Myopia

Causes, Treatment, and Prevention of an Increasingly Common Disease

NATIONAL ACADEMIES Sciences Engineering Medicine

Committee on Focus on Myopia: Pathogenesis and Rising Incidence

Board on Behavioral, Cognitive, and Sensory Sciences

Agenda

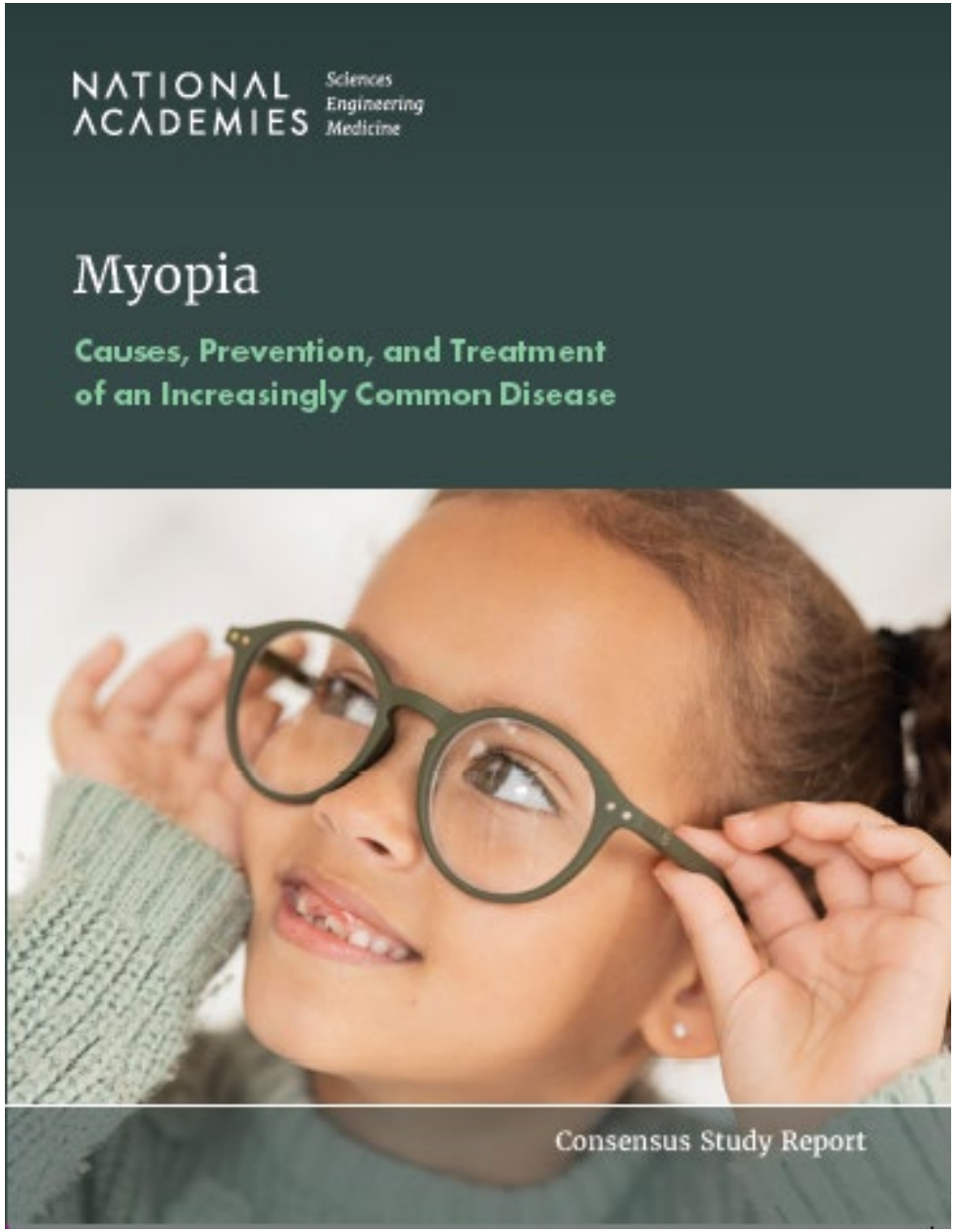
1. Introductions and Overview
2. National Academies Study Process
3. Understanding Myopia and Its Prevalence
4. Assessment and Diagnostic Techniques
5. Onset and Progression of Myopia
6. Myopia Pathogenesis
7. Current and Emerging Treatment Options for Myopia
8. Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

Introductions and Overview

01

Study Sponsors:

- American Academy of Optometry
- American Optometric Association
- Health Care Alliance for Patient Safety
- Herbert Wertheim School of Optometry & Vision Science, University of California, Berkeley
- Johnson & Johnson Vision
- National Eye Institute
- Reality Labs Research
- Research to Prevent Blindness
- Warby Parker Impact Foundation



Consensus Committee Members

K. DAVINA FRICK (Co-Chair), Johns Hopkins Carey Business School

TERRI L. YOUNG (Co-Chair), University of Wisconsin-Madison

AFUA O. ASARE, University of Utah

DAVID BERSON, Brown University

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JEREMY A. GUGGENHEIM, Cardiff University

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National Academies Study Process

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The National Academies of Sciences, Engineering, and Medicine

Bridging Science and Society for >150 Years

The National Academies provide independent, trustworthy advice and facilitate solutions to complex challenges by mobilizing expertise, practice, and knowledge in science, engineering, and medicine.

Board on Behavioral, Cognitive, and Sensory Sciences

- Established in 1997
- Provides vision on how to advance public policy and practice by leveraging cutting-edge research in behavioral, cognitive, and sensory sciences
- Dozens of reports on topics across a wide swath of science including evaluations of substance abuse programs, aging, intelligence & counter-intelligence, suicide prevention, replicability in science, antiracism and DEI in STEMM, how people learn and many others.

Current Core Sponsors	
American Psychological Association	National Aeronautics and Space Administration
National Institutes of Aging	National Science Foundation

Our Consensus Study Process

Conflict of Interest Hurdles

- Perceived COI concerns delayed the committee nominations process
- Relationships with industry are anticipated in Optometry & Ophthalmology
- Some were asked to participate in the workshop or serve as reviewers
- One unavoidable COI was accepted as a member of the committee

Abbreviated Statement of Task

- What are the gaps in knowledge and barriers to progress in understanding the link between known risk factors for myopia development in children and the mechanisms controlling eye growth?
- To what extent do changes in environmental factors (e.g., outdoor time, near work, electronic devices) explain the rapid increase in myopia prevalence?
- What are the socioeconomic, demographic, and regional barriers to diagnosing refractive correction in underserved populations? What research efforts might lead to effective methods for mitigating these issues?

Evidence Gathering: Public Workshop

Workshop on the Rise in Myopia: Exploring Possible Contributors and Investigating Screening Practices, Policies, and Programs
December 5-6, 2023

Foundations of the Study
Martin Banks, Ph.D., Herbert Wertheim School of Optometry & Vision Science, University of California, Berkeley
Bill Geisler, Ph.D., University of Texas at Austin Center for Perceptual Systems
David Williams, Ph.D., University of Rochester Institute of Optics

Exploring Novel International Initiatives and Implications for the Development and Progression of Myopia
David Mackey, AO, University of Western Australia Medical School, Centre for Ophthalmology and Visual Science
Daniel Ting, MBBS (Hons), M Med (Ophth), FAMS, PhD (UWA), Singapore National Eye Centre
Pei-Chang Wu, M.D., Ph.D., Chang Gung University
Andrew Bastawrous, OBE, London School of Hygiene & Tropical Medicine & Peek Vision
Priya Morjaria, Ph.D., International Center for Eye Health & Peek Vision

Myopia Screening Practices, Policies, and Programs
Megan Collins, M.D., M.P.H., Johns Hopkins Berman Institute of Bioethics
Donna Fishman, M.P.H., National Center for Children's Vision and Eye Health
Jessie Mandle. M.P.H., Healthy Schools Campaign

The workshop also included presentations by authors of the commissioned papers listed on the next slide.

Evidence Gathering: Five Commissioned Papers

- **Bullimore, M.** (2025). How Have Animal Models Increased our Understanding of Human Myopia? Invest Ophthalmol Vis Sci 66:2
- **Marcos, S.** (2025). Optical and visual diet in myopia. Invest Ophthalmol Vis Sci 66:3
- **Williams, K. & Hammond, C.** (2025). Perspectives on genetic and environmental factors in myopia, its prediction, and the future direction of research. Invest Ophthalmol Vis Sci 66:4
- **Harewood, J., Contreras, M., Huang, K., Johnson, S. & Wang, J.** (2025). Access to myopia care—A scoping review. Invest Ophthalmol Vis Sci 66:5
- **Khanal, S., Tomiyama, E. & Harrington, S.** (2025). Childhood Myopia Part I: Contemporary Treatment Options. Invest Ophthalmol Vis Sci 66:6
- **Khanal, S., Tomiyama, E. & Harrington, S.** (2025). Childhood Myopia Part II: Treatment Mechanisms, Emerging Options, and Considerations. Invest Ophthalmol Vis Sci 66:7

Top Takeaway Messages

- Myopia is a disease
- Exposure to outdoor settings reduces myopia onset
- Paucity of data on myopia prevalence in the US prevents adequate tracking and policy decisions
- Improved understanding of mechanisms involved in myopia onset and progression would aid development of better treatment.

