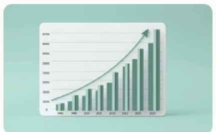
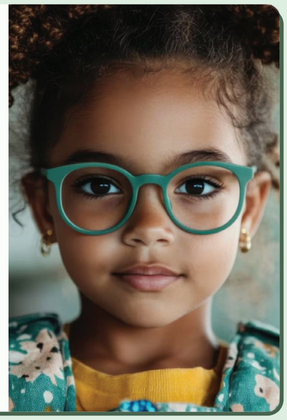
Myopia Epidemic

Nearsightedness: Rising Prevalence, Serious Public Health Concern

Myopia, or nearsightedness, is a common vision condition in which you can see objects up close but not far away. It has become increasingly common common around the world, particularly among children and adolescents. This rise This rise in myopia is a serious public health concern, with potentially lasting effects lasting effects on vision and ocular health.





Case Study: 8-year-old male

Case:

- 8 year old male
- VA with habitual Rx 20/40 OD, OS, OU -3.00 and -3.50, 6 months months ago he was seen and Rx had changed from -1.50 to this. 1.50 to this.
- MRx -4.00 and -4.50
- Ocular health unremarkable
- What should we do?

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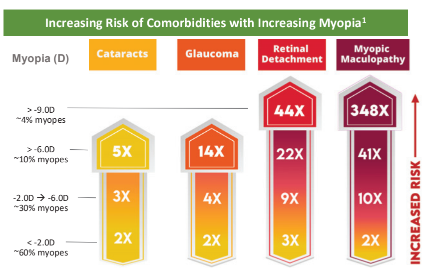
Recent Epidemiology Studies Have Changed How We Look at Myopia



It is predicted by the WHO report on **Myopia to be the #1 cause of blindness worldwide** in the future (Cataract is presently)
(WHO report breakdown is in the Appendix section)

Data derived from
- Blue Mountains Eye Study, 2002 (>3500 patients)
- Beaver Dam Eye Study, 2001 (>5900 patients)
- Rotterdam Eye Study, 2011 (>3900 patients)
- Summarized in [1]Flitcroft et al., 2012

Myopia and Presbyopia are Vastly Different

Of ALL refractive errors, Myopia has the most severe visual consequences

Excessive axial elongation of the eye, caused from myopia progression, can cause mechanical stretching of the outer coats of the eyeball and retina, resulting in various pathologic changes such as staphyloma, chorio-retinal atrophic lesions, lacquer cracks, choroidal neovascularization, retinal detachment, glaucoma, etc.

- Presbyopia does not cause co-morbidities to the degree that myopia does, because there is no abnormal mechanical stretching of the eye with presbyopia.
- Presbyopia is a condition that develops with aging and results in insufficient accommodation for near work in a patient whose distance refractive error is fully corrected. Although not truly a refractive error, presbyopia is considered in the AAO Refractive considered in the AAO Refractive Preferred Practice Pattern document, because its correction has similarities to the correction of refractive errors.
- Pathologic myopia affects eyes bilaterally and has the potential to cause blindness for which there exists no effective restorative treatment.
- An increased risk of glaucoma and visual field defects with myopia has been found.
- Individuals with higher levels of myopia are more likely to have decreased foveal function as assessed by multifocal full-field electroretinogram.
- Myopia not only affects an individual in visual related tasks but also with mobility, activities of daily living and quality of life.

Blindness or low vision can occur in one-third of high myopes, mainly caused by myopic macular degeneration. This large health risk requires public awareness and a focus to initiate strategies to reduce this burden.

1: http://dx.doi.org/10.1016/j.ophtha.2017.10.003. AAO Refractive Preferred Practice Pattern

2: Ophthalmic and Physiological Optics, The Journal of the College of Optometrists; 35 (2015) 465-475

3: Ophthalmology; Vol. 122, Number 1, January 2015

Myopia Control: Why Each Diopter Matters

No level of myopia is truly safe from myopic maculopathy

Published: Optometry and Vision Science: Official Publication of the American Academy of Optometry; 2019 Jun;96(6):463-465.

Authors: Mark Bullimore MCOptom, PhD, FAAO and Noel Brennan MScOptom, PhD, FAAO

Review: Applied data from five large population-based studies of the prevalence of myopic maculopathy on 21,000 patients.

Key Take Aways:

"1 diopter increase in myopia is associated with a 67% increase in prevalence of myopic maculopathy. Slowing myopia by 1 diopter should reduce the likelihood of a patient developing myopic maculopathy by 40%."

"Some may say so what? We would like to provide evidenced-based answers to this question..."

- "Less myopia = less visual disability when uncorrected"
- Corrected or not, greater refractive error produces greater disability and dependence on correction mode correction mode needed.
- "Lower levels of myopia are associated with better postoperative uncorrected visual acuity and fewer secondary surgical enhancements."
- "10 million people had visual impairment from myopic maculopathy in 2015, of whom 3.3 million were blind. By 2050, visual impairment will grow to 55.7 million (1 in 175), 18.5 million of whom will be blind. The risk of myopic maculopathy and its impact on public health are not limited to high myopes."
- "In fact, myopes of less than 5 diopters contributed 43% of the cases of myopic maculopathy in the Australian Blue Mountains Eye Study."

Lifetime Myopia Progression in High Myopia Patients

AL continued to progress, even in older patients; Myopic maculopathy was nearly 7X higher risk higher risk

Published: JAMA Ophthalmol. 2024;142(2):87-94.

Authors: Shiran Zhang, MD and colleagues

Conclusion: At 8 years of follow-up, the rapid progression trajectory was associated with a higher risk of developing pathological myopic macular degeneration and poorer best-corrected visual acuity compared with the stable progression trajectory

Key Take Aways:

"It is projected that by 2050, 1 in 10 people globally will have high myopia, and up to 18.5 million people will be blind due to myopic maculopathy."

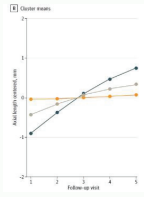
"Patients with high myopia with an axial length (AL) of 30 mm or greater have a **25 to 94 times higher risk** of vision impairment compared with patients with AL less than 24 mm.6 Furthermore, unlike mild or moderate myopia, high myopia tends to progress into adulthood."

"A total of 793 participants (median [range] age, 17.8 [6.8-69.7] years; 418 females [52.7%] and 375 and 375 males [47.3%]) and 1586 eyes with available AL measurements at both baseline and at least 1 and at least 1 visit during 8 years of follow-up were included."

"3 trajectories of axial elongation progression were identified: stable (0.02 mm/y), moderate (0.12 moderate (0.12 mm/y), and rapid (0.38 mm/y) progression."

Lifetime Myopia Progression in High Myopia Patients

AL continued to progress, even in older patients; Myopic maculopathy was nearly 7X nearly 7X higher risk



Cluster (progression trajectory)	Pathological MMD* OR (95% CI)
1 (Stable progression)	1 [Reference]
2 (Moderate progression)	5.33 (0.96 to 29.50)
3 (Rapid progression)	6.92 (1.07 to 44.60)

Key Take Aways Continued:

Proposed Congressional Legislation, May 2024

https://eyewire.news/news/proposed-bipartisan-legislation-would-create-first-federally-funded-program-to-address-childrens-vision-and-eye-health?c4src=article:infinite-scroll

05.15.2024

Proposed Legislation Would Create First Federally Funded Program to Address Children's Vision and Eye Health

New legislation, called the "Early Detection of Vision Impairments in Children (EDVI) Act," in the US House of Representatives seeks to establish grants for states and communities to improve children's vision and eye health through coordinated systems of care. The EDVI Act is a bipartisan proposal, co-sponsored by Congressional Vision Caucus (CVC) co-chairs, US Representative Gus Bilirakis (FL-12), and US Representative Marc Veasey (TX-33). Companion legislation is expected to be introduced in the US Senate.

Under the EDVI Act, the Health Resources and Services Administration (HRSA) at the US Department of Health and Human Services, will award grants and cooperative agreements for states, communities, and tribes to:

- Implement approaches (such as vision screenings) for the early detection of vision concerns in children, referrals for eye exams, and follow-up mechanisms;
- identify barriers in access to eye care;
- reduce disparities in eye health; and/or
- develop state-based data collection, surveillance, and performance improvement systems.

Proposed Congressional Legislation, May 2024, is Backed by All Major All Major Associated Medical Academies/Associations (OD/MD) (OD/MD)

A broad spectrum of public health organizations support the legislation, including American Academy of Ophthalmology, American Academy of Optometry, American Association for Pediatric Ophthalmology and Strabismus, American Optometric Association, American Society of Ophthalmic Registered Nurses, Association of Clinicians for the Underserved, Association of Maternal and Child Health Programs, Children's Vision Equity Alliance, Family Voices, Healthy Schools Campaign, National Alliance for Eye and Vision Research, National Association of School Nurses, and the School-Based Health Alliance, among others.

Congressional Support

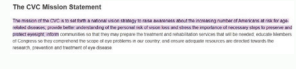
The proposed legislation in May 2024 has garnered significant backing from all major medical academies and associations in both optometry (OD) and ophthalmology (MD) fields.

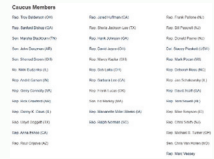
United Medical Community

This unprecedented support from the medical community underscores the importance importance and urgency of addressing the myopia epidemic through legislative action. legislative action.

