Review Article

The Epidemiology of Myopia in Hong Kong

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Abstract

__Introduction__: **The prevalence of myopia amongst the Chinese has escalated in recent decades. While this refractive error was previously a little more than an inconvenience and a source of unwanted expense to the affected individuals, it is now sufficiently prevalent to warrant national concern. Myopia is also a major cause of low vision. This review aims to provide information on the prevalence of myopia in the Chinese community in Hong Kong.** __Materials and Methods__: **Based on a number of studies carried out mainly at the Centre for Myopia Research in The Hong Kong Polytechnic University, myopia in the Chinese community in Hong Kong is described.** __Results__: **Infants in Hong Kong appear to have refractive errors similar to infants of European descent; however, by the age of 7 years myopia is already prevalent. The annual incidence of myopia thereafter averages 11% to 12%; by the age of 17 years more than 70% are myopic, and this prevalence is greater than in people of European descent. In Hong Kong, myopia is much less prevalent in the older generation.** __Conclusion__: **The increase in prevalence of myopia over a short period of time is postulated to be due to environmental factors. Children of Chinese descent have a susceptibility to environmental factors which cause myopia.**

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Introduction

Myopia is a refractive condition in which the image of a distant object is formed anterior to the retina of the unaccommodated (relaxed) eye. It occurs when the refractive power of the eye is too great compared to the length of the eyeball and this may occur because the eye has a greater refractive power, a longer axial length, or a combination of both. In fact, the axial length is nearly always too great compared to the refractive power and the myopic eye is, importantly, a long eye.[1]

The prevalence of myopia amongst the Chinese has escalated in recent decades.[2-5] While this refractive error was previously a little more than an inconvenience and a source of unwanted expense to the affected individuals, it is now sufficiently prevalent to warrant national concern.

Myopia is a major cause of low vision. Low vision means that vision is below a certain legally defined standard (which may vary from country to country) even with the use of an optical correction. The greatest cause of low vision in Hong Kong (HK) in the 1980s was cataract, followed by myopia and age-related macular degeneration.[6] Recent improvements to the healthcare system are likely to have significantly reduced the number of people with treatable cataract, so that myopia and age-related macular degeneration are probably the main causes of low vision in HK. It should be pointed out here that myopia, per se, is unlikely to cause low vision. Rather it is the sequelae of myopia, such as retinal detachment, which cause blindness.

Data collected in 29 provinces of the People's Republic of China (PRC) in the 1980s showed that refractive error was the greatest cause of blindness in that country after cataract.[7]

Myopia has financial implications for both affected individuals and the community. While the most obvious cost of myopia, that of spectacles or contact lenses, remains the responsibility of the individual, governments bear the costs of educating eye care professionals and providing healthcare and social services for those whose myopia results in visual impairment. The financial cost of myopia in 1990 in the United States, with a population of about 270 million and a myopia prevalence of about 30%,[8] was estimated to be US$4.8 billion.[9]

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The human cost of myopia, in terms of visual impairment, loss of productive life, stress on the individual and the family, and so on, is clearly considerable.

Singapore, Hong Kong and other Chinese communities are not merely faced with an ageing population, but with an ageing myopic population, in which (based on the increase in myopia prevalence) the incidence of retinal detachment and the prevalence of visual disability due to myopia-related pathology are likely to increase in the next two decades. Naturally, there is great concern over this situation among eye care professionals working in affected communities, and much work has been carried out to define the scale of the problem, to try to identify the causes, and most recently, to test possible myopia control treatments. Refractive surgery will not be considered in this paper, but it should be noted that surgery corrects myopia by reducing the refractive power of the cornea, whereas the cause of myopia is nearly always an enlarged eyeball. It is this enlarged eyeball that puts the myopic eye at risk for retinal detachment, for example, and so refractive surgery does not reduce the risks to vision associated with moderate to high degrees of myopia.