Top Takeaway Messages, continued

Health impacts of this global myopia epidemic disproportionately affect the most vulnerable communities

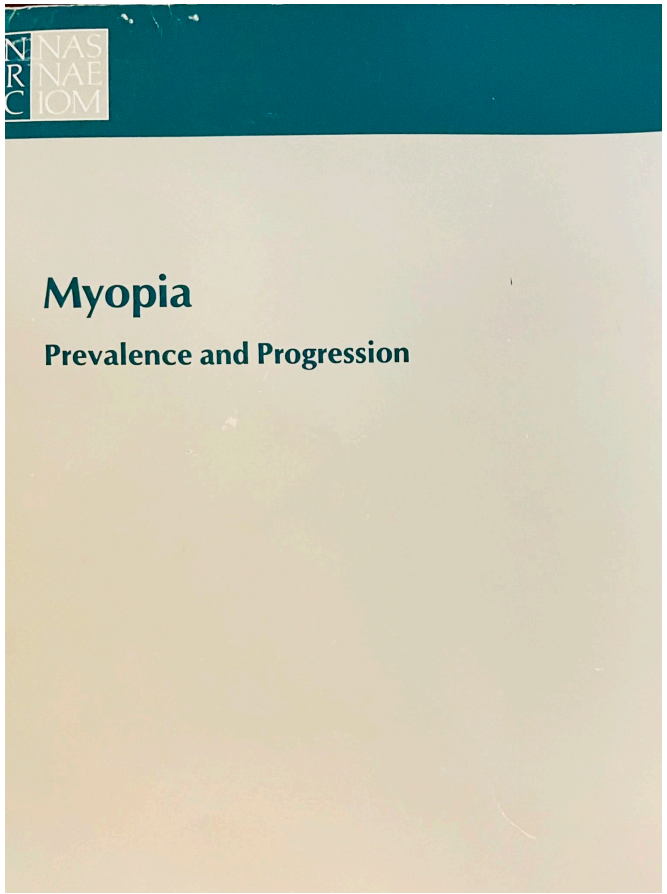
Safety is a fundamental component of effective treatment

Intentional intervention at a young age is ideal, as early-onset myopia has wide-reaching quality of life and economic implications

Understanding Myopia and Its Prevalence

03

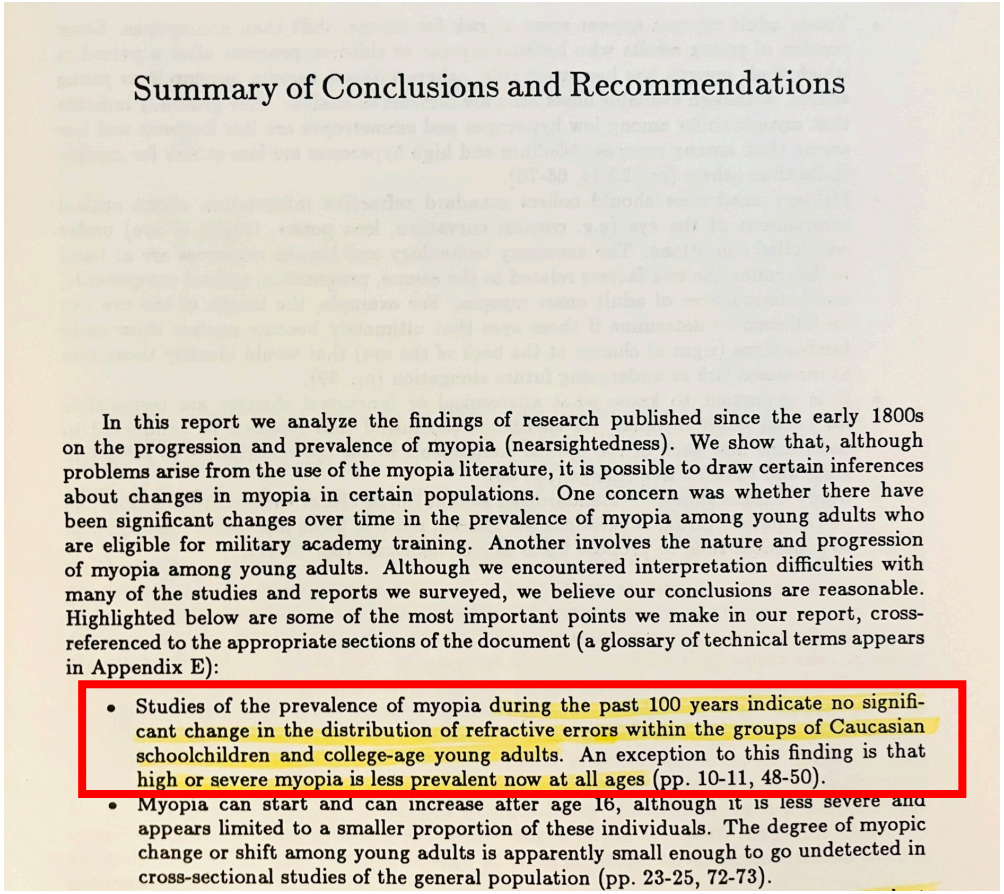
Myopia Prevalence and Progression: 1989



Anthony J. Adams
William R. Baldwin
Irving Biederman
Brian J. Curtin
Sheldon M. Ebenholtz
David A. Goss
George B. Hutchison
Johanna M. Seddon
Joshua Wallman

Myopia Prevalence and Progression: 1989

"Studies of the prevalence of myopia during the past 100 years indicate no significant change in the distribution of refractive errors within the groups of Caucasian schoolchildren and college-age young adults."



Summary of Conclusions and Recommendations

In this report we analyze the findings of research published since the early 1800s on the progression and prevalence of myopia (nearsightedness). We show that, although problems arise from the use of the myopia literature, it is possible to draw certain inferences about changes in myopia in certain populations. One concern was whether there have been significant changes over time in the prevalence of myopia among young adults who are eligible for military academy training. Another involves the nature and progression of myopia among young adults. Although we encountered interpretation difficulties with many of the studies and reports we surveyed, we believe our conclusions are reasonable. Highlighted below are some of the most important points we make in our report, cross-referenced to the appropriate sections of the document (a glossary of technical terms appears in Appendix E):

- Studies of the prevalence of myopia during the past 100 years indicate no significant change in the distribution of refractive errors within the groups of Caucasian schoolchildren and college-age young adults. An exception to this finding is that high or severe myopia is less prevalent now at all ages (pp. 10-11, 48-50).
- Myopia can start and can increase after age 16, although it is less severe and appears limited to a smaller proportion of these individuals. The degree of myopic change or shift among young adults is apparently small enough to go undetected in cross-sectional studies of the general population (pp. 23-25, 72-73).