The Congressional Vision Caucus (CVC)

Bi-Partisan coalition of Congressional members; Prevent Blindness was instrumental in their development and they continue to work closely together





Screening and Clinical Services Have Impact

Patient screening and timely action leads to improved outcomes

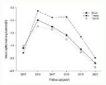
Published: BMC Ophthalmology; 2024; 24:221

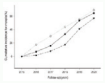
Authors: Pingping Lyu and colleagues

Key Take Aways:

"Initially, in 2015, the study encompassed 14,572 children aged 4–6 years, of whom 5,917 needed a referral. Our cohort consisted of 5,511 children who had two or more vision screenings and complete personal information over the follow-up period from January 2015 to December 2020."

Patients who received timely clinical services, after screening, had less myopia and had less change in SE, compared to compared to patients who were tardy receiving or never received clinical services.





The Myopia Health Threat Is Substantial

Myopia leads to Retinal Detachment and Myopic Maculopathy

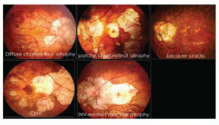
Published: WHO Press; World Health Organization (WHO) 2015

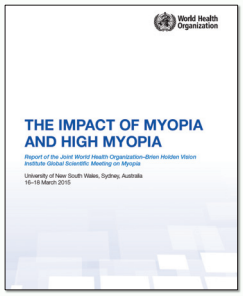
Authors: Brien Holden PhD, DSc and colleagues

Myopic macular degeneration

MMD is a major cause of vision impairment in high myopia. A number of terms are used, including MMD, myopic maculopathy, myopic retinopathy and myopic choroidal neovascularization.

Fig. 3. Myopic macular degeneration





COVID-19's Impact on Myopia Prevalence and Progression

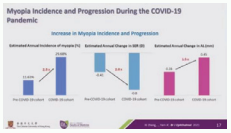
There has been a dramatic break from long-time historical trends

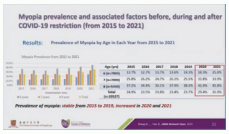
Presented: American Academy of Ophthalmology Meeting, 2023 by XJ Zhang, The Chinese University of Hong Kong

Key Take Aways:

Estimated Annual Incidence of Myopia, Estimated Annual Change in SER (D) and Estimated Annual Change in AL (mm) all significantly increased during COVID-19 to unprecedented COVID-19 to unprecedented levels.

Prevalence of myopia jumped in 2020 and 2021 in each age group (6, 7 and 8 years old); 20,527 total subjects





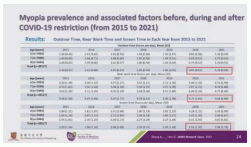
Myopia Prevalence and Progression During COVID-19 (Continued)

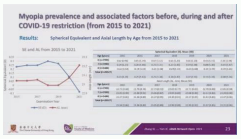
Lives and Lifestyles have changed since COVID-19

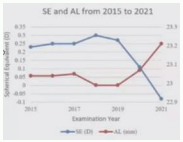
Key Take Aways Continued:

During COVID-19, outdoor time decreased approximately ~50%, and both near work and screen time increase approximately ~50% across age groups.

SE and AL change broke with historic trends during COVID-19, dramatically accelerating







Myopia is Booming and Historic Predictions Seem Modest

The COVID-19 pandemic didn't just reshape how children learn, it reshaped their eyeballs

"The COVID-19 pandemic didn't just reshape how children learn and see the world. It transformed the shape of their eyeballs."

Reported a near doubling in the incidence of pathologically stretched eyeballs among six-year-olds compared with pre-pandemic levels.

"Widely cited projections in the mid-2010s *(WHO 2016, for example)* suggested that myopia would affect half of the world's population by mid-century, mid-century, which would effectively double the incidence rate in less than four than four decades...

Now, those alarming predictions seem much too modest, says Neelam Pawar, a pediatric ophthalmologist at the Aravind Eye Hospital in Tirunelveli, India. **"I don't think it will double," she says. " It will triple ."**

There is one other preventive measure gaining momentum: a drug called atropine.

AAO Reports: COVID-19 Quarantine Reveals that Behavior Changes Have an Effect Have an Effect on Myopia Progression

Published: Ophthalmology, Volume 128 Issue 11 p1493-1660, e1-e236

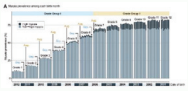
Author: Liangde Xu, PhD and colleagues

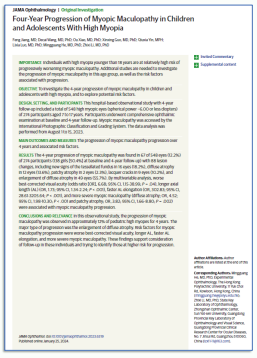
Key Take Aways:

This was a large-scale intervention study of myopia development with 12-month follow-up among school children in 1,305 elementary and high schools in 11 districts of Wenzhou City, Zhejiang Province, China. A total of **1,001,749 students 7 to 18 years of age** were included.

6-month myopia progression among all school children **increased by approximate 1.5 times** before the COVID-19 quarantine to after the COVID-19 quarantine (P < 0.001).

Also, age and time starting school looks to have a direct effect on myopia onset, and as myopia prevalence in the population increases, the proportion of high myopia increases.





Myopic Maculopathy Progression In Young High Myopes

There are now multiple studies showing similar alarming results

Published: JAMA Ophthalmology; 10.1001; January 25 2024

Authors: Feng Jiang MD and colleagues

Conclusion: In this observational study, the progression of myopic maculopathy was observed in approximately 12% of pediatric high myopes for 4 years.

Key Take Aways:

"In the Taizmi Study, it [myopic maculopathy] constituted the primary cause of monocular blindness among individuals aged 40 years and older in the Japanese population."

"Current predictions indicate that visual impairment from myopic maculopathy will affect 55.7 million people, with an estimated 18.5 million experiencing blindness worldwide by 2050. In addition, addressing the prevention and treatment of myopia and myopic maculopathy carries a considerable economic burden."

Guo reported that myopic maculopathy progression was observed in 18.8% of children's eyes with high myopia.

"Mean age, 11.8 years; mean SE, −7.65 with a mean follow-up of 4.9 years reported that myopic maculopathy progressed in 52 of 274 progressed in 52 of 274 eyes."

- This Jiang study is not the first study in young high myopes; **there are now multiple, specific to young high myopes, and they are showing similar alarming trends.**

"548 eyes from 274 participants were included in this analysis." Baseline mean age was 13.6 years old; baseline mean SE was -9.120, and baseline AL was 27.08 mm

"The progression of myopic maculopathy was detected in 67 of 548 eyes (12.2%) with 88 lesion changes. Among these changes, the new development of C1 was observed in16 eyes (from C0 to C1) [16 of 88 (18.2%)]. The progression of C2 included the new development of C2 in 12 eyes (13.6%), as well as the enlargement of C2 in 49 eyes (55.7%). New signs of C3 were identified in 1 eye transitioning from C0 to C3 and in 1 eye transitioning from C2 to C3 (2.3%).

The Economic Burden of Vision Impairment is Great

Costs differences are dramatic compared to non-vision impaired impaired individuals

Published: British Medical Journal; Open 2013; 3:e003471. doi:10.1136/bmjopen-2013-003471

Authors: Juliane Köberlein and colleagues

Conclusions: VI&B cause a considerable economic burden for affected persons, their caregivers and society at large, which increases with the degree of visual impairment. This review provides insight into the distribution of costs and the economic impact of VI&B.

Key Take Aways:

- "A total of 22 studies were included. Hospitalisation and use of medical services around diagnosis and treatment at the onset of VI&B were the largest contributor to direct medical costs." Costs were overall nearly two-fold higher than non-blind patients.
- "Care was the major contributor to other direct costs, with the time spent by caregivers increasing from 5.8 h/week for persons with vision >20/32 up to 94.1 for persons with vision ≤20/250. VI&B caused considerable indirect costs due to productivity losses, premature mortality"
- "Blindness and visual impairment impact not only the individual but also the family, caregivers and the community, leading to a leading to a significant cost burden. In Australia, the overall cost placed visual disorders seventh among diseases, ahead of coronary heart disease, diabetes, depression and stroke in terms of economic burden on the health system."
- "The search yielded a total of 390 articles. After applying all inclusion and exclusion criteria, 22 studies were included in the systematic in the systematic review. Altogether, there were nine studies conducted in the USA, six studies conducted in Australia, two studies two studies from France and Canada and one study from each of the following countries: Germany, the UK, Japan."

The Economic Burden of Vision Impairment

Economic burden exceeds coronary heart disease, diabetes, depression and stroke

Key Take Aways:

"Costs related to the recurrent hospitalisation and ongoing but less frequent use of medical services remain major cost components in persons with VI&B in the long term."

"With worsening visual acuity, direct non-medical costs for support services and assistive devices increased from US$ PPP 53.90. for a person with visual acuity ≥20/20 up to US$ PPP 608.71 for a person with visual acuity ≤20/80.32". **This represents an 11X increase.**

"Blindness and visual impairment impact not only the individual but also the family, caregivers and the community, leading to a significant cost burden. In Australia, the overall cost placed visual disorders seventh among diseases, **ahead of coronary heart disease, diabetes, depression and stroke in terms of economic burden on the health system."**

Study	Cost outcomes	US$ PPP in 2011
Bramley *et al*[23]	Annual costs per patient compared in degrees of vision impairment from no vision loss to onset of moderate or severe vision impairment or blindness	
	No vision loss US$8157	8695
	Moderate visual impairment US$13 162	14 029
	Severe visual impairment US$15 312	16 321
	Blindness US$18 870	19 900

Kymes *et al*[24]	Lifetime costs of POAG (primary open-angle glaucoma) to non-POAG patients	
	Incidence costs US$41 039	46 456
	Prevalence costs US$19 268	21 811
	Drug costs US$7099	8035
	Incremental incidence costs US$27 326	30 933
	Incremental prevalence costs US$5555	6288
	Incremental drug costs US$4179	4731

Myopia is a primary risk factor for open angle glaucoma.