Measuring Myopia

The quantification of myopia is not straightforward because refraction comprises 3 components, namely, sphere, cylinder and cylinder axis, all of which contribute to the visual outcome. Myopia is frequently quantified as the spherical equivalent refractive error (SERE), which is the algebraic sum of the sphere power plus half the cylinder power, the unit being dioptre (D). This is not an ideal method, but better alternatives[10,11] are considerably more complex and are not in common use, even among researchers. As this paper is intended for a general medical audience, SERE will be used, a minus sign before a dioptric value indicating myopia and a plus sign hyperopia (also called hypermetropia).

Refractive error is measured on a continuous scale, and the point at which myopia can be said to exist is not clear-cut. Most researchers define myopia as a SERE of either ≤–0.5 D or ≤–0.75 D. To give the reader a feeling for the dioptre scale used to measure refractive error, it may be helpful to consider a simple classification of myopia, much used in the past, and sometimes still used by clinicians.[12] In Hine’s classification, myopia of less than 3 D is termed “low”, that from 3 D to 6 D is termed “moderate” and that greater than 6 D is termed “high”. An individual with perfect vision (emmetropia) can see clearly in the far distance (at “infinity”); 1 D, 3 D and 6 D myopes see clearly at 1 m, 0.33 m and 0.16 m, respectively, objects further away appearing blurred.

Myopia in HK Infants

One of the first questions asked by myopia researchers in HK was, does myopia develop in Chinese children because they start life relatively more myopic than children of European descent (hereafter called “Western”), who are typically hyperopic in the first years of life. Using retinoscopy, an objective method of refractive error determination, Edwards[13] measured the refractive error of 158 full-term Chinese infants in HK, using cyclopentolate 1% (a cycloplegic agent which prevents accommodation). The mean SERE of 153 children (mean age, 10.8 weeks) was +2.47 D (SD, 1.61 D) and the prevalence of myopia at that age was zero. Other studies have varied in terms of subject age and cycloplegic agent used; however, the mean SERE in a comparable Italian study (except that tropicamide 0.5 % was used to produce cycloplegia) was +2.6 D.[14] Therefore, it seems likely that there is no great difference in SERE between European and Chinese infants, at least at this early age.

Table 1 shows longitudinal data from 50 of the 153 HK children who were followed up until approximately 40 weeks of age, and cross-sectional data from the Italian study. Firstly, notice that hyperopia decreased rather rapidly in the HK infants, whereas there was little change in the Italian infants over the same period. Secondly, note the decrease in the standard deviation (SD) of the mean in the Hong Kong subjects. This is a characteristic of a phenomenon known as emmetropisation, in which it is thought that the young eye, through some active mechanism, “grows towards emmetropia”. The idea of emmetropisation came about because refractive error in Western populations is not Gaussian in distribution, but rather is leptokurtic, with a preponderance of values around emmetropia. As will be seen shortly, this phenomenon is not seen in Chinese children, who indeed could be said to exhibit “myopisation”. In fact, emmetropisation nearly always refers to a reduction in hyperopia and, to the authors’ knowledge the only time when a reduction in physiological myopia has been recorded in humans is in premature babies.[15]

Astigmatism in HK Infants

Interestingly, astigmatism is rather common in both Western[16-19] and Chinese[13] infants. Unlike myopia and hyperopia, which are corrected by a spherical lens, astigmatism is corrected by a cylindrical lens that has direction, or axis, and power. Whereas the axis of astigmatism may be approximately horizontal or vertical in Western children, in astigmatic Chinese infants the vertical meridian of the cornea is almost invariably steeper than the horizontal one (so-called “with-the-rule” astigmatism), perhaps due to differences in eyelid structure.

Table 1. Figures for SERE in Infancy from Broadly Comparable Studies

Mean age (weeks) HK (Italian)	HK study SERE (SD) (D)	Italian study SERE (D)
11.3 (10)	+2.98 D (1.55)	+2.60
19.6 (20)	+1.97 D (1.47)	+3.00
28.4 (30)	+1.33 D (1.40)	+2.70
36.9 (40)	+0.80 D (1.19)	+2.50

D: dioptre; SD: standard deviation;
SERE: spherical equivalent refractive error
The HK study was longitudinal HK study and Italian one cross-sectional.[12,13] The Italian values were obtained by the present authors by interpolation of graphical data and so no SD values are available.