Myopia Prevalence: 2024

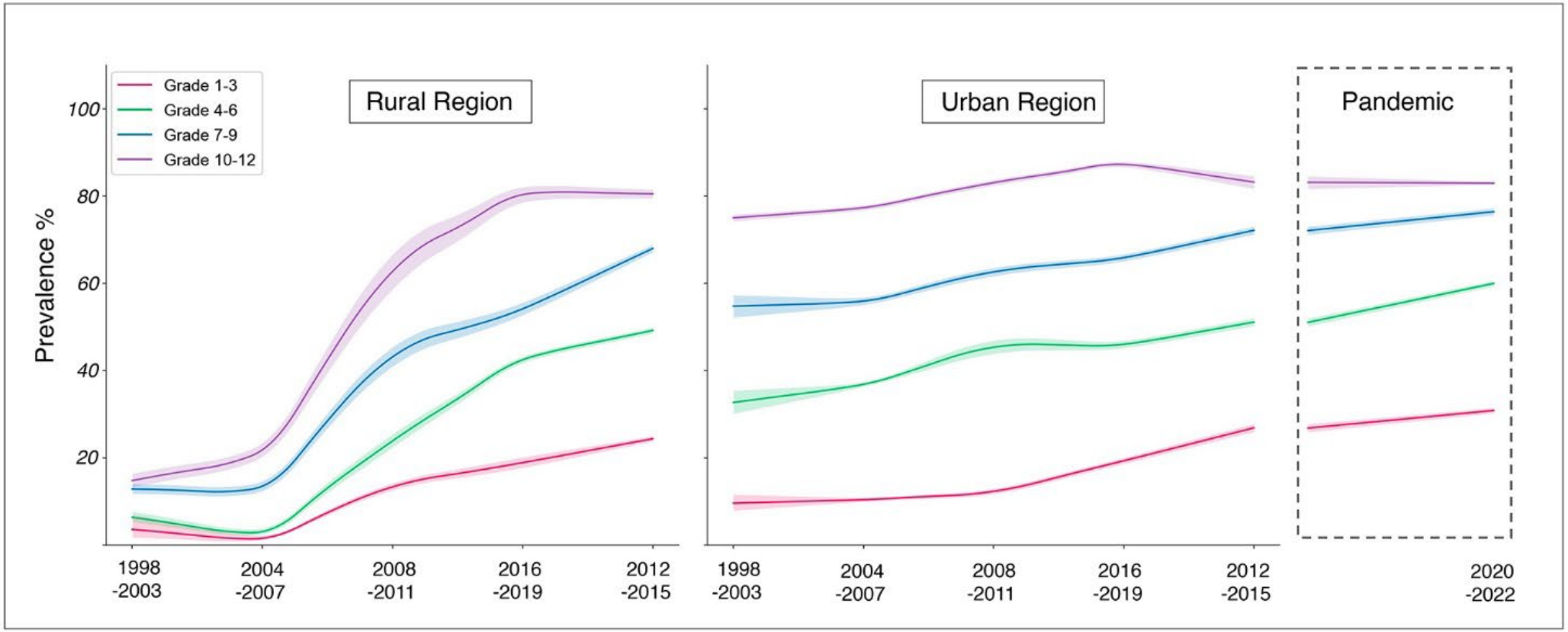


FIGURE 3-2 Prevalence of myopia in 7.5 million Chinese children in rural and urban regions by period of measurement.

Wang YX et al., ARVO 2023

Myopia Prevalence: 2024

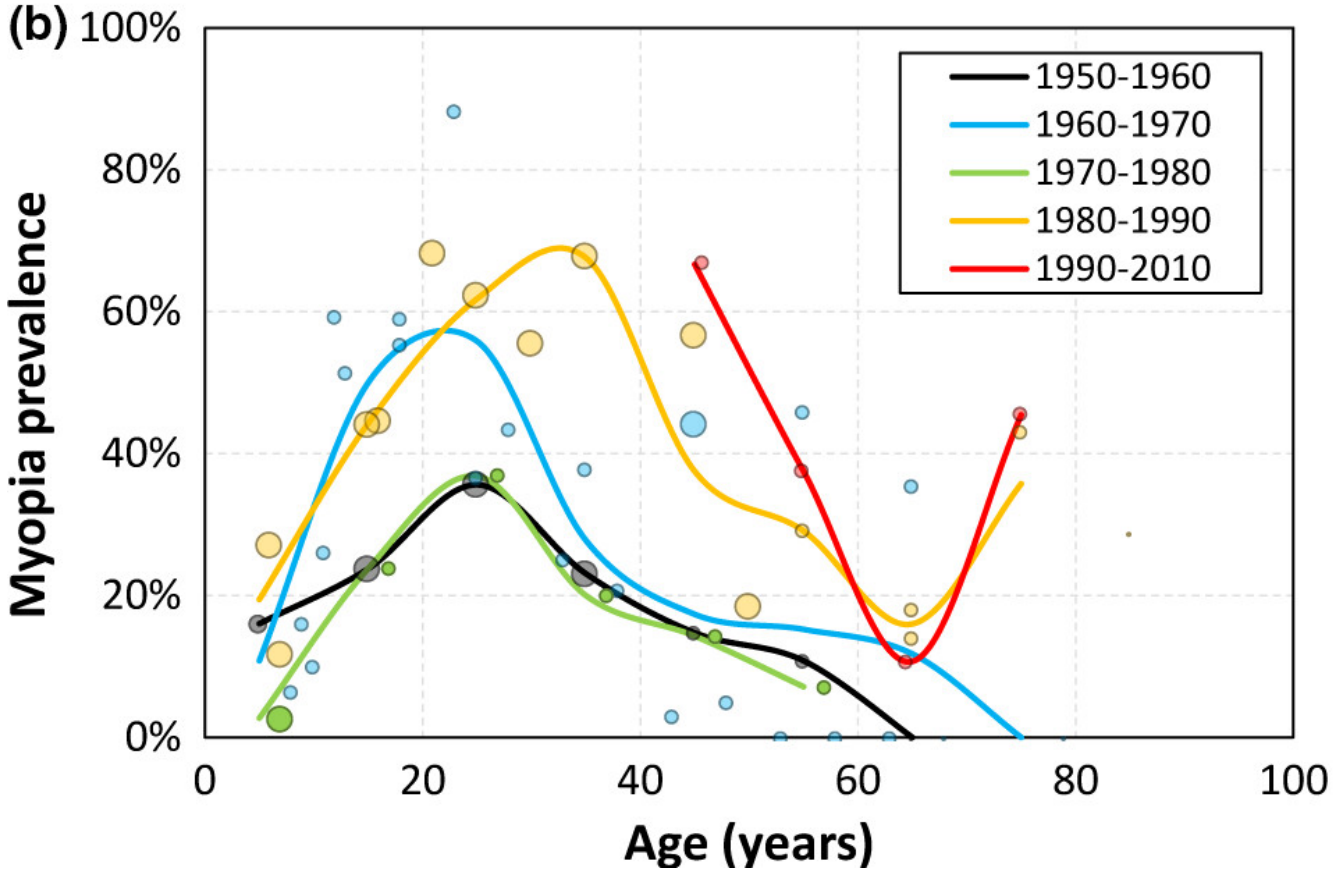


FIGURE 3-3 Myopia prevalence in northern native communities 1950-2010, by age.

Rozema JJ et al., *Ophthal Physiol Opt* 2021

Understanding Myopia and Its Prevalence

Understanding of myopia prevalence in the U.S. is hampered by data limitations (variable definitions, age of data)

Between ~1970s and early 2000s, U.S. prevalence for ages 12 to 54 increased from 25% to 41.6%.

Myopia is predicted to continue to increase in the United States and globally; in some parts of the world, myopia prevalence already exceeds 90%

Understanding Myopia and Its Prevalence

Recommendations and funding priorities

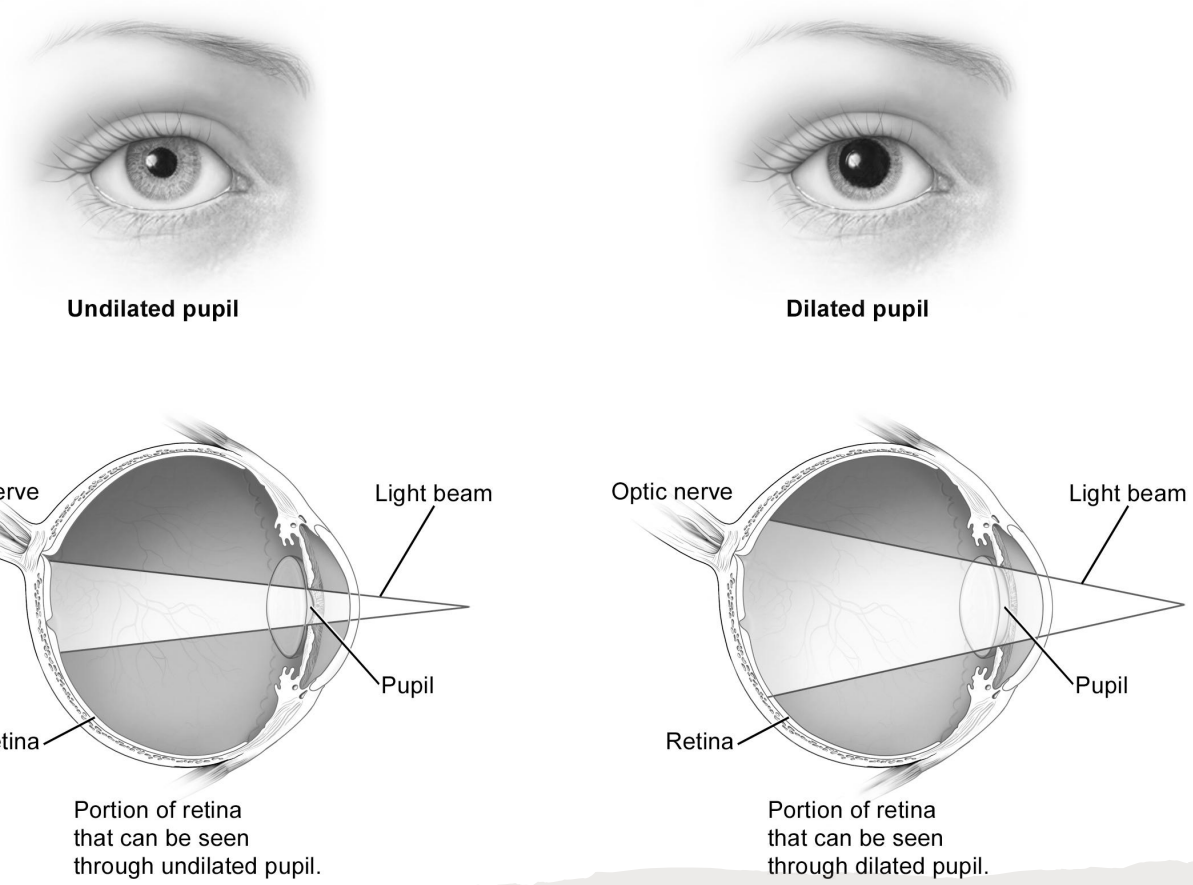
1. U.S.: collect consistent data nationwide for a central repository
2. International: develop consistent definitions and measurement methods

Assessment and Diagnostic Technologies

04

Assessment and Diagnostic Technologies

Cycloplegia is a critical component of an eye exam in children.