BMJ Open The economic burden of visual impairment and blindness: a systematic review

Juliana Kilbarkin,[1] Karolina Barbu,[1] Corinna Schaffert,[1] Robert P Finger[2,3]

ABSTRACT

Strengths and limitations of this study

The Economic Burden of Vision Impairment (Continued)

The results did not include Anti-VEGF treatment costs, which increases the difference between non-visually impaired persons and many other serious diseases serious diseases exponentially

Key Take Aways:

"Mortality associated with visual impairment was reported to increase linearly from 4.5% in persons with normal visual acuity (≥20/20) to 22.2% in blind persons (visual acuity of <20/200)."

"**In this first systematic review of costs associated with VI&B**, we could demonstrate a considerable impact of VI&B in terms of the associated direct and indirect costs, as well as intangible effects such as loss of wellbeing, independence and excess mortality."

"A large proportion of the direct costs reported in reviewed studies are not directly related to eye-related medical care, but to **falls and other accidents due to visual impairment."**

The annual mean costs of other potentially incapacitating chronic diseases such as diabetes mellitus

(€5262 or US $6889) or the first year after a stroke (US $14361) were much lower for diabetes and similar for the stroke estimate compared to the mean annual cost of severe VI&B.

"In severely VI&B, these costs are incurred every year following the loss of vision and do not decrease significantly over the following years unlike the reported unlike the reported annual costs for stroke."

"With the introduction of anti-Vascular-Endothelial-Growth-Factor treatment for a number of potentially blinding eye diseases such as neovascular age-related macular degeneration, diabetic macular oedema or macular oedema in retinal vein occlusions since all reviewed studies were conducted, the overall direct medical costs associated with visual impairment can be expected to be much higher today."

- This is an extremely important point, because this important published piece concludes that costs of vision impairment are higher than many cardiovascular conditions, before anti-Vascular-Endothelial-Growth-Factor treatments were prominent. This further impacts the conclusions dramatically by billions of dollars annually.

"In conclusion, VI&B cause a considerable economic burden for affected persons, their caregivers and society at large, which increases with the degree of visual impairment for all assessed cost categories as well as intangible effects. This review highlights a large amount of cost categories which should be considered in economic evaluations in eye health."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ABSTRACT

Strengths and limitations of this study

The Economic Burden of Vision Impairment (Continued)

Quality of Life scores and other costs are dramatically impacted

Key Take Aways:

Cost burdens of vision impairment also affect mental health, quality of life, fall risk, etc.:

Roberts *et al*[41]	Indirect costs for visual impairment and blindness Productivity losses US$4.667 billion Lower employment US$4.230 billion Absenteeism US$0.384 billion Premature mortality US$0.053 billion Dead-weight losses US$1.609 billion
Rosenny *et al*[42]	Depressive occurs in patients with vision loss more often (about 17%) than in patients with no vision loss; placements in nursing homes are demanded in 23.2% more, injuries happen in 22.4% more cases and femur fractures in 87.4% more cases
Cruess *et al*[43]	Loss of well-being and loss in quality of life evokes 77 306 DALYs or rather $C 11.7 billion in 2007 (US$ PPP 15.11 billion in 2011)
Wood *et al*[44]	Increased visual impairment was significantly associated with an increased incidence of falls and other injuries. 54% of participants had at least one fall, 30% had more than one fall and 83% of falls ended in injuries
Porz *et al*[45]	In a questionnaire with a score scale 0–100 points, patients with VA ≥0.3 achieved 79.32 for mobility and independency, 69.64 for emotional well-being and 73.86 for reading and achievement of information;
Roberts *et al*[46]	Loss of well-being was measured in DALYs; converted into a monetary value, this results in total annual costs of US$ 46.598 billion (US$ PPP 51.8 billion in 2011) and costs per capita of US$ 29 690 per year (US$ PPP 33 047).


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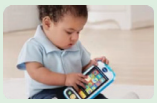
Juliana Kilbarkin,[1] Karolina Barbu,[1] Corinna Schaffert,[1] Robert P Finger[2,3]

ABSTRACT

Strengths and limitations of this study

Myopia is Growing in Both Prevalence and Severity Severity

Smart phones are not going away and children are being conditioned at early ages




The Guardian

Why staring at screens is making your eyeballs elongate – and how to stop it

Environmental Factors Have Run Amuck

Human Biology is changing due to technology and addictive behaviors, and *Cell Phones are Here Phones are Here to Stay*

- Natural Human Biology puts emphasis on a wider range of vision, especially distance vision distance vision
- Going back to Caveman and Cavewoman days; you had to be able to spot predators and predators and potential food from a far to survive.
- Never in human history has there been so much near vision use
- It is not uncommon for cell phone addicts to be on their phone >5 hours a day
- That amount of use in children signals the eye to overgrow so it can accommodate more for accommodate more for near vision, rather than a more natural wide range of vision. Distance vision. Distance vision especially suffers.

The Largest Company in the World is Taking on Myopia

Tools to protect kids from myopia a default feature in all new iPhones

What is Screen Distance?

Starting in iOS 17 and iPadOS 17, Screen Distance is turned on by default for children under 13 in a Family Sharing group.

Viewing something like a device or book too closely for an extended period of time can increase eye strain and the risk of myopia. The Screen Distance feature in Screen Time uses the TrueDepth camera to detect when you hold your iPhone closer than 12 inches for an extended period, and encourages you to move it farther away. Screen Distance can help children engage in healthy viewing habits that can lower their risk of myopia and can give people of all ages the opportunity to reduce digital eyestrain.

1. Children 13 years of age or under: anti-myopia software default in iOS 17 and later; automatically on 24/7
2. When a child receives a warning, the iOS sends a notification to the parents that the warning was triggered, coupled with myopia education, cited from the IMI

Myopia Epidemic Prevalence >50 Years; >81,000 Individuals

Myopia and Severe Myopia Prevalence Growing at Alarming Rate and Expected Costs

Published: American Journal of Ophthalmology; 2024;259: p.35-44; 2023

Authors: Prashant D. Tailor and colleagues

Results: Among 81,706 sampled subjects, the myopia prevalence *increased from 33.9%* (95% CI, 31.1- (95% CI, 31.1- 36.8) *in the 1960s to 57.1%* (95% CI, 56.6-57.6) *in the 2010s* (P < .001). The high myopia high myopia prevalence *increased from 2.8%* (95% CI, 1.95-3.98) *in the 1960s to 8.3%* (95% CI, 8.08- CI, 8.08-8.62) *in the 2010s* (P < .001).

The mean SE decreased from the 1960s (–0.42 D; 95% CI, –0.59 to + 2.49) to the 2010s (–1.85 D; 95% CI, –1.88 to + 2.96) (P < .001).

Conclusion: From 1966 to 2019 in Olmsted County, Minnesota, there was a 68% and 199% increase in increase in myopia and high myopia prevalence, respectively.

Key Take Aways:

"In the United States, the National Health and Nutrition Examination Surveys (NHANES) reported a 66% reported a 66% increase in myopia prevalence in a cross-sectional study between the 1970s (25.0%) to 1970s (25.0%) to the early 2000s (41.6%) over approximately 3 decades."

"Increasing myopia prevalence is particularly concerning within a given population because of the association of increasing visual morbidity (retinal detachment, choroidal neovascularization, and macular atrophy) and the increasing socioeconomic factors necessary to address refractive correction and myopia-related healthcare expenses. Vitale et al estimated that increased myopia prevalence from 25% to 37% would increase associated annual US healthcare costs from $2 billion to more than $3 billion."

Myopia Epidemic Prevalence >50 Years; >81,000 Individuals

Myopia and Severe Myopia Prevalence Growing at Alarming Rate and Expected Costs

Key Take Aways (Continued):

"Our study examined trends of myopia and high myopia with data randomly sampled from a large, population database, the Rochester Epidemiology Project (REP) from a stable, US population in Olmsted County, Minnesota, from 1966 to 2019."

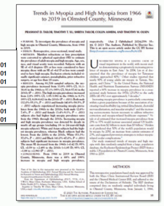
"The REP database is a regional population-based index with diagnostic information associated with subject encounters. The REP also links directly to medical records and contains nearly all residents (participation approaches 98%) of Olmsted County, Minnesota. Diagnostic information is captured from the Mayo Clinic and local community healthcare facilities. The REP has robust ophthalmology participation, with 1 REP project reporting that 87% of patients over a 50-year period had documented ocular examinations at a REP-affiliated institution."

"Across all decades, there was a statistically significant increase in myopia prevalence (P < .001)."

Statistically significant increases in high myopia prevalence occurred in all decades (P < .001).

"Racial variation observations include that Black subjects in Olmsted County (2000s) had a lower myopia prevalence when compared to White subjects (41% vs 53%, respectively), similar to data from NHANES (34% vs 43%, respectively), and this trend has been documented in other populations. In Olmsted County, the prevalence of myopia/high myopia (2010s) in Asian subjects was 68% and 16%, respectively."