Edwards and Fan[20] followed up 32 children aged 7 to 8 years who had participated in the above-mentioned infant study.[13] They found that the incidence of SERE was significantly less but the incidence of astigmatism was significantly greater in infancy in children who were myopic at age 7 to 8 years. There was, however, extensive overlap in SERE between the children who were myopic at age 7 to 8 years and those who were not, and infant SERE was not a good predictor of myopia at age 7 to 8 years.

It is strange that astigmatism is found so frequently in babies and its effect on vision is uncertain. Degraded retinal images cause myopia in young animals.[21-23] It is possible that there is some link between infant astigmatism and the future development of myopia, and further research is needed in this regard.

Myopia in Kindergarten Children

Chan and Edwards[24] investigated refractive error in 570 HK children, aged from 36 to 65 months, from 3 kindergartens in HK. As 95% of children attend kindergarten, this population can be considered representative of the general population in this age range. The mean SERE in 84 children with a mean age of 38.3 months was +0.49 D (SD, 0.58 D) and in 150 children with an average age of 62.3 months the corresponding figure was +0.42 D (SD, 0.51 D). Bearing in mind that Edwards[13] found a mean SERE of 0.8 D at 37 weeks, it seems that there is little change in SERE between late infancy and at the age of about 5 years. Looking separately at the spherical and astigmatic components of refractive error, both of these appear to remain rather stable during this period.

Myopia in School Children and Young Adults

There have been a number of studies on the prevalence and incidence of myopia in HK children. In a cross-sectional study, Lam and Goh[3] found that the prevalence of myopia was almost 30% at age 6 to 7 years, just under 60% at age 10 to 11 years and 74% at age 16 to 17 years. There may have been an element of self-selection in the sample, which, as myopic families are more likely to have been interested in participating, is likely to have increased the prevalence of myopia especially in the younger samples which tended to be smaller in size. In a longitudinal study, Edwards[25] found a prevalence of 11% at age 7 years and 55% at age 12 years (n = 83). The sample had been originally recruited by a team studying growth and nutrition, and all 126 families in the growth and nutrition study, except for 3 for whom convenient appointments could not be arranged, took part in the myopia study. It is likely, therefore, to have been a representative sample. The prevalence of greater amounts of myopia (often called progressive myopia because it tends to increase or progress at a greater rate than lower types) was 1.6% at age 7 years. It is interesting to note that while the lower type of myopia (so-called physiological myopia) has increased in prevalence in the Chinese, progressive myopia seems, to have decreased (although evidence of this comes from Western populations).[26,27]

Most investigations on myopia in children have been school-based, and so the older samples are again biased as they do not include children who have left school at the age of 16 years. Given the evidence that children who perform well at school are more likely to be myopic than those who did not,[28,29] the prevalence in older children may also be overestimated.

Two longitudinal studies were carried out to determine the incidence rates of myopia. Lam et al[30] found an average incidence of 11.8% between the ages of 6 and 17 years (each age group was followed up over 2 years) and Edwards[25] reported rates varying from 9% at age 7 to 8 years to 18% at age 11 to 12 years, with an average incidence of 12.6%. In contrast, the average incidence in Finnish children seems to be between 2% and 3%.[31] Should a treatment to prevent myopia appear promising (most probably because it has been shown unequivocally to retard myopia progression), it will be difficult (and perhaps also unethical) to maintain an untreated control group and so incidence figures will be valuable.

In the 2 longitudinal studies carried out in HK, the annual changes in refractive error in children with myopia averaged –0.51 D and –0.46 D, whereas in children who were not myopic the corresponding figures were –0.1 D and –0.17 D.[25,30] These progression figures are valuable to researchers trying to establish whether a treatment for myopia has any efficacy, as a knowledge of the expected change is needed in the calculation of subject numbers.