Source: NEI-medialibrary-3183745.jpg

BOX 8-3
10 Clinical Practices to Improve Vision Care Access, Adherence, and Continuity

1. Successful screening tools can be inexpensive and low-tech (visual acuity testing using optotypes) or more expensive and higher tech (instrument-based). Increasing access to care should be based on local resources available.
2. If a child fails an in-office screening, refer and follow up.
3. Both referral and follow up care should be case managed and confirmed.
4. If a child has had a previous vision screening and passed, repeat screening in office. If failed, refer and follow up. If a child has had a previous vision screening and failed, do not rescreen. If a child fails, believe it. Utilize time to encourage follow up care.
5. Avoid passing a previously failed screening. False negatives are the worst outcome.
6. If a child has an eye doctor or wears glasses or has a history of wearing glasses, do not rescreen. Utilize time to encourage follow up care with the same eye doctor. Underscore that the eye doctor should take care of the eyes and vision.
7. A physical exam of the eyes is likely not enough. Children who are myopic can often function quite well and may have no clinically observable signs of myopia.
8. Developmental delay constitutes a failed vision screening. Children with special needs fail by history alone. Conversely, high myopia discovered in a comprehensive eye exam may be a dysmorphic feature that contributes to conditions of broader developmental delay.
9. If glasses do not appear to help the child, encourage glasses wear and regular follow up with the eye doctor. Blur despite glasses indicates amblyopia. Children who not wear glasses at a young age and who have amblyogenic factors may never have clear vision.
10. If a child is seen by an eye doctor who doesn't dilate the child's eyes, choose another eye doctor.

Assessment and Diagnostic Technologies

- Axial length and other structural measurements of the eye should be obtained when resources allow.
- Design assessments and tests to better understand the myopic eye, its development, and its environment (the visual diet).
- Develop consensus standards for the assessments and diagnostics deemed most important for population-level studies.

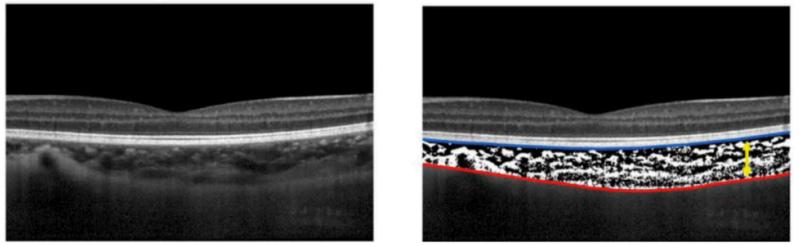


FIGURE 4-4 Optical coherence tomography (OCT) images of the choroid.
NOTE: The image on the left is an averaged B-scan, and the image on the right shows the anterior (blue) and posterior (red) boundaries labeled to then calculate a thickness value between the two boundaries.
SOURCE: Reprinted from Ostrin et al., 2023, under a Creative Commons Attribution-NonCommercial-No Derivatives 4.0 International License (https://creativecommons.org/licenses/by-nc-nd/4.0/).

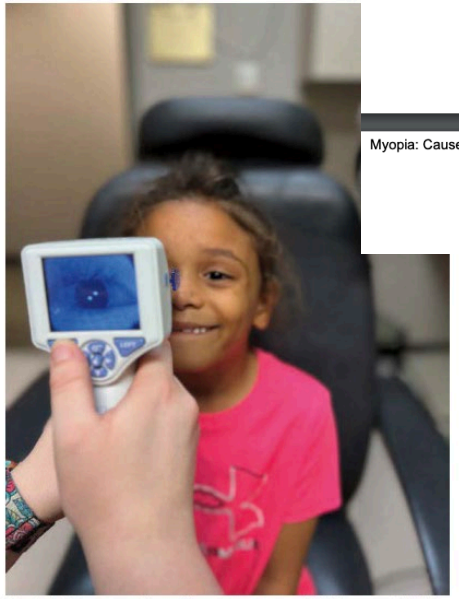
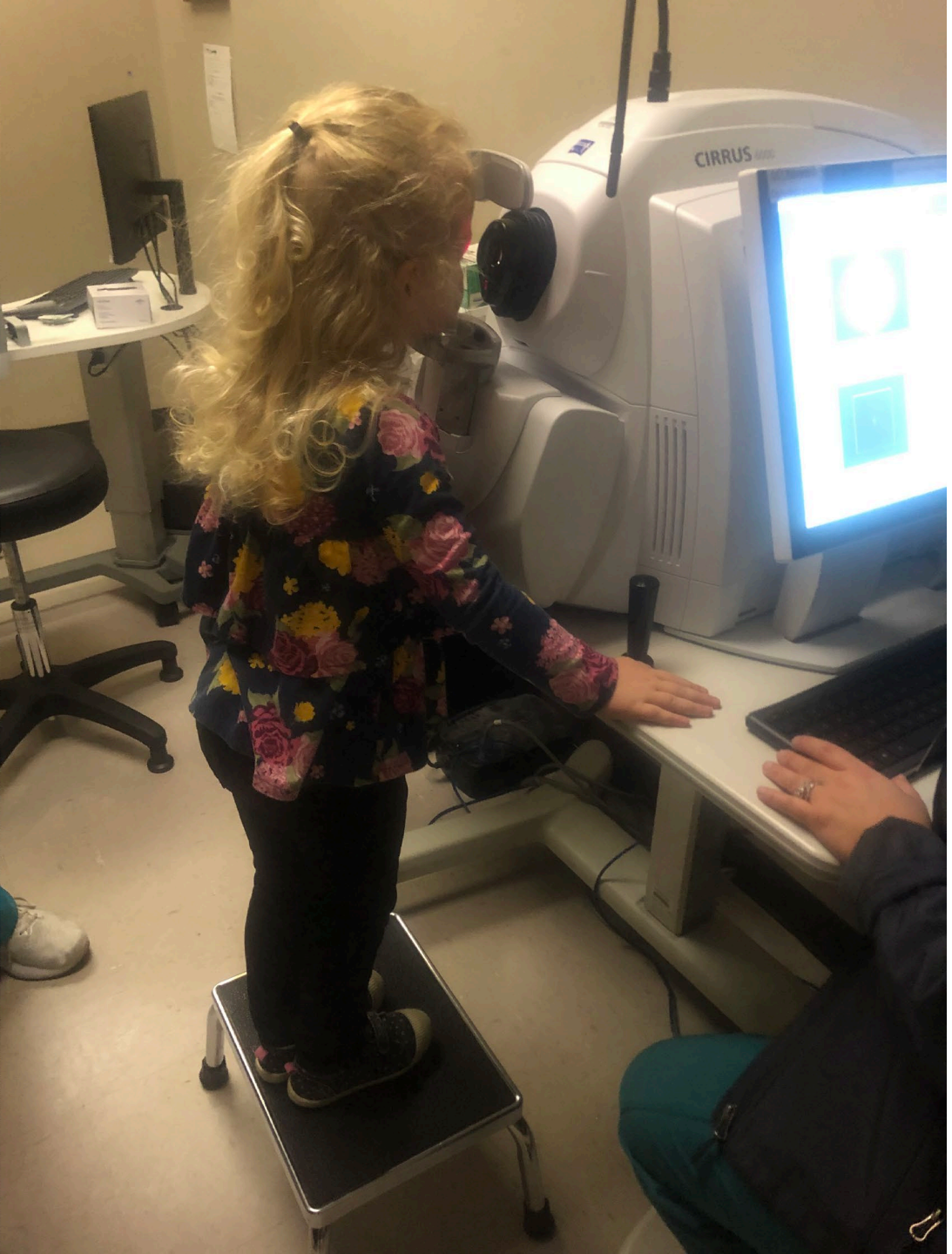


FIGURE 4-5 Example of a commercially available pupillometer being used clinically.
SOURCE: Courtesy of Katherine Weise, OD, University of Alabama at Birmingham.



Assessment and Diagnostic Technologies

Myopia onset usually occurs in childhood. Because of the importance of identifying myopia as early as possible, it is imperative that diagnostic technologies are child-friendly to the greatest possible extent.