Estimated High Myopia Prevalence, AAO Definition (SE –6.0 D or less), % (95% CI)							
Overall	2.8 (2.0-4.0)	4.0 (3.1-5.2)	5.1 (3.9-6.4)	5.8 (4.7-7.1)	7.9 (7.7-8.2)	8.3 (8.1-8.6)	**<.0001**
Men	2.6 (0.9-4.3)	3.3 (2.0-5.1)	8.3 (5.7-11.0)	6.8 (4.6-8.9)	6.9 (6.5-7.3)	7.4 (7.0-7.6)	**<.0001**
Women	3.4 (2.0-4.9)	4.7 (3.3-6.4)	4.8 (3.0-6.6)	6.5 (4.9-8.5)	8.7 (8.3-9.1)	9.1 (8.7-9.4)	**<.0001**
Estimated High Myopia Prevalence, WHO Definition (SE –5.0 D or less), % (95% CI)							
Overall	5.0 (3.8-6.5)	7.0 (5.8-8.4)	8.4 (7.0-10.1)	10.3 (8.8-11.9)	12.0 (11.7-12.3)	12.6 (12.2-12.9)	**<.0001**
Men	4.7 (2.5-6.9)	5.3 (5.3-7.2)	12.9 (9.7-16.1)	10.9 (8.3-13.6)	10.6 (10.1-11.1)	11.0 (10.6-11.5)	**<.0001**
Women	6.2 (4.2-8.2)	8.4 (6.5-10.2)	8.8 (6.4-11.2)	12.4 (10.1-14.6)	13.1 (12.6-13.5)	13.7 (13.2-14.1)	**<.0001**



Myopia Epidemic Prevalence >50 Years; >81,000 Individuals

Myopia and Severe Myopia Prevalence Growing at Alarming Rate and Expected Costs

Key Take Aways (Continued):

"Myopia prevention is key to address the myopia epidemic. By intervening during childhood, perhaps these trends could be reduced or stopped. Proposed therapies include increased time outdoors, optical devices, *pharmacologic intervention (e.g., low-dose atropine)*, and possibly orthokeratology."

"We also need to consider the increasing socioeconomic costs associated with both the refractive management demands as well as the healthcare costs, especially those associated with high myopia. Healthcare policy decisions directed toward prevention seem logical and rational, and we speculate that these would be highly cost-effective. Policy delays would lead to progressive acceleration of myopia."

Refractive Trajectory Over 22 Years

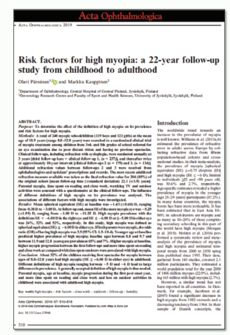
Urgency and Timeliness of Treatment is Vital

Published: Acta Ophthalmology. 2019: 97: 510-518

Authors: Olavi Parssinen and Markku Kauppinen

Results: 240 total myopic school children (from 3rd to 5th grades) were recruited. Of those, 204 of the original cohort were followed for a mean of 22.1 years. Younger age at baseline predicted higher prevalence of high myopia (defined as -6.00D in this study). Higher myopia at baseline, higher myopic progression between the first follow-ups and more time spent on reading and close work as compared with time spent outdoors were associated with high myopia.

Conclusion: "About 32% of the children receiving first spectacles for myopia between ages 8.8-12.8 years had high myopia in adulthood (defined as -6.00D in this study). Parental myopia, age at baseline, myopic progression during the first post onset year, and more time spent on reading and close work and less on outdoor activities in childhood were associated with adulthood high myopia"



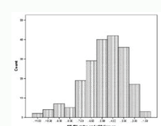


Fig. 1. Distribution of spherical equivalent (SE, in dioptres, D) of the more myopic eye at study end. Categories of spherical equivalent: −1.00 to −1.99 = −1.5, −2.00 to −2.99 = −2.5, etc.

Refractive Trajectory Over 22 Years

Key Take Aways:

- Following WHO's definition of high myopia (-5.00D), 52% of children in the study progressed to high myopia.
- All children wore glasses or contacts, which showed the positive effect of single vision glasses/lenses was negligible, at best, in slowing disease progression in this study.
- **Very few patients remained at or under -3.00D after 22 years**
- **Time is of the essence. Do not wait and observe progression for a year. Start treatment as soon as possible. You cannot get those diopters back.**
- **Even low myopes were found to have >30% chance of developing Myopic Macular Degeneration.**

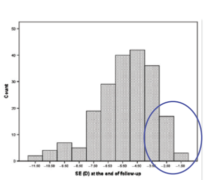
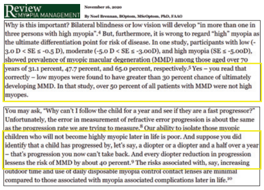


Fig. 1. Distribution of spherical equivalent (SE, in dioptres, D) of the more myopic eye at study end. Categories of spherical equivalent: −1.00 to −1.99 = −1.5, −2.00 to −2.99 = −2.5, etc.



Review of Myopia Management — November 16, 2020 — By Noel Brennan, BOptom, MScOptom, PhD, FAAO

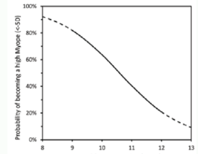
Why is this important? Bilateral blindness or low vision will develop "in more than one in three persons with high myopia".[4] But, furthermore, it is wrong to regard "high" myopia as the ultimate differentiation point for risk of disease. In one study, participants with low (-3.0 D < SE ≤ -0.5 D), moderate (-5.0 D < SE ≤ -3.00D), and high myopia (SE ≤ -5.00D), showed prevalence of myopic macular degeneration (MMD) among those aged over 70 years of 31.1 percent, 47.7 percent, and 65.0 percent, respectively.[5] Yes – you read that correctly – low myopes were found to have greater than 30 percent chance of ultimately developing MMD. In that study, over 50 percent of all patients with MMD were not high myopes.

You may ask, "Why can't I follow the child for a year and see if they are a fast progressor?" Unfortunately, the error in measurement of refractive error progression is about the same as the progression rate we are trying to measure.[8] Our ability to isolate those myopic children who will not become highly myopic later in life is poor. And suppose you did identify that a child has progressed by, let's say, a diopter or a diopter and a half over a year – that's progression you now can't take back. And every diopter reduction in progression lessens the risk of MMD by about 40 percent.[9] The risks associated with, say, increasing outdoor time and use of daily disposable myopia control contact lenses are minimal compared to those associated with myopia associated complications later in life.[10]

Refractive Trajectory Over 22 Years

Urgency and Timeliness of Treatment is Vital

Figure: Probability of becoming a high myope (< -5D) by age of first spectacles, modelled using data from Table 2 of Pärssinen and Kauppinen.[3]



>80% of Children, whose age of first spectacles was 9, progressed to severe myopia in adulthood

Axial Elongation, Due To Myopia, Causes Causes Stretching of the Eyeball

This biomechanical stretching leads to numerous retinal related irreversible blinding, or sight threatening, degenerative conditions; not just retinal detachment

Published: Ophthalmic and Physiological Optics, The Journal of the College of Optometrists; 35 (2015) 465-475

Authors: Pavan Kumar Verkicharla, Kyoko Ohno-Matsui and Seang Mei Saw

Review: "Excessive axial elongation of the eye in high myopia can cause biomechanical stretching leading to various to various ocular complications. The purpose of this review is to provide an update on various pathologic changes, changes, especially in the chorio-retina and sclera that have been reported recently using advanced ophthalmic bio-ophthalmic bio-imaging modalities such as optical coherence tomography, magnetic resonance imaging and fundus and fundus photography."

Key Take Aways:

- "Excessive axial elongation of the eye in high myopia can cause mechanical stretching of the outer coats of the coats of the eyeball resulting in various pathologic changes such as staphyloma, chorio-retinal atrophic lesions, atrophic lesions, lacquer cracks and choroidal neovascularization, etc."
- Pathologic myopia "affects eyes bilaterally and has the potential to cause blindness for which there exists no effective restorative treatment".
- "It not only affects an individual in visual related tasks but also with mobility, activities of daily living and quality of and quality of life."


OPO OPHTHALMIC & PHYSIOLOGICAL OPTICS
INVITED REVIEW
Current and predicted demographics of high myopia and an update of its associated pathological changes
Pavan Kumar Verkicharla, Kyoko Ohno-Matsui and Seang Mei Saw

Long-Term Myopia Progression Tracking of 443 Individuals

Association of Age at Myopia Onset with Risk of High Myopia in Adulthood in a 12-Year Follow Up of a Chinese Cohort (Study title)

NIH National Library of Medicine
National Center for Biotechnology Information

JAMA Ophthalmol. 2020 Nov; 138(11): 1–6.
Published online 2020 Sep 17. doi: 10.1001/jamaophthalmol.2020.3451

Importance

Early-onset myopia is well known to progress to high myopia in adulthood. However, no accurate estimation of how a specific age at myopia onset is associated with the probability of developing high myopia in adulthood is available, and a very-long-term follow-up study with data from annual visits is needed.

Objective

To estimate the risk of developing high myopia in adulthood associated with a specific age at myopia onset from a data set with a 12-year annual follow-up.

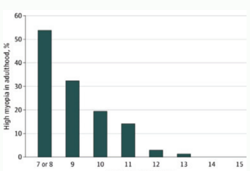
Conclusions and Relevance

These findings suggest that the risk of high myopia is relatively high in children with myopia onset during the early school ages. Each year of delay in the age at onset substantially reduces the chance of developing high myopia in adulthood, highlighting the importance of identifying effective prevention strategies under investigation, such as increasing outdoor time.

