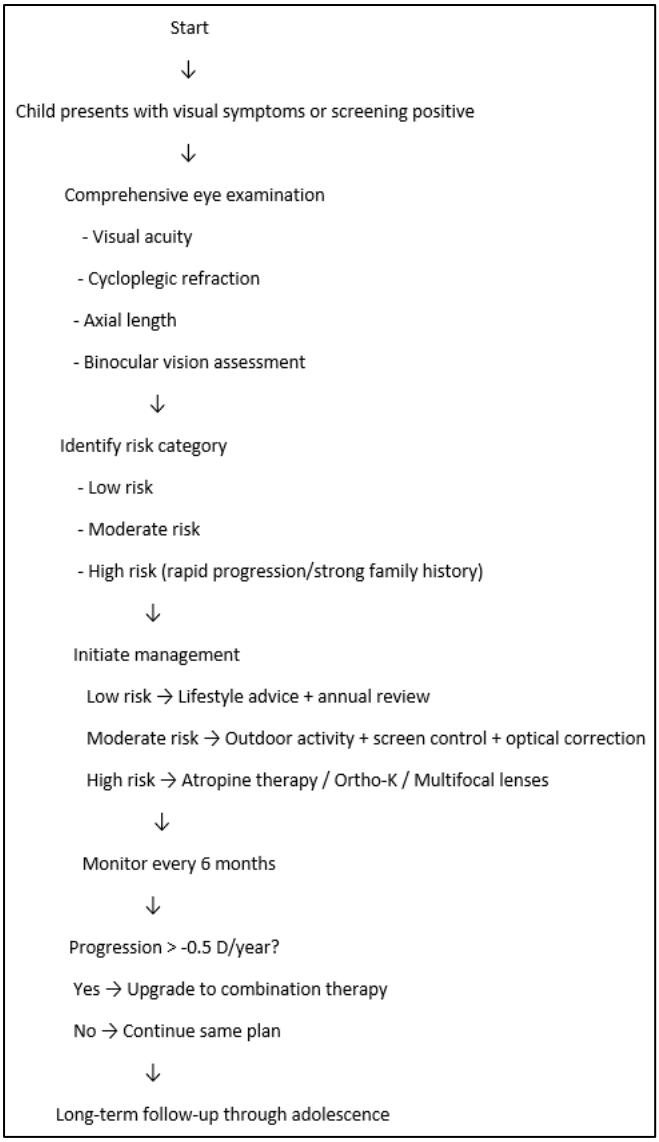

Fig 1 Flowchart

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