Assessment and Diagnostic Technologies

Recommendations and funding priorities

1. Use cycloplegic drops for accurate assessment
2. Develop better diagnostic myopia technologies
3. Establish consensus on myopia treatment standards
4. Make technology adaptable, accessible, portable

Onset and Progression of Myopia

05

Onset and Progression of Myopia

- Over 400 genomic regions with refractive error-associated variants.
- Polygenic scores show 20% increase in refractive error variance explained over demographic factors alone.
- Question remains about the mechanism by which genes confer susceptibility to myopia.

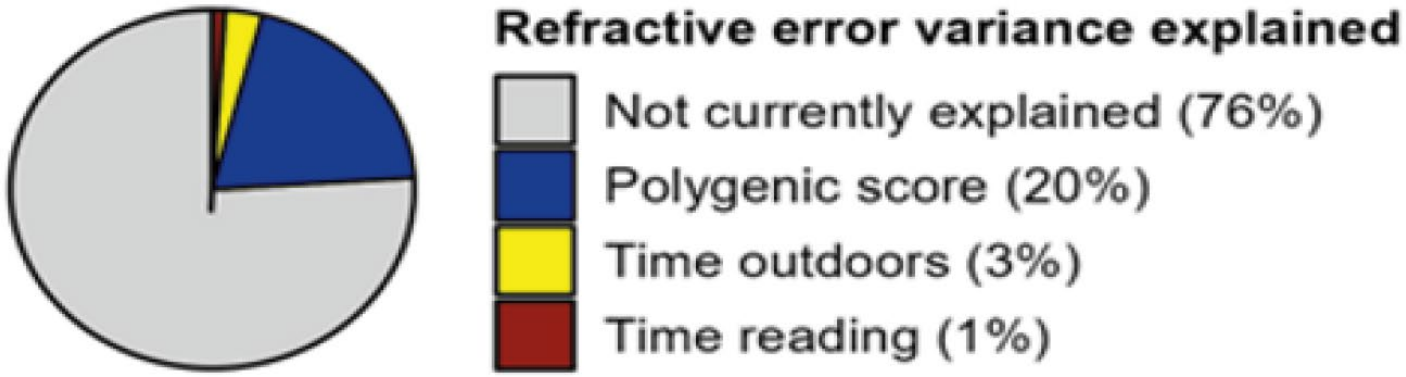


Figure 5-3 Predicting refractive error and high myopia

Onset and Progression of Myopia

While genetics plays a role in the onset and progression of myopia, much of genetic risk is modifiable by the environment.

Hypothesis: genetic factors determine susceptibility, environmental factors modulate risk.

Onset and Progression of Myopia

Time outdoors has protective effects on myopia onset

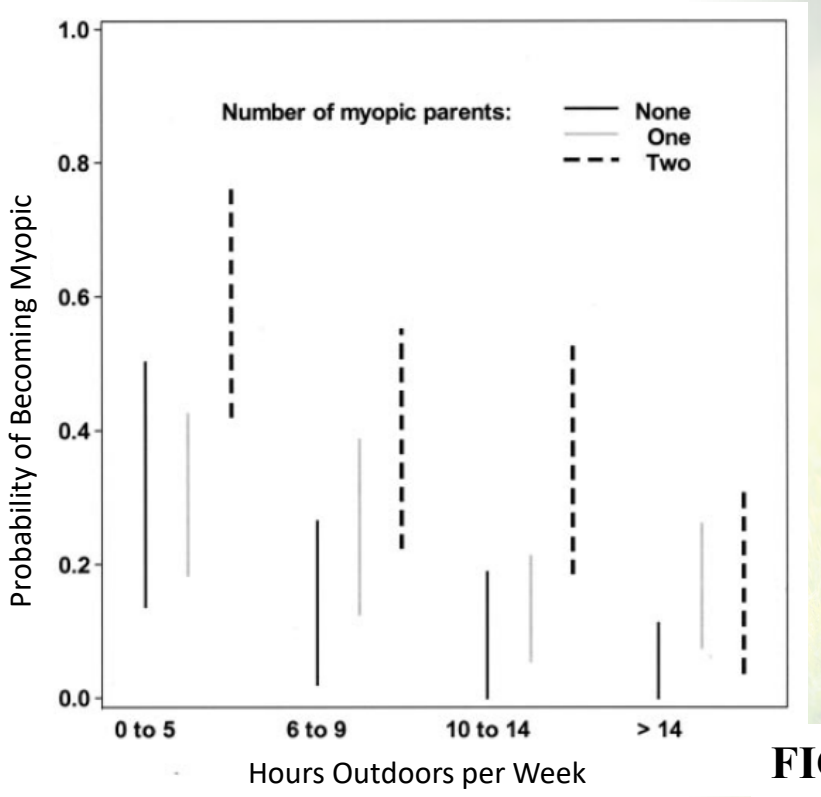
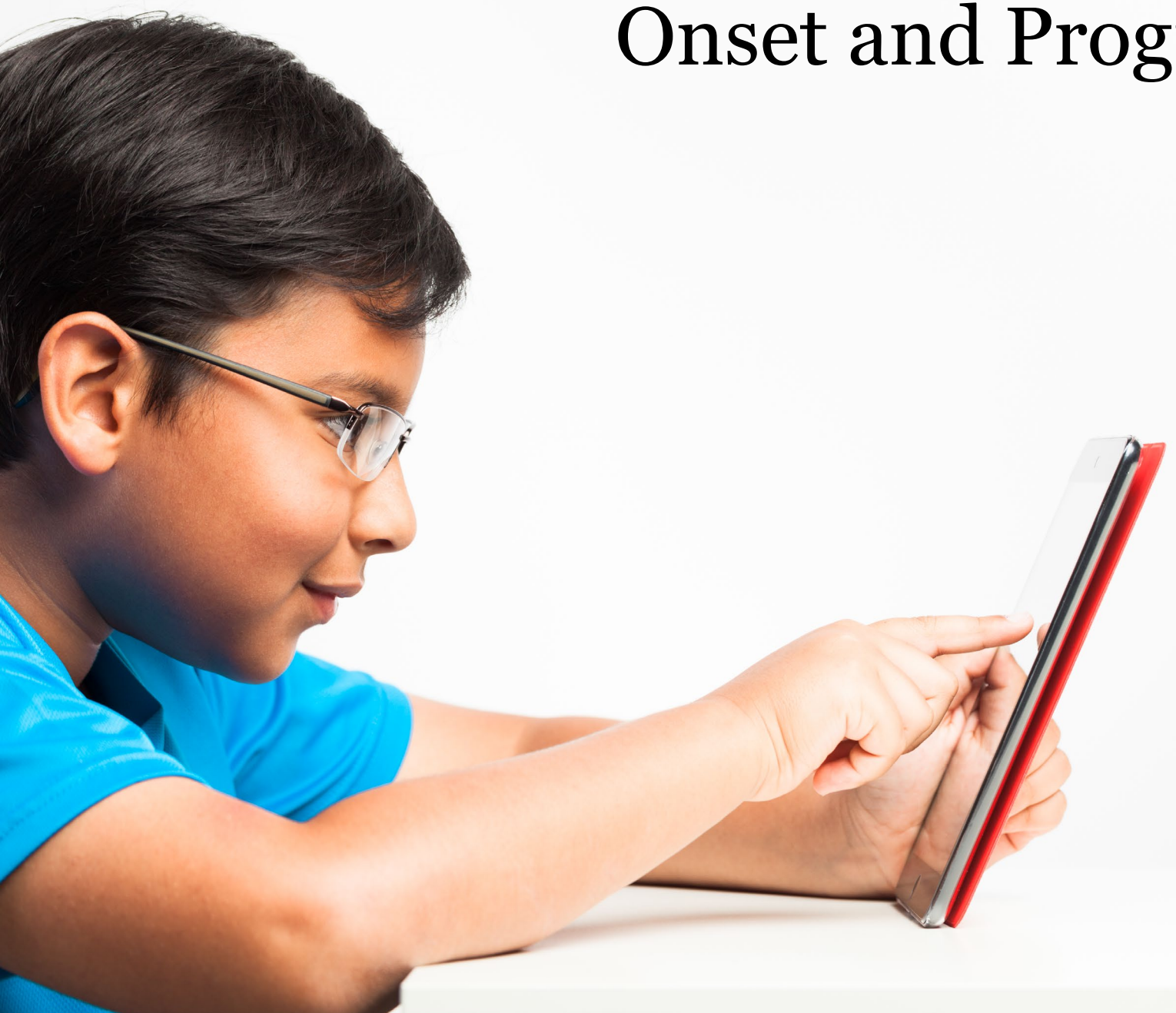


FIGURE 5-9 Adapted from Jones et al., *IOVS* 2007



Onset and Progression of Myopia

Data supporting roles for near work and electronic devices in myopia is limited or inconclusive

Additional research is needed to determine specific features of visual diet that cause or inhibit myopia