Long-Term Myopia Progression Tracking of 443 Individuals

Association of Age at Myopia Onset with Risk of High Myopia in Adulthood in a 12-Year Follow Up of a Chinese Cohort (Continued)

NIH National Library of Medicine
National Center for Biotechnology Information



JAMA Ophthalmol. 2020 Nov; 138(11): 1–6.
Published online 2020 Sep 17. doi: 10.1001/jamaophthalmol.2020.3451

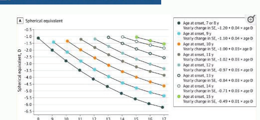
"Among participants with age at myopia onset of 7 or 8 years, 14 of 26 (53.9%; 95% CI, 33.4%-73.4%) developed high myopia in adulthood; among those with onset at 9 years of age, 12 of 37 (32.4%; 95% CI, 18.0%-49.8%); among those with onset at 10 years of age, 14 of 72 (19.4%; 95% CI, 11.1%-30.5%); among those with onset at 11 years of age, 11 of 78 (14.1%; 95% CI, 7.3%-23.8%); among those with onset at 12 years of age, 2 of 67 (3.0%; 95% CI, 0.4%-10.4%); among those with onset at 13 years of age, 1 of 71 (1.4%; 95% CI, 0.0%-7.6%); and among those with onset at 14 or 15 years of age, 0 of 92."

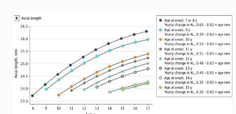
Long-Term Myopia Progression Tracking of 443 Individuals

Association of Age at Myopia Onset with Risk of High Myopia in Adulthood in a 12-Year 12-Year Follow Up of a Chinese Cohort (Continued)

NIH National Library of Medicine
National Center for Biotechnology Information

JAMA Ophthalmol. 2020 Nov; 138(11): 1–6.
Published online 2020 Sep 17. doi: 10.1001/jamaophthalmol.2020.3451

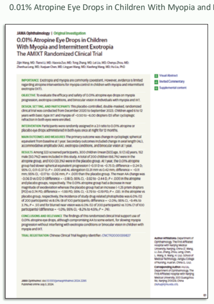




- This study reinforces the immense importance of starting myopia management as soon as possible, especially in children who become myopic (defined in this study as a spherical equivalent -1.0 D), before age 13.
- This study also showed that children who became myopic before the age of 10 can be expected to progress to becoming severely myopic, as defined at -5.0 D, in adulthood. adulthood.

Atropine 0.01% In Patients with Exotropia

0.01% Atropine Eye Drops in Children With Myopia and Intermittent Exotropia


JAMA Ophthalmology | Original Investigation
0.01% Atropine Eye Drops in Children With Myopia and Intermittent Exotropia
The AMIXT Randomized Clinical Trial

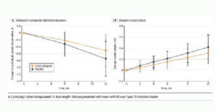
Published: JAMA Ophthalmol. doi:10.1001/jamaophthalmol.2024.2295

Authors: Zijin Wang, MD and colleagues

Key Take Aways:

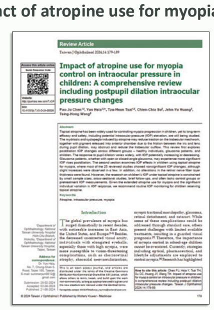
"Exotropia and myopia commonly coexistent. The The myopia prevalence rate in populations with exotropia has been reported to reach as high as 57.7%."

This placebo-controlled, double-masked, randomized clinical trial established that **0.01% atropine eye drops, appeared effective and safe in slowing myopia progression without interfering with exotropia conditions or binocular vision in children with myopia and IXT**.



Atropine 0.01% Has No Significant Effect on IOP Changes

Impact of atropine use for myopia control on intraocular pressure in children


Review Article
Impact of atropine use for myopia control on intraocular pressure in children: A comprehensive review including postpupil dilation intraocular pressure changes

Published: Taiwan J Ophthalmol - Volume 14, Issue 2, April-June 2024

Authors: Pao-Ju Chen and colleagues

Key Take Aways:

"To summarize, the majority findings from previous studies demonstrated no significant difference between the control and atropine-treated groups."

"Overall, substantial evidence supporting IOP elevation in children under topical atropine treatment is lacking."

"Elevated IOP following pupil dilation is more frequently encountered in patients with compromised outflow facilities, stemming from either closed-angle or open-angle with reduced trabecular meshwork outflow. This risk is less prevalent in the general population."

Atropine 0.01% Has No Significant Effect on Myopia (False)

The study's data contradicts the authors own conclusion

Published: Medicina 2024, 60, 1022. https://doi.org/10.3390/medicina60071022

Authors: Dovile Simonaviciute and colleagues

Key Take Aways:

The author concluded that "compared to the control group, the administration of 0.01% atropine eye drops demonstrated no significant effect on changes in SE and AL over a 1-year follow-up", however, **the conclusion was not congruent and directly conflicted the study's data and results.**

Section 3.1: "Notably, children in the 0.01% atropine eye drops group experienced significantly greater myopia progression before study enrollment compared to the control group."

- The baselines were significantly different between the active & control arms.
- The mean baseline progression rate (1-year before to the study; Table 2 below) for **the atropine group was exactly 48% higher than the placebo group** (-1.01D – -0.68D = -0.33D / baseline - 0.68D control = -48.529%).

The efficacy outcomes at 1 year for each group, compared to its each group's progression rate was very positive for low-dose atropine. **Atropine 0.01% slowed progression down** (as measured at Change of SE) in its own fast progressors group **by 50.49% at Year 1** (-1.01D the year prior to the study, compared to -0.51D at the end of Year 1 of the study). **Control slowed progression down by a minimal amount (-0.68D relative to -0.50D).**

Table 2. Changes in spherical equivalent in the control group and 0.01% atropine group 1 year before the study enrollment and over the 1-year follow-up.

Variables	Control Group (*n* = 34)	0.01% Atropine Eye Drops Group (*n* = 45)	*p*-Value
Change of SE 1-year before the study, D/year	−0.68 (−2.0–−0.25)	−1.01 (−2.0–−0.25)	0.018
Change of SE over 1-year follow-up, D/year	−0.50 (−1.5–0.5)	−0.50 (−1.5–0.5)	0.721
	p = 0.111 [1]	*p* < 0.001 [2]	

Myopia Prevalence and Progression During COVID-19

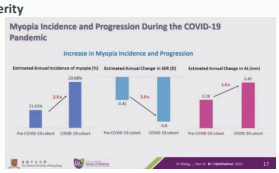
Myopia trends significantly increased in both prevalence and severity

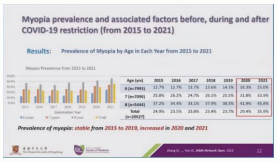
Presented: American Academy of Ophthalmology Meeting, 2023 by XJ Zhang, The Chinese University of Hong Kong

Key Take Aways:

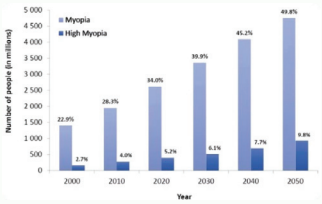
Estimated Annual Incidence of Myopia, Estimated Annual Change in SER (D) and Estimated Annual Change in AL (mm) all significantly increased during COVID-19 to unprecedented levels.

Prevalence of myopia jumped in 2020 and 2021 in each age group (6, 7 and 8 years old); 20,527 total subjects



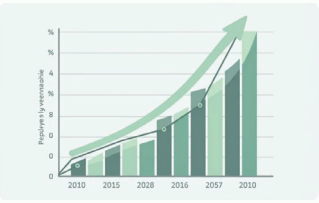


Myopia Epidemic



Global Myopia Prevalence

This image illustrates the global prevalence of myopia, highlighting the highlighting the increasing trend and projected epidemic proportions. The proportions. The data presented is based on the study by Holden BA, Fricke BA, Fricke TR, Wilson DA, et al. published in Ophthalmology 2016.



Myopia Trend Over Time

This graph demonstrates the rising trend of myopia prevalence over the years, emphasizing the urgency of addressing this growing epidemic. The data aligns with the findings presented in the Ophthalmology 2016 study by Holden and colleagues.

Understanding the Why

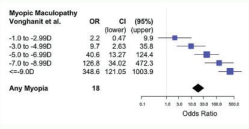
Increasing myopia severity, increasing risk

Level of Myopia	Cataracts	Glaucoma	Retinal Detachment	Myopic Maculopathy Maculopathy
-1.00 to -3.00 D	2x	2x	3x	2x
-3.00 to -6.00 D	3x	3x	9x	10x
Over -6.00 D	5x	14x	22x	41x

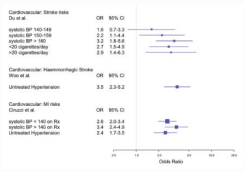
Press, D. *Review of Myopia Management.* (2020).

Flitcroft, D. I. *Prog. Retin. Eye Res.* 31, 622–660 (2012).

Ocular Health Consequences



Odds ratio of having myopic maculopathy when you are a high myope



Odds ratio of having a stroke when you smoke over a pack a day

40.6

Odds ratio of having myopic maculopathy when you are a high myope

2.9

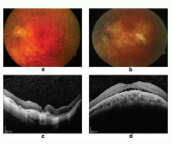
Odds ratio of having a stroke when you smoke over a pack a day

Flitcroft, D. I. *Prog. Retin. Eye Res.* 31, 622–660 (2012).