Myopia is also the most common refractive condition in young adults. Goh and Lam[32] found that 71% of a sample of 122 subjects aged 19 and 39 years were myopic. However, the prevalence of myopia is likely to be overestimated as the sample was taken from those attending a vision screening programme; however, it is clear that the incidence of myopia was much more prevalent than in European population of the same age group (in which 50% to 60% of hyperopia was reported).[33] Ho and colleagues[34] found myopia to be present in 87% of a cohort of 2000 first year medical students in HK and 22% had myopia of 6 D or more.

Myopia in Older Adults

It is clear that the prevalence of myopia is much less in older adults. This is not because myopia decreases as individuals age, but because older members of the Chinese community did not develop myopia during their teenage years as their sons and daughters have done. In a study carried out 10 years ago, Lam et al[4] found myopia in 46% of their sample aged 40 to 44 years (these individuals are now in their mid-50s) with a steady decease in prevalence to only 8.6% in individuals aged 65 years and over (now aged approximately 75 years and over). Over the age ranged studied, the prevalence of myopia was 29%. This is less than half the prevalence in younger people, and importantly suggests that visual complications due to myopia could double in the coming years.

Nature or Nurture

The difference in myopia prevalence between generations yields important clues as to the possible causes of the myopia "epidemic" in younger people. It seems certain that both heredity and environment play a role in the development of myopia;[35] however, a change occurring over such a short period of time must be due to environmental influences. It is clear that great changes have occurred in the lifestyles of Chinese communities over the past three or four decades, particularly with regards to education, and one or more of these lifestyle factors may be critical.

The different interactions between heredity and the environment in 3 generations have been described by Wu and Edwards.[36] The odds of having myopia were 0.06, 0.26 and 0.35 for grandparents, parents and children, respectively. Parents whose own parents (the study grandparents) were myopic were more likely to be myopic themselves compared to cohort members whose parents were not myopic (odds ratio, 6.71), thus showing a genetic influence. However, the genetic influence was much diluted in the children's generation (odds ratio, 1.85) because of an increase in the likelihood of myopia in children whose parents were not myopic, this suggesting an increasing environmental effect.

Myopia Control

Given the threat to vision posed by axial elongation due to moderate and higher degrees of myopia, there is considerable interest in retarding the development of myopia and many myopia control methods have been promoted over the years. These have included the use of bifocal lenses, rigid contact lenses, vision therapy, biofeedback training, undercorrection or overcorrection of prescription spectacles, use of base-in prisms and the use of cycloplegic agents such as atropine. No method has been unequivocally shown to retard myopia development (see Grosvenor[37] for a comprehensive review). One HK study[38] indicated that use of progressive addition lenses (PALs) retarded myopia development; however, a more recent and larger clinical trial[39] did not find either a statistically or clinically significant difference in myopia progression over 2 years between 121 children who wore PALs and 133 children in a control group who wore conventional spectacle lenses. Subjects in the PAL group progressed by just 0.14 D less than subjects in the control group, over 2 years. A similar study carried out in the US found that subjects in a PAL group progressed by 0.2 D less than those in a control group over a 3-year period,[40] a difference which again is clinically insignificant. The results from a number of similar studies in Chinese populations are awaited.

Conclusion

Such great increases in myopia prevalence over one or two generation strongly suggest that Chinese children have a susceptibility to some environmental factor, or factors, which result in excessive eye growth, and thus in myopia. Unfortunately, recent research has not determined the factors involved, nor has it resulted in a treatment to prevent the development of myopia or to slow down the progression of myopia once it is present. As the myopia "epidemic" is a relatively recent event, the causative environmental factors are likely to be linked to recent changes in lifestyles in Chinese communities, with intensive and competitive education being implicated. It is difficult for physicians to know how to advise concerned parents when a child with myopia is progressing rapidly. For the time being, the best advice is probably the maintenance of a healthy lifestyle, with school activities balanced by others that do not involve intensive near work.

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