Onset and Progression of Myopia

Recommendations and funding priorities

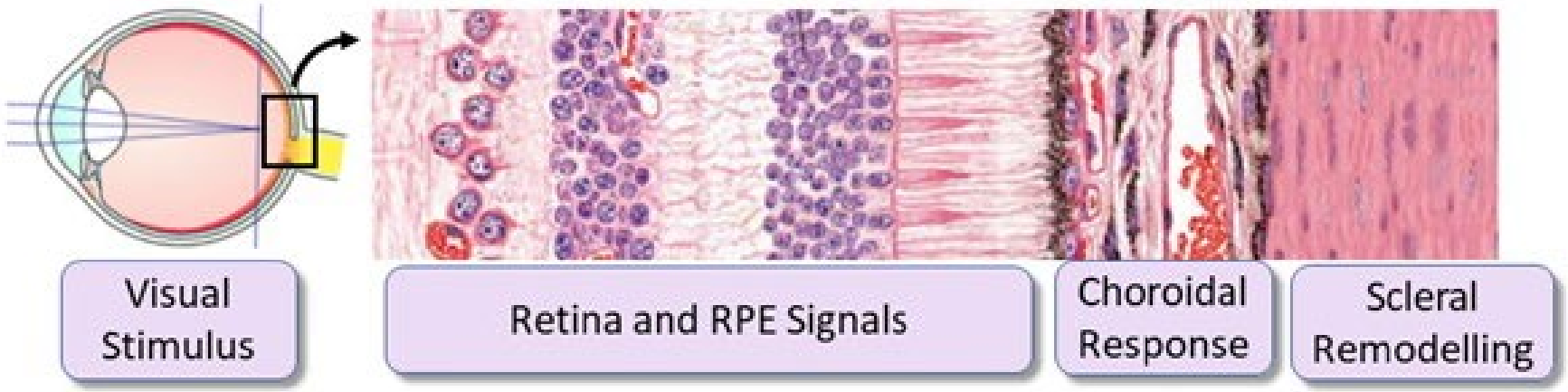
1. Promote outdoor time for children outdoors (at least one hour per day in school and up to 2 hours total)
2. Determine the relative importance of more near work versus less time outdoors, or other factors to better understand the link between education and myopia
3. Identify specific features of the indoor and outdoor visual diet that contribute to or inhibit myopia development
4. Study younger children
5. Encourage industry collaboration

Myopia Pathogenesis: From Retinal Image to Scleral Growth

06

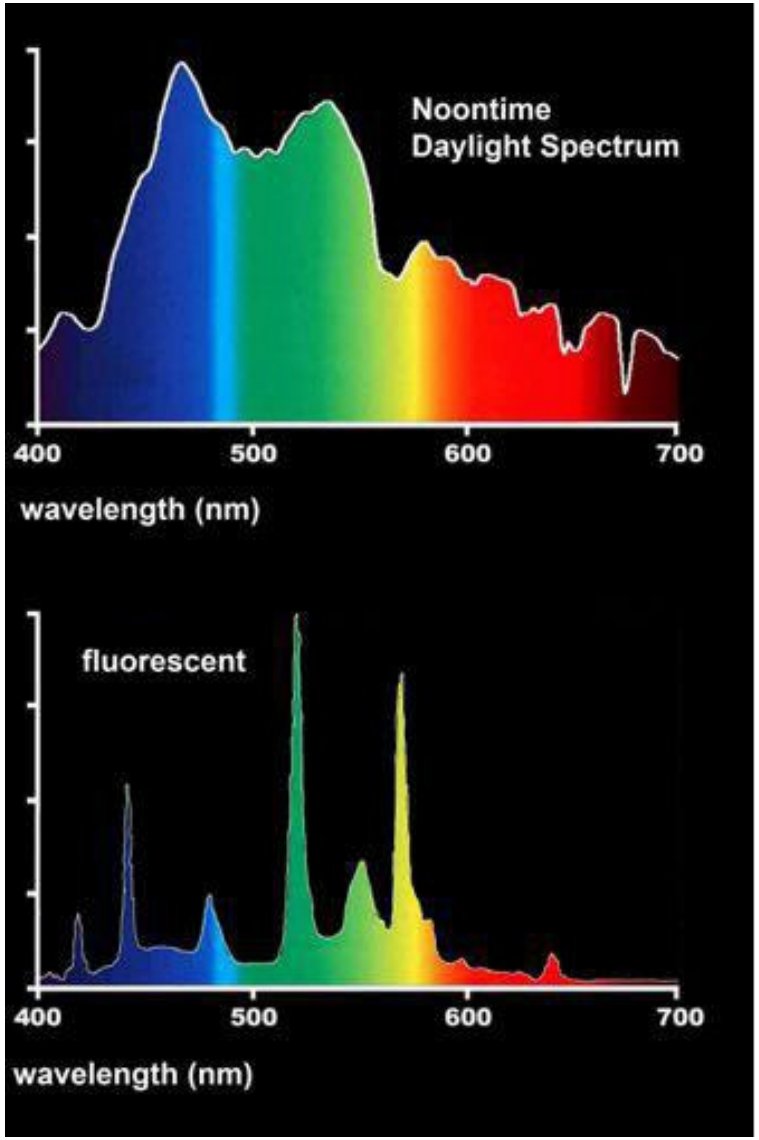
Myopia Pathogenesis: From Retinal Image to Scleral Growth

Animal models of myopia provide convincing evidence that ocular growth is regulated by a conserved process initiated by a visual stimulus on the retina, which is then relayed through the RPE and choroid, and ultimately acts on the sclera to effect changes in eye size and refraction.



Myopia Pathogenesis: From Retinal Image to Scleral Growth

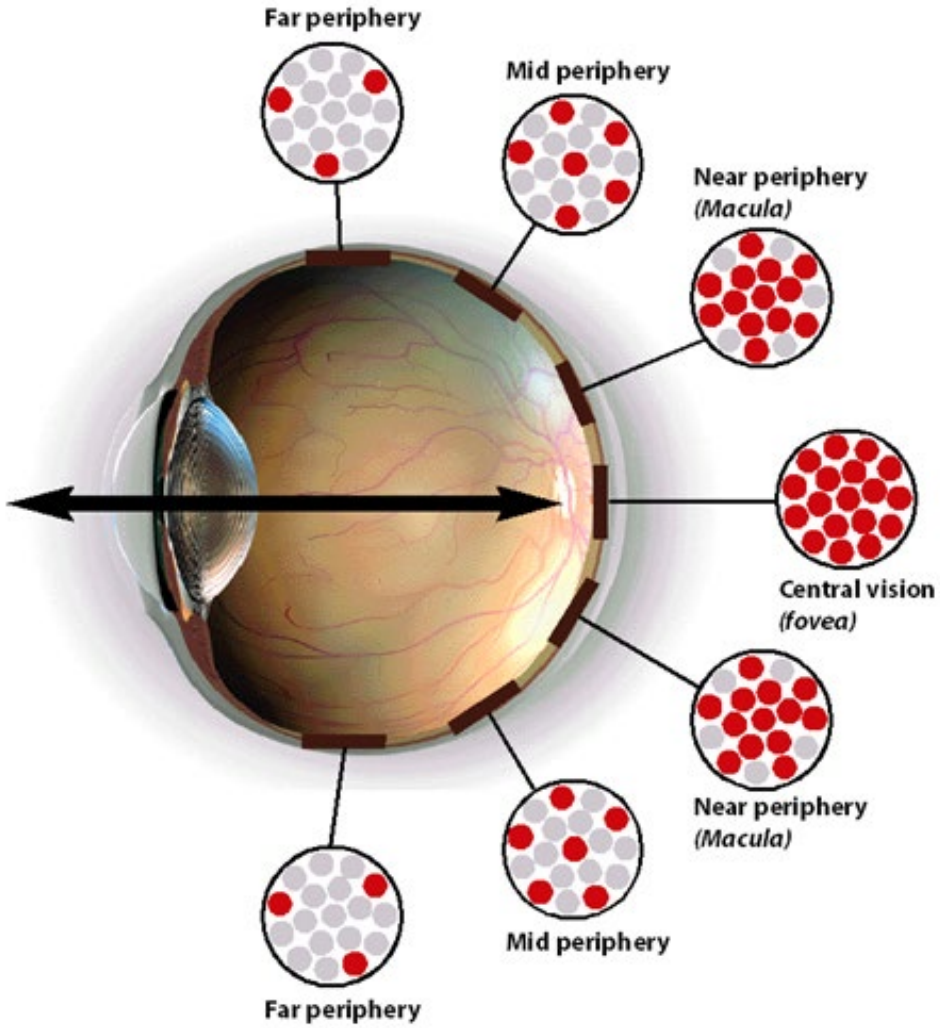
- Image properties necessary to maintain normal ocular growth, and those contributing to myopia development are currently unknown.
- Image properties, such as defocus, chromaticity, and luminance, are possible candidates responsible for fine tuning this process and may explain the apparent protective effect of outdoor activity on myopia development.