Ocular Health Consequences

1 D increase in myopia

67% increase in prevalence of myopic maculopathy



1 D slowing of myopia

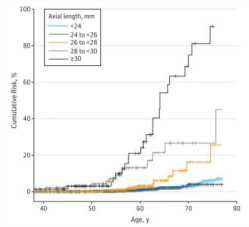
40% reduction in likelihood of myopic maculopathy

Bullimore, MA & Brennan, NA. (2019). *Optom Vis Sci*

Ruiz-Medrano J, Montero J, Flores-Moreno I, et al. (2019). Prog Ret Eye Research

Risk of Visual Impairment

- Axial length of 26 mm or more is associated with increased risk increased risk of visual impairment



Tideman JWL, Snabel MCC, Tedja MS, et al. JAMA Ophthalmol 2016

Shift in Mindset

- Myopia is a sight-threatening disease, not just refractive error
- Myopia control won't reduce prevalence, just severity

Bullimore, M. A., & Brennan, N. A. (2022). *Ophthalmic and Physiological Optics. Optics*.

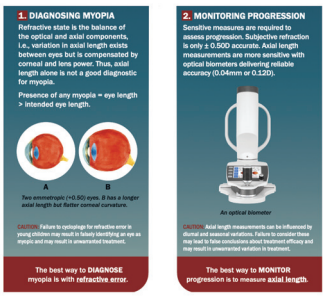
REFRACTION

- Functional measure of vision
- Accessible
- Parents understand
- Poor repeatability: ±0.4-0.6 D
- Requires cycloplegia

AXIAL LENGTH

- Measure of structural form
- Good repeatability: ±0.12 D
- Objective, quick, non-invasive
- Expensive equipment, limited availability

Sankaridurg P, He X, Naduvilath T, et al. Acta Opthalmol 2017
Wolffsohn JS, Kollbaum PS, Berntsen DA, et al. Invest Ophthalmol Vis Sci 2019
Brennan N, Toubouti Y, Cheng X, et al. Prog Retin Eye Res 2021



bhvi.org/wp-content/uploads/2021/04/BHVI_20200103_Myopia-Management-Axial-Length-Refractive-Error-Guidelines-Flyer.pdf

Reducing Risk and Monitoring

Reducing Risk

Reducing the risk for behavioral and environmental factors that contribute to myopia onset and progression is important. This includes spending more time outdoors, reducing near work, and ensuring proper lighting and ergonomics.

Monitoring Progression

Monitoring myopia progression is essential. Regular eye exams and exams and axial length measurements help in tracking the progression and effectiveness of myopia management strategies. strategies.

bhvi.org/wp-content/uploads/2021/04/BHVI_20200103_Myopia-Management-Axial-Length-Refractive-Error-Guidelines-Flyer.pdf

Axial Length

- Increasing axial length is correlated with progressing myopia
  - 1 mm eye growth = increase of myopia by 3 D
  - 0.1 mm = 0.3 D
- Average *emmetropic* eye growth/year:
  - 0.10 mm
- Average *myopic* eye growth/year:
  - 0.33 mm (age 8-11)
  - 0.17 mm (age 13-16)

Hou W, Norton TT, Hyman L, Gwiazda J; COMET Group. Eye Contact Lens. 2018 Jul;44(4):248-259.

Mutti DO, Hayes JR, Mitchell GL, et al. Invest Ophthalmol Vis Sci 2007.

Risk of Future Myopia

Hyperopic Buffer by Age

- Age 6: ≥ +0.75 D
- Age 7-8: ≥ +0.50 D
- Age 9-10: ≥ +0.25 D
- Age 11: Plano

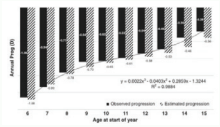
Understanding the Buffer

The hyperopic buffer represents the amount of hyperopia (farsightedness) that can help lower the risk of developing myopia at different ages. As children grow older, the required buffer decreases, indicating a changing risk profile for myopia development over time.

Zadnik K, Sinnott LT, Cotter SA, et al. JAMA Ophthalmology.2015;133(6):683-689.

Factors Related to Myopia Progression

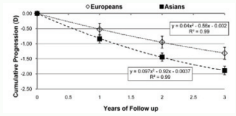
- Age
- Ethnicity
  - Mean rate of progression is 0.55 D/year for Caucasian vs. 0.82 D/year for Asian children



Sankaridurg, PR, & Holden, BA. (2014). *Eye*, *28*(2), 134–141.

Factors Related to Myopia Progression

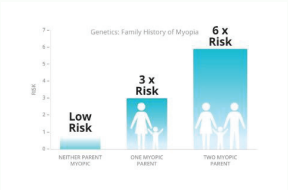
- Age
- Ethnicity
- Genetics



Donovan L, Sankaridurg P, Ho A, Naduvilath T, Smith EL, A. Holden B. *Optometry and Vision Science*. 2012;89(1):27-32.

Factors Related to Myopia Progression

- Age
- Ethnicity
- Genetics
- Near work



1. Closer working distance
2. Higher accommodative demand
3. Larger lag of accommodation
4. Hyperopic defocus
5. Axial elongation

Myopia Management Strategies

Goals

- First, prevent axial elongation (myopia onset)
- Then, slow axial elongation (myopia progression)

Prevention is Important

Delaying myopia onset by one year:	Lower ultimate level of myopia by 0.75 D 0.75 D or more	Equate to up to 3 years of myopia control control

Bulletin: Wolffsohn JS, Brennan NA. Ophthalmic Physiol Opt. 2020;40(2):127-131.

Delaying Onset

- Near work
- Increase working distances (>30 cm)
- Decrease time spent doing continuous reading (<30 min)
- Intensity rather than total duration

Delaying Onset

- Outdoor time
  - Recommend 2 hours/day or 10 hours/week
  - Unsure of mechanism: higher light levels, spectral composition of light, dioptric demand
  - Not activity-dependent
  - Seasonal variation

Ip JM, Saw SM, Rose KA, et al. Invest Ophthalmol Vis Sci. 2008;49(7):2903.

Slowing Myopia Progression

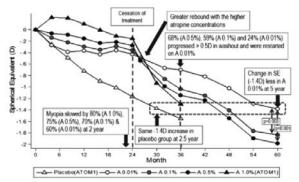
- Pharmaceutical therapy
- Spectacle lenses
- Peripheral defocus contact lenses
- Orthokeratology

Atropine

- Non-selective antimuscarinic
- Exact mechanism is unclear but thought to act on receptors in the retina
- Ocular side effects: photophobia, blurred near vision
- Systemic side effects: decreased lacrimation, allergic reaction, tachycardia, restlessness, and dryness of the mouth, throat, and skin, irritability, delirium

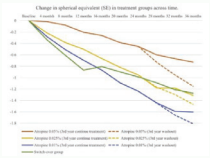
ATOM 1 and 2

ATOM 1 and 2



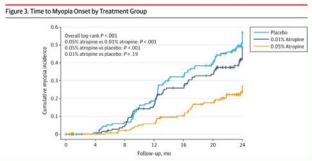
Chia A, Lu QS, & Tan D. (2016). *Ophthalmology*, *123*(2), 391–399.

LAMP 2



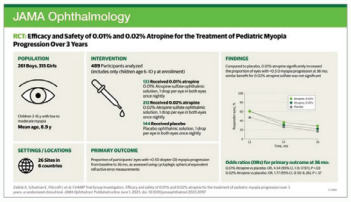
Yam JC, Zhang XJ, Zhang Y, et al. (2021). *Ophthalmology*, *129*(3), 308–321.

CHAMP Study – June 2023

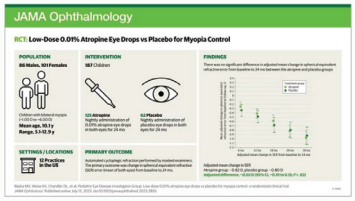


Yam JC, Zhang XJ, Zhang Y, et al. (2023). *JAMA*, *329*(6), 472-81.

PEDIG Study – July 2023



CHAMP vs. PEDIG



ATLAS

- 20 year f/u on ATOM1, 10 year f/u on ATOM2
- 71/400 (18%) from ATOM1 + 158/400 (40%) from ATOM2
- Higher myopia progression from final visit to current study in:
  - Younger age
  - Randomized to higher concentrations (0.1% and 0.5% vs. 0.01%)
  - Those requiring retreatment
- No difference in final SE and AL between atropine and placebo/untreated and between different concentrations
- No difference in ocular complications between atropine treated and placebo/untreated but higher incidence of MMD with 0.5% 0.5%

ATLAS

- Potential reasons atropine may be ineffective long-term
  - No benefit to short-term atropine
  - Rebound effects with abrupt cessation
  - Long-term rebound effects
- Questions remain
  - What is the duration of treatment required to provide sustained outcome?
  - When can treatment be stopped?
  - Should tapering dosage be used?
  - Should treatment be continued into mid-teens?

