

Issues and Challenges for Myopia Research

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Myopia is an ocular disorder of major public health and socioeconomic significance in many East Asian urban cities.¹ In Singapore, the prevalence of myopia is one of the highest worldwide, affecting 28% of school children at the start of their primary education and 70% of those completing university education.¹⁻³ Four of 10 adult Chinese people >40 years old have myopia.⁴ Of greater concern is that a substantial proportion of Singaporeans have high myopia, usually defined as a refraction of -6.0 D or higher. One in 10 adults has high myopia, compared to 1 in 50 in most Western populations.⁴ There is also increasing evidence that both prevalence and severity of myopia may be increasing. Serial cross-sectional data from military recruits and school children of similar ages in Singapore show that myopia prevalence has increased from the 1970s to the late 1990s.^{5,6} However, the definitions and measurement techniques of repeated surveys differ and may not be directly comparable.

What is the clinical and public health significance of these trends? Do we know what is the aetiology of myopia? Can we identify new and modifiable risk factors for myopia progression? Will therapies to halt progression of myopia become available? What are current and future challenges for myopia research? These and other issues are addressed in this issue of the journal.

Why do We Care about Myopia?

An important question is the clinical significance of myopia. There has long been a concern that blindness and visual impairment from myopia will lead to major public health problems for many countries in Asia.⁷ However, whether this will occur is not clear, and the exact ocular morbidity of myopia is not well-defined. Although blindness registry data indicate that myopia is the fourth leading cause of blindness in Singapore,⁸ these data are not representative of the general population. In fact, well-conducted population-based prevalence surveys in the United States (US) suggest that myopia is not a leading cause of either visual impairment or blindness in adults (although, admittedly, the rates of myopia are lower in the US).^{9,10}

High or pathological myopia has been associated with myopic macular degeneration, macular holes, retinal breaks and retinal detachment.¹¹ However, the significance of low and moderate levels of myopia, which affect the vast majority of the population, is unclear. We know even less about the clinical significance of pathological ocular complications, such as retinal breaks found in patients with longer axial lengths. Nonetheless, several recent large population-based studies suggest that even mild to moderate levels of myopia may be related to higher risk of cataract^{12,13} and glaucoma^{14,15} in adults >40 years of age. In addition, myopia has also been associated with diminished quality of life, visual function and lower utility values. A study of 112 adult myopic patients showed that patients with high myopia (refractive error at least -10.0 D) had significantly worse visual function and vision-related quality of life scores.¹⁶ The utility values of myopic high school children in Singapore are also lower.¹⁷

Beyond the medical implications, myopia incurs significant socioeconomic costs. Direct cost related to the correction of myopia, including refractive eyewear and surgery, is estimated to be in excess of SGD\$150 million a year.⁷ There are also substantial indirect costs related to treatment of myopia complications, such as retinal detachment and contact lens-related corneal ulcers.

Aetiology of Myopia: the Nature versus Nurture Debate

Despite several decades of research, the aetiology of myopia is unknown. The relative contribution of genetic predisposition (nature) versus environmental risk factors (nurture) has been the subject of much study and debate.¹⁸⁻²⁰ Several lines of evidence point to a strong genetic role. First, racial differences in myopia prevalence between different countries and, in Singapore, between

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different racial groups, point towards a genetic predisposition to myopia.¹⁸ In a recent study in Singapore, higher rates of myopia were seen in Chinese compared to Indian and Malay school children, despite controlling for education.²¹ Second, a consistent association between a parental history of myopia and development of myopia has been documented.²²⁻²⁴ This relationship remains after controlling for similar lifestyle habits in parents and children.¹⁹ Third, data from twin studies show significantly greater concordance in myopia rates among monozygotic compared to dizygotic twins.²⁵ Finally, genetic studies have identified several loci for certain pathological variants of myopia.^{26,27}

In support of an “environmental” contribution of myopia, population-based studies have shown higher myopia prevalence⁴ and longer axial lengths²⁸ in younger compared to older cohorts (suggesting changing environmental factors over time). Environmental factors could explain the rapid increase in myopia rates in a few decades in populations where the gene pool remains the same. High incidence and progression rates of myopia have been reported in individuals who spend long hours on near-work activity, such as carpet weavers, visual display terminal workers and microscopists.²⁹⁻³¹ Several environmental risk factors for myopia, including higher educational attainment, higher socioeconomic status and increased amount of near-work activities, are well-documented in children^{32,33} and adult^{4,34} populations. However, the exact mechanism of how these factors induce the development and progression of myopia remains controversial.

Recent research has also identified several novel risk factors for myopia. Of these, “night-light” as a potential risk factor has generated the greatest controversy and media attention.^{35,36} Dietary factors have also been recently suggested as possible risk factors for myopia.¹ These risk factors are potentially modifiable and deserve further investigations. However, it is difficult to obtain accurate recall data on night-light habits before 2 years or nutrient data in the young child.

Future Research Direction

As this issue of *Annals* will show, much needs to be done in myopia research. Few experimental studies on animal models are available, but these experiments will offer critical insights into the possible mechanisms of action of these interventions and, therefore, their potential long-term impact on developing eyes. An accurate and precise quantification of “near-work activity” remains problematic and is another area of useful investigation.³⁷ Modifiable parameters of near work, such as posture while reading and breaks during reading and lighting, need to be further studied. In designing epidemiological studies to investigate risk factors of, and morbidity and complications for myopia, researchers should collect ocular biometric data, which may provide information beyond refractive data alone. Newer devices, such as non-contact optical biometry instruments, have been found to provide reliable and accurate axial length data, and may be used in large studies involving children. Other research areas should be concentrated on elucidating the genetic factors involved in the pathophysiology of myopia. Finally, the testing of novel therapeutic approaches in rigorous randomised controlled trials to obtain valid and unambiguous conclusions is critical, and is discussed in detail in the following article. Myopia affects a significant proportion of people of all ages. Tackling this problem will, therefore, necessarily require a multi-disciplinary approach involving laboratory scientists, clinicians, ophthalmologists and other public healthcare providers.

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