Source:
https://www.reddit.com/r/Biohackers/comments/15h58wu/are_there_any_lightbulbs_designed_to_mimick_the/

Myopia Pathogenesis: From Retinal Image to Scleral Growth

- Although the fovea centralis is the retinal area of sharpest vision, research indicates that the images on peripheral retina are also important for regulating eye growth. This finding has implications for optical correction of myopia.



Source: https://socratic.org/questions/why-don-t-we-get-color-or-detail-information-from-our-peripheral-vision

Myopia Pathogenesis: From Retinal Image to Scleral Growth

Recommendations and funding priorities

1. Fund interdisciplinary studies on myopia mechanisms
2. Support innovative multidisciplinary vision research
3. Support research examining key components in the retina to scleral chemical cascade

Current and Emerging Treatment Options for Myopia

07

Current and Emerging Treatment Options for Myopia

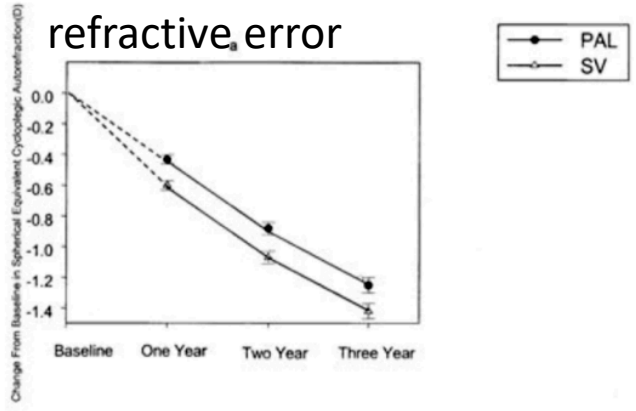
- Myopia treatment no longer refers to simply correcting blurry vision.
- Treatment options for myopia progression have increased over the last 20 years; however, they have limited effects and stop working after cessation.
- The preponderance of evidence suggests myopia progression should be treated when resources allow.

Myopia progression treatment: Early results

First Optical Intervention

- COMET (Gwiazda J, 2003)

Spherical equivalent refractive error



Axial length

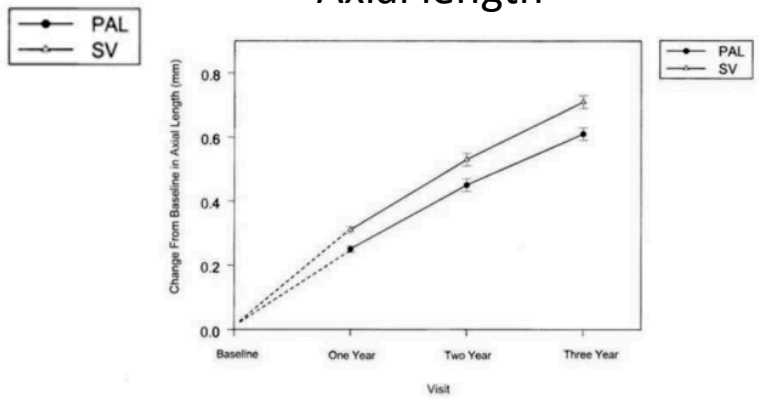


FIGURE 7-2 COMET study results.
NOTES: Progressive-Addition Lenses (PAL) had a treatment effect compared to single-vision lenses (SV). The treatment effect on both spherical equivalent refractive error and axial length was largely seen only in the first year of the study. Mean change in (A) spherical equivalent refractive error. (B) Mean increases in the axial length of eyes of children in the PAL and SVL groups at each annual visit. *Dashed lines* are included for illustrative purposes, to show the similarity of the two treatment groups at baseline. Error bars, SE.
SOURCE: Gwiazda et al., 2003.

1% Atropine Treatment

- ATOM (Chia A, 2016)

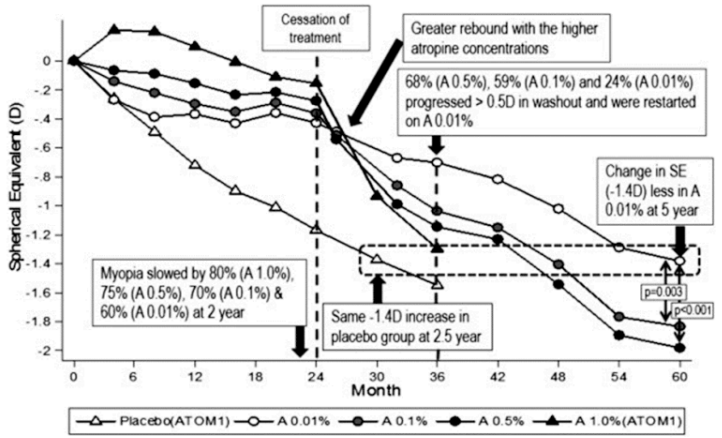
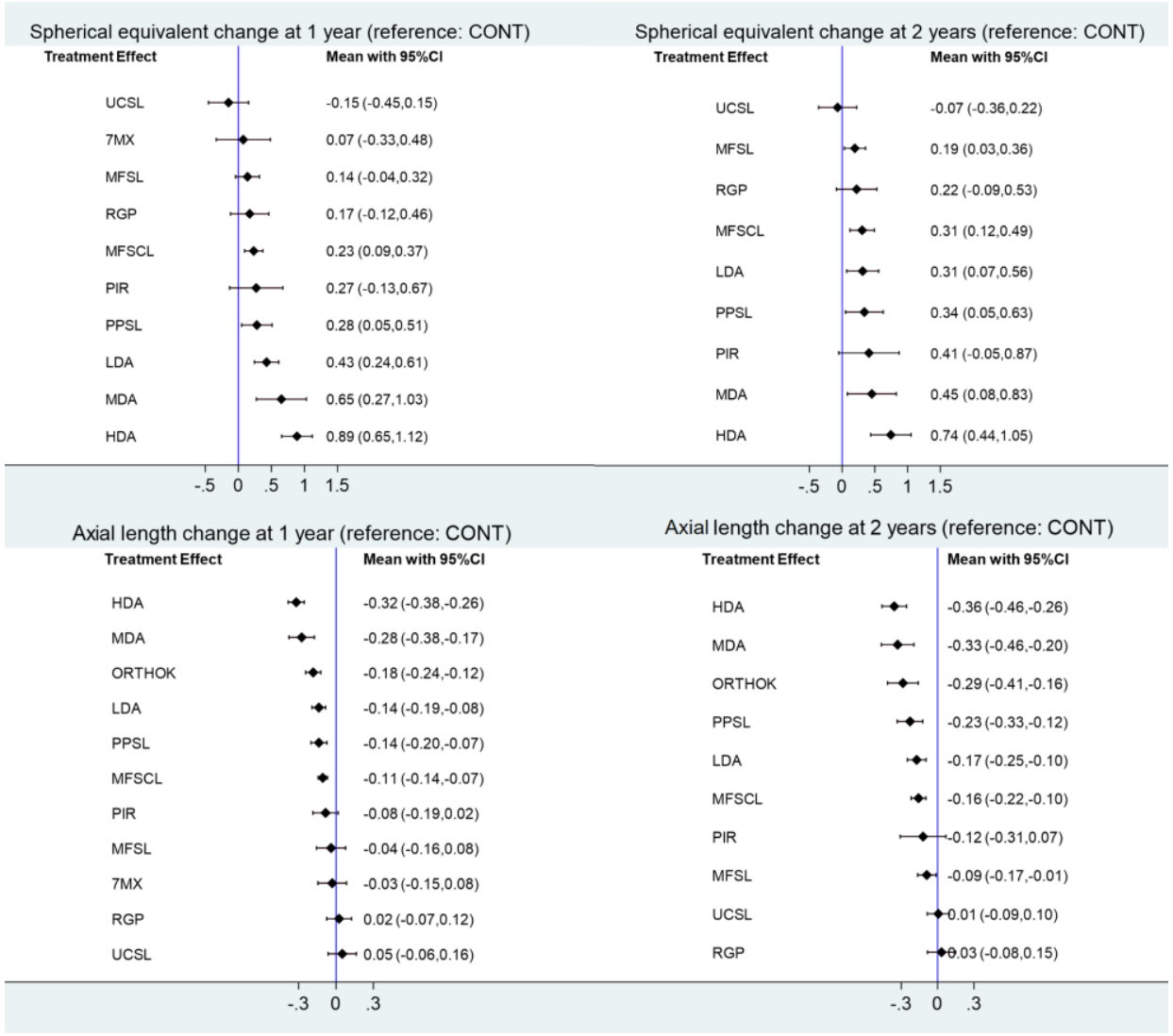


FIGURE 7-6 ATOM/ATOM 2 study results.
NOTE: The spherical equivalent refractive error plotted across time for the three atropine treatment groups (0.01%, 0.1%, and 0.5%) and placebo control.
SOURCE: Chia et al., 2016.