Compounded Atropine

- 0.01% vs. 0.025% vs. 0.05%
- Considerations for compounding

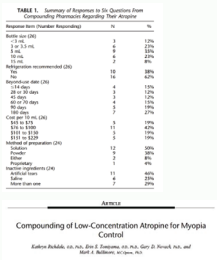


TABLE 1. *Summary of Responses to Six Questions From Compounding Pharmacists Regarding Their Atropine*

Response Item (Number Responding)	N	%
Bottle size (26)		
2 mL	3	12%
3 or 3.5 mL	6	23%
5 mL	8	31%
10 mL	9	35%
15 mL	1	4%
Refrigeration recommended (26)		
Yes	10	38%
No	16	62%
Beyond-use date (26)		
≤14 days	4	15%
28 or 30 days	3	12%
31–59 days	4	15%
60 or 90 days	4	15%
90 days	5	19%
>90 days	7	27%
Cost per 10 mL (26)		
$45 to $75	5	19%
$76 to $105	11	42%
$111 to $130	5	19%
$131 to $150	5	19%
Method of preparation (24)		
Solution	12	50%
Powder	2	8%
Either	2	8%
Proprietary	1	4%
Inactive ingredients (24)		
Xylitol base	11	46%
Saline	4	25%
More than one	7	29%

ARTICLE

Compounding of Low-Concentration Atropine for Myopia Control

Kathryn Richdale, OD, PhD, Erin E. Tomiyama, OD, PhD, Gary D. Novack, PhD, and Mark A. Bullimore, MCOptom, PhD

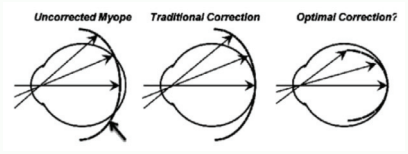
Richdale K, Tomiyama ES, Novack G, Bullimore MA. *Eye Contact Lens*. 2022.

What's in the Bottle?

- Samples of 0.01% from 9 different pharmacies:
  - pH 6.9
    - Atropine stable at 2-4, subject to degradation
    - Degradation products do not have anticholinergic activity (reduce efficacy)
    - Lower concentrations degrade more rapidly
  - Concentration 93% after 30 days
    - Already low-dose, reduced efficacy
- Need a product with good stability, sterility for efficacy

Richdale K, Skidmore K, Tomiyama ES, Bullimore MA. *Eye Contact Lens*. 2023;49(6):219-23.

Prevailing Theory: Peripheral Defocus



Uncorrected myope

Single vision correction

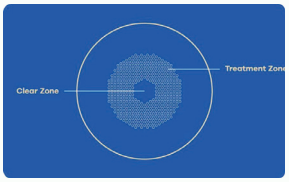
Optimal correction

Smith EL. (2011). *Optometry and Vision Science*, *88*(9), 1029–1044.

Bifocal / PALs

Walline JJ, Lindsley KB, Vedula SS, et al. (2020). *Cochrane Database of Systematic Reviews*, 1(12), CD004916.

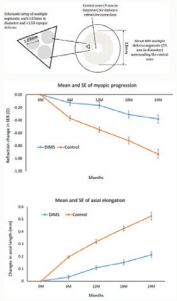
Novel Spectacle Designs



Hoya's MiyoSmart

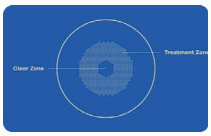
Hoya MiyoSmart

- DIMS = Defocus Incorporated Multiple Segments

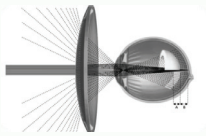


Lam C.S.Y., Tang WC, Tse DY, Lee R.P.K., Chun R.K.M., Hasegawa K, et al. Br J Ophthalmol. 2019.

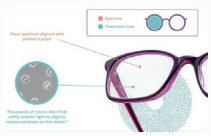
Novel Spectacle Designs



Hoya's MiyoSmart



Essilor's Stellest



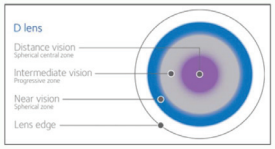
SightGlass Vision DOT

Soft Multifocal Contact Lenses

- Center distance design with plus power in periphery
- All "off-label" except one FDA-approved lens
- Factors to consider when deciding between lenses:
- Daily disposable vs. reusable
- Cost
- Amount of astigmatism

Center-Distance Aspheric Multifocal

(CooperVision Biofinity / Proclear Multifocal)



- Daily wear, monthly replacement
- Off-label for myopia control
- Center-distance (D lens) with a 1.5-mm central optic zone

- SiHy (Biofinity), hydrogel (Proclear)
- Proclear has 2 base curves and higher add powers
- Both have toric options

BLINK Study

- Enrolled 294 children, 7-11 years, -0.75 to -5.00 D
- Adjusted mean progression after 3 years:
  - 1.01 D / 0.66 mm single vision (Biofinity sphere)
  - 0.85 D / 0.58 mm medium add (Biofinity D +1.50)
  - 0.60 D / 0.42 mm high add (Biofinity D +2.50)
- +2.50 was more effective than +1.50 or single vision
- +1.50 was not different than single vision

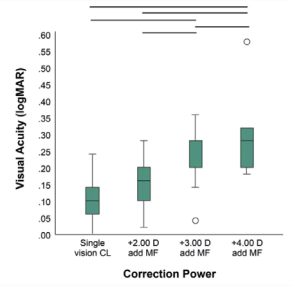
Walline J, et al, for the BLINK Study Group. JAMA 2020;324:571-80

Peripheral Defocus in BLINK

- Mean peripheral defocus explained 30% of the -0.23 mm slowing of AL over 3 years with +2.50 add
- No evidence that pupil size modified magnitude of treatment effect
- Defocus was not significant when added to the model
- Another optical factor that better explains slowing of AL or not a linear dose-response relationship

Berntsen D, et al, for the BLINK Study Group. IOVS 2023;64(14):3-10

Higher Adds Degrade Acuity



Low Contrast Visual Acuity (logMAR)

Proclear Multifocal

Bickle KM, Mitchell GL, Walline JJ. *Optom Vis Sci.* 2021;98(5):483-489.

Dual-Focus Concentric Lens (CooperVision MiSight) MiSight)

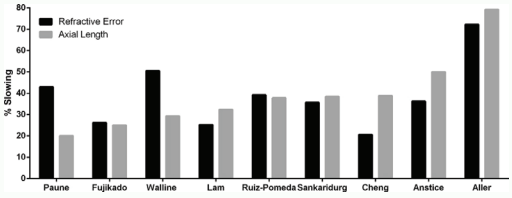
- Daily disposable, hydrogel
- Design based on concentric ring multifocal design
  - Correction zones provide clear distance vision in all gazes
  - Treatment zones create myopic retinal defocus
- FDA approved to slow myopia progression in 8-12 year-olds

EDOF Multifocal CLs (VTI NaturalVue)

- Daily disposable, hydrogel
- Absence of a spherical central optic zone creates peripheral blur
- Rapid, continuous increase in add power from the center to the periphery, creating a "virtual pinhole"
- Universal add power, effective up to +3.00 D
- Limited myopia management data

Soft Multifocal Contact Lens Efficacy

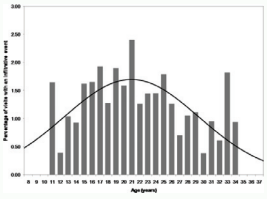
Soft Multifocal Contact Lens Efficacy



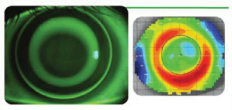
Wildsoet CF, Chia A, Cho P, et al. Invest Ophthalmol Vis Sci. 2019;60:M106–M131.

Orthokeratology

- GP lens worn overnight to flatten the central cornea and temporarily reduce myopia
- Reverse geometry = secondary curve is steeper than BC
- Ideal fit = bullseye pattern

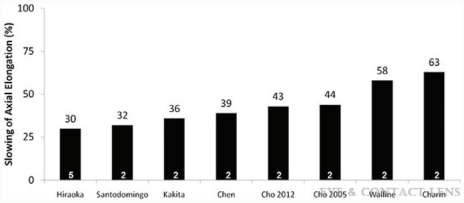


Orthokeratology Efficacy



ROMIO Study

- Change in axial length over 2 years:
  - OK: 0.36 ± 0.24 mm
  - SVS: 0.63 ± 0.26 mm
- Mean increase in control group was 0.27 mm more after 2 years



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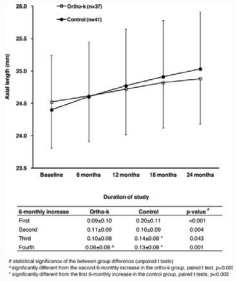


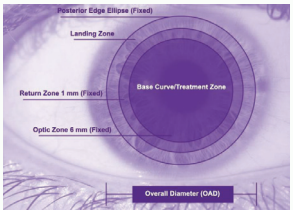
6-monthly increase	Ortho-k	Control	p-value#
First	0.09±0.10	0.30±0.11	<0.001
Second	0.11±0.09	0.16±0.09	0.004
Third	0.10±0.08	0.14±0.09 *	0.043
Fourth	0.06±0.08 *	0.13±0.09 *	0.001

statistical significance of the between-group difference (unpaired t tests)
* significantly different from the second 6-monthly increase in the ortho-k group, paired t test, p<0.001
* significantly different from the first 6-monthly increase in the control group, paired t tests, p<0.002

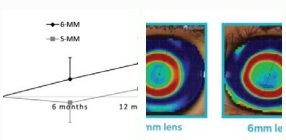
Cho P, Cheung SW. Invest Opthal- mol Vis Sci. 2012;53:7077–7085.