Myopia Cochrane Review: A Living Document



- **No treatment on average provides more than a 0.75 D treatment effect for spherical equivalent refractive error by year two**
- **No treatment on average provides more than a 0.37 mm treatment on axial elongation by year two**
- After pharmaceuticals, peripheral-plus spectacle lenses and orthokeratology contact lenses may be the most effective optical treatments.
- The treatment effect is not sustained in year 2 for the pharmaceuticals even while on treatment, suggesting that treatment effect is not as cumulative as would be ideal.
- Ortho-k has the biggest treatment effect in year two.
- Treatment effect for spherical equivalent refractive error and axial length are highly correlated.
- Under correction or no correction may promote axial elongation and myopia progression.

FIGURE 7-9 Lawrenson et al., 2023. Estimates of effect from network meta-analyses for all treatments versus control for progression of myopia. **7MX** : 7-methylxanthine; **HDA** : high-dose atropine; **LDA:** low-dose atropine; **MDA** : moderate-dose atropine; **MFSCL** : multifocal soft contact lenses; **MFSL** : multifocal spectacle lenses ; **ORTHOK** : orthokeratology; **PIR** : pirenzipine; **PPSL** : peripheral plus spectacle lenses; **RGP** : rigid gas-permeable contact lenses; **UCSVL**: undercorrected single vision spectacles

Current and Emerging Treatment Options for Myopia

- Improved understanding of mechanisms would aid in the development of better treatment options.
- Safety is a fundamental component of effective treatment as treatment will likely last through childhood.

Recommendations and funding priorities:
Supporting new treatment options

What we know:

- Predictors of myopia progression
  - Child's existing refractive error
    - +0.50 at age 5 or <1.00 D in 1st grade
  - Age
- Past myopia progression does not predict future progression.
- Myopia tends to progress faster when onset is at younger ages

What we don't know:

- Effect of treatment in preschool-aged children
- Effect of treatment in children with high myopia

Recommendations and funding priorities:
Supporting new treatment options

What we do know:

- The largest treatment effect of any published treatment option remains under *0.75 diopters over 2 years*.
- Some treatment options are effective in the first year and less effective in subsequent years.

What we don't know:

- How and when treatment should be stopped?
- Is rapid eye growth during rebound more detrimental than slow and steady growth?

Treatment Options: Priorities for Future – **Clinical/Translational**

- Optical
  - Develop optical corrections for best visual performance including:
    - Spectral composition of light
    - Peripheral refractive characterization
    - Contrast

Myopia: Causes, Prevention, and Treatment of an Increasingly Common Disease

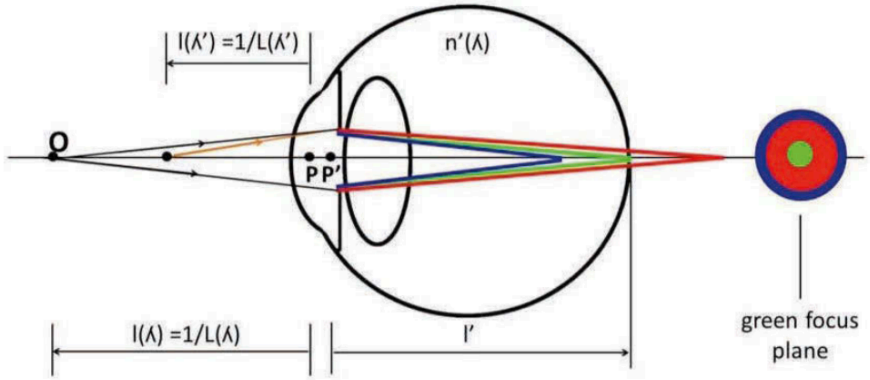


FIGURE 7-11 Illustration of longitudinal chromatic aberration in the eye.
NOTE: Rays of longer wavelength (red) are focused behind the retina and shorter wavelength rays (blue) are focused in front of the retina. As a consequence, the image of a point in the green focus plane is a focused on green, with halos in red and blue.
SOURCE: Vinas-Pena (2015). Reprinted with permission from the author.

Treatment Options: Priorities for Future – **Clinical/Translational**

- Pharmaceutical
  - Identify dosing characteristics including concentration and cadence to slow eye growth
- Combination Therapy
  - Monotherapies must show effectivity first
- Time outdoors
  - Determine optimal parameters for time outdoors including:
    - Duration per day
    - Spectral distribution
    - Time of day
    - Needed safety measures to prevent or delay myopia onset.

Ideal characteristics of Myopia Control Therapies

- Preventative
- Feasible for a child
- Meaningful treatment effects (similar or accruing) with each year of use, without rebound effects
- Effective in a diverse populations
- Based on robust mechanism and translational research
- FDA-approved
- Safe
- Beneficial for long-term ocular health
- Cost effective

Current and Emerging Treatment Options for Myopia

Recommendations and funding priorities

1. Support new myopia treatment strategies
2. Ensure treatment safety for children
3. Fund long-term clinical trials at earlier ages

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

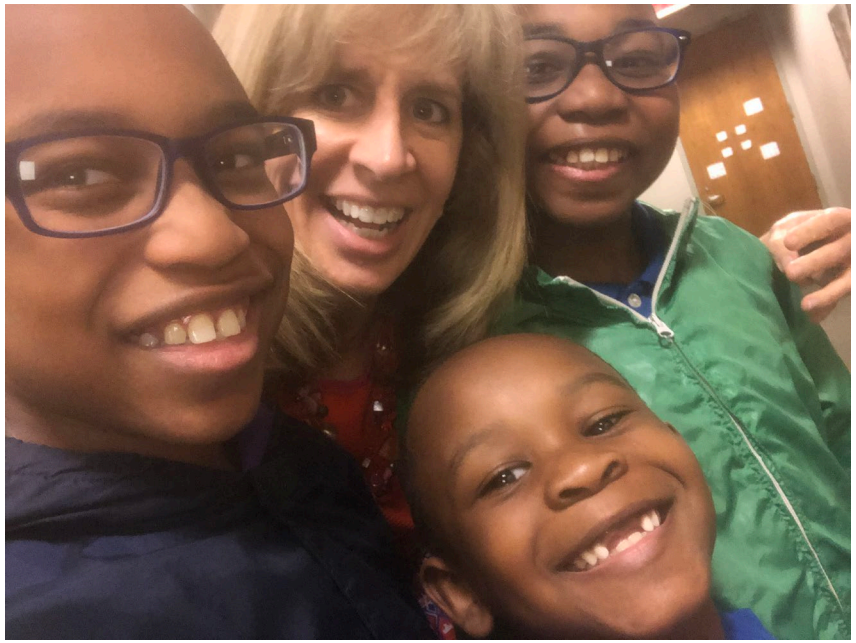
08

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

1. Lack of awareness about visual health
2. Shortage of eye care professionals
3. Lack of national consensus and surveillance
4. Funding shortfalls to support vision health programs

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

- **Access to eye care professionals** is limited by low availability, **especially in rural and low-income communities**, despite an increasing demand for eye care providers (optometrists and ophthalmologists) in the United States
  - Berkowitz et al., 2024;
  - Feng et al., 2020;
  - Kodjebacheva et al., 2015;
  - Lee et al., 2007, 2023;
  - Siegler et al., 2024



Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

96.4% of U.S. counties
had neither a
pediatric optometrist
nor a pediatric ophthalmologist

- Identified nearly 600 pediatric optometrists
- Just over 1,000 pediatric ophthalmologists in the United States
  - Siegler et al., 2024

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

- National Center for Health Workforce Analysis (NCHWA):
  - Across 38 medical and surgical specialties, **ophthalmology is projected to have the second worst rate of workforce adequacy** (projected supply over projected demand)
    - Berkowitz et al. 2024

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

- Ophthalmology:
  - 2020 to 2035
    - **12% decline in supply** of ophthalmologists
    - **24% increase in demand**
      - → **workforce adequacy of just 30%**
        - 77% workforce adequacy in metro vs.
        - **29% nonmetro geographies**
          - Berkowitz et al. 2024

Optometry:

- 1990 to 2017
  - 100% adequacy following increases in the density of optometrists
- 2035
  - **89% workforce *inadequacy*** is expected under the reduced barriers demand scenario
    - Berkowitz et al., 2024
    - Feng et al., 2020

Identifying Children with Myopia and the Links to Treatment: Methods and Barriers

Recommendations and funding priorities

1. National consensus and data surveillance system
2. Vision screening before first grade, eye exam when needed
    - research on evidence-based approaches
    - funding for community-based programs
3. Myopia should be classified as a disease and a diagnosis

Thank you!

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For more information and to access the full report after public release, visit the study website: https://www.nationalacademies.org/our-work/focus-on-myopia-pathogenesis-and-rising-incidence

Or email:
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Check out other studies under way at the Board on Behavioral, Cognitive, and Sensory Sciences: https://www.nationalacademies.org/bbcss/board-on-behavioral-cognitive-and-sensory-sciences