Decreased Optic Zone Diameter

- Smaller treatment zone size
- Greater correction

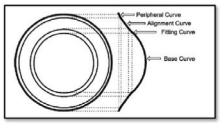


Paragon CRT Dual Axis



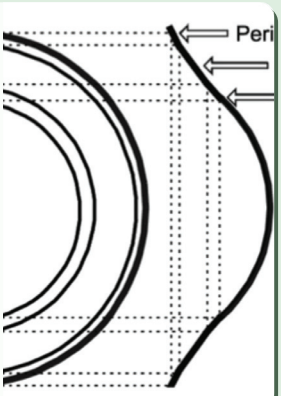
Bausch + Lomb VST

- Several lenses operate under this approval
- Fit up to 5.00 D of myopia and 1.50 D of astigmatism



Acuvue Abiliti

- FitAbiliti software
- Fit up to 4.00 D of myopia and 1.50 D of astigmatism



Acuvue Abiliti

- FitAbiliti software
- Fit up to 4.00 D of myopia and 1.50 D of astigmatism

Orthokeratology Safety

- Microbial keratitis:
- Overall incidence: 7.7 per 10,000 patient-years
- Incidence in children: 13.9 per 10,000 patient-years

Orthokeratology Safety

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  - Overall incidence: 7.7 per 10,000 patient-years
  - Incidence in children: 13.9 per 10,000 patient-years

M.A. Bullimore, L.T. Sinnott, L.A. Jones-Jordan. Optom Vis Sci 90 (2013) 937–944.

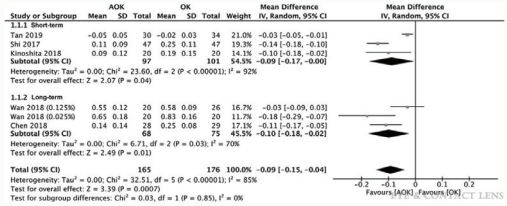
Combination Therapy

- Could combine treatments to potentially get greater myopia control efficacy
- Atropine + orthokeratology
- Atropine + soft multifocal lenses

Combination Therapy

- Could combine treatments to potentially get greater myopia control efficacy
- Atropine + orthokeratology
- Atropine + soft multifocal lenses

Combo: Atropine + OK



Gao, Canran; Wan, Shuling; Zhang, Yuting; Han, Jing. Eye & Contact Lens47(2):98-103, February 2021.

Still to come…

- Myopia control spectacles to the US
- More FDA approved contact lenses for myopia management
- Hybrid lenses
- Commercially available low-dose atropine

Toric Options

Prevalence of Astigmatism

- 28.4% of American children have astigmatism
- Double in myopes compared to hyperopes

Kleinstein RN, Jones LA, Hullett S, et al. *Arch Ophthalmol.* 2003;121(8):1141.

Exclusion from Studies

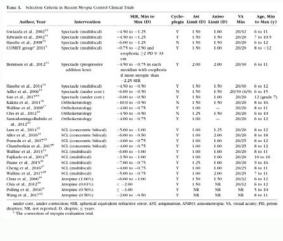


TABLE 2. Typical Inclusion/Exclusion Criteria, Although Should Be Altered to Address Specific Study Hypothesis

Selection Criteria
Refractive error
Cyclopleged spherical or Spherical Equivalent myopia of at least −0.75 D
Astigmatism ≤1.00 D
Anisometropia ≤1.50 D
Age
6–12 years
Visual acuity
20/20 minimum
Exclusion Criteria
Previous RGP wear
History of previous myopia control treatment
Ocular pathology
Binocular vision anomaly
Medications that may affect pupil size, accommodation or have an impact on ocular surface
Systemic disease that may affect vision, vision development or the treatment modality

Wolffsohn JS, Kollbaum PS, Berntsen DA, et al. *Investig Opthalmology Vis Sci.* 2019;60(3):M132.

Soft Toric Multifocal Lens Design

BACK

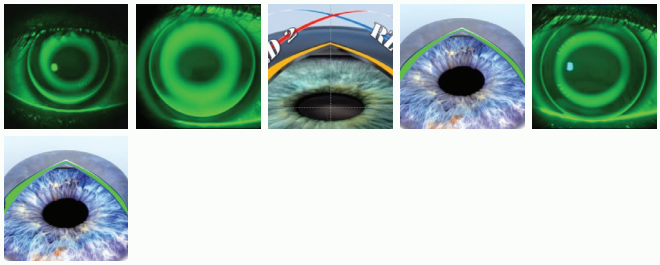
Up to 5.75 D and 5 degrees

FRONT

MULTIFOCAL Center distance

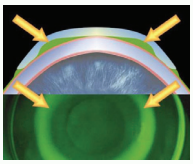
Image adapted from www.coopervision.com

Toric Periphery Orthokeratology

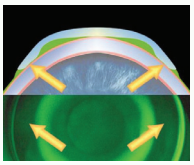


Toric Periphery Orthokeratology

• Toricity can improve centration treatment efficacy



reverse curve



alignment curve

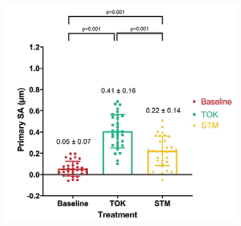
VOTE Study

- Visual Outcomes for Toric Efficacy
- 30 non-presbyopic adults (18-39 years)
- Up to -5.00 D myopia and 1.25 - 3.50 D astigmatism
- Crossover study, wore toric orthokeratology (TOK) and soft toric multifocal lenses (STM) for 10 days each with 2-week washout in between washout in between

Peripheral Myopic Defocus

Tomiyama ES, Berntsen DA, Richdale K. *Invest Ophthalmol Vis Sci*. 2022;63(8):10.

Spherical Aberration



Tomiyama ES, Hu C, Marsack JD, Richdale K. *Ophthalmic Physiol Opt*. 2021;41(4):726-735. Gambra E, Wang Y, Yuan J, Kruger PB, Marcos S. *Vision Res*. *Vision Res*. 2010;50(19):1922-1927.

Summary

- In patients with moderate to high astigmatism, both soft toric multifocal lenses and toric orthokeratology lenses are options
- Toric orthokeratology provided more myopic defocus and induced greater higher-order aberrations

Clinical Implementation

When to Start

- Start as early as possible
  - As soon as the child can handle CL wear
- Talk to parents about myopia management even before the child becomes myopic if:
  - Either parent is myopic
  - Any family history of high myopia, RD

Deciding Which Treatment: Atropine vs. Contact Lenses Contact Lenses

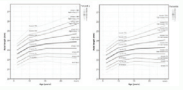
- Child's age and maturity level
- Parent's level of control/involvement
- Visual needs
- Ability to handle any side effects

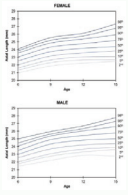
Deciding Which Treatment: Orthokeratology vs. Soft Soft Multifocal

- Child's age and maturity level
- Parent's level of comfort/control with daytime vs. nighttime wear
  - Familiarity with the two modalities
- Refractive error
  - Ortho-K limited to -6 D myopia and -1.75 D astigmatism
- Add power and amount of peripheral plus that is achievable
- Safety profile
- Corneal curvature relative to the amount of myopia

Growth Curves

	Percentile	Female		Male	
		European	Chinese	European	Chinese
6 years	25	21.66	22.03	22.14	22.55
	50	22.06	22.54	22.59	22.99
	75	22.49	23.04	23.01	23.50
9 years	25	22.33	23.16	22.83	23.70
	50	22.79	23.72	23.31	24.32
	75	23.25	24.31	23.79	24.89
15 years	25	22.68	23.83	23.17	24.39
	50	23.15	24.37	23.65	25.01
	75	23.65	25.20	24.21	25.80





Sanz Diez P, Yang L, Lu M, et al. Graefes Arch Clin Exp Ophthalmol 2019

Tideman JWL, Polling JR, Vingerling JR, et al. Acta Ophthalmol 2017

Determining Efficacy

	AGE	7	8	9	10	11	12
AXIAL LENGTH (mm)	Asian	0.52	0.46	0.41	0.36	0.32	0.28
	Non-Asian	0.35	0.31	0.28	0.25	0.22	0.20
REFRACTIVE ERROR (D)	Asian	-1.12	-0.94	-0.78	-0.66	-0.56	-0.50
	Non-Asian	-0.98	-0.82	-0.69	-0.56	-0.45	-0.35

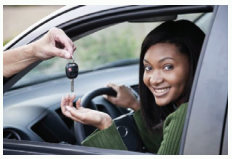
Donovan L et al. Optom Vis Sci 2012;89:27-32

https://www.seeyourabiliti.com/professionals/Managing-Myopia#Determining-Myopia

Visit Schedule

- Atropine: 1-week follow-up after first starting
- Orthokeratology: 1 day, 1 week, 1 month, 3 month follow-ups
- Soft multifocal lenses: 1-week follow-up

When to Stop



- Myopia can continue to progress into early adulthood
- Visual performance issues in teens may prompt "graduation" to single-vision lenses
- Continue to monitor progression after ceasing myopia control, can restart treatment if needed

Hrynchak PK et al. *Optom Vis Sci* 2013;90(11):1331-41.

COMET Group. *Invest Ophthalmol Vis Sci* 2013;54:7871-4.

When does myopia stabilize?

- COMET Study:
  - Large ethnically diverse group of 469 myopic children
  - Mean age at stabilization = 15.6 ± 4.2 years
  - Mean Rx at stabilization = –4.87± 2.01 D
  - No significant difference between sexes
  - African Americans stabilized earlier (13.8 years) and had less myopia (–4.36 D)
  - Participants with two myopic parents (vs. none) had -1.00 D more myopia at stabilization, but didn't differ in age of stabilization

COMET Group. *Invest Ophthalmol Vis Sci*. 2013;54(13):7871-7884.

When does myopia stabilize?

- Large variation in age of stabilization:
- 50% stabilize by 15 years 50% progress beyond 15 years
- 75% stabilize by 18 years 25% progress beyond 18 years
- 90% stabilize by 21 years 10% progress beyond 21 years
- 95% stabilize by 24 years 5% progress beyond 24 years

Questions?

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