The Effect of Parental History of Myopia on Children’s Eye Size and Growth: Results of a Longitudinal Study

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PURPOSE. To evaluate the effect of parental myopia on eye size and growth in Chinese children.

METHODS. A school-based, cross-sectional survey was performed in Chinese children 5 to 16 years of age. A longitudinal cohort study was conducted 1 year later. The effects of parental myopia, parental education level, and near work performed by the child on the refractive error and ocular biometry of the child were assessed.

RESULTS. There were 7560 children enrolled in the initial study (response rate: 76.3%). One year later, 4468 children (response rate: 75.9%) in the original cohort (with the exception of those who had completed primary schooling) were evaluated, to determine eye growth. Although children with a stronger parental history of myopia tended to be less hyperopic before the onset of myopia (spherical equivalent refraction [SER] = 0.43 D, 0.67 D, and 0.68 D in children with two, one, and no myopic parents respectively; P = 0.007), the axial lengths did not follow the same pattern (axial length [AL] = 23.11, 23.07, and 23.15 mm; P = 0.429). Eye growth and myopic shift in refraction occurred more rapidly among children with a stronger parental history of myopia (annual AL growth/myopia progression = 0.37 mm/year, 0.22 D, 0.26 mm/year, 0.07 D, and 0.20 mm/year, 0.02 D in children with two, one, and no myopic parents, respectively; P < 0.001).

CONCLUSIONS. Ocular biometric data in Chinese children suggest that parental history of myopia influences the growth rate of the eye, rather than its size before the onset of myopia, as previously reported in Caucasian children. Further longitudinal studies involving children of different ethnicities are warranted. (Invest Ophthalmol Vis Sci. 2008;49:875–876) DOI:10.1167/iovs.06-1097

Myopia occurs due to a mismatch between the refractive power and length of the eye, which results in image formation anterior to the retina.1 Although epidemiologic studies have identified age,2–8 gender,2–7 parental history of myopia,1,3,9 parental education,10 and the amount of near work performed by the child1,3,10–12 as risk factors for the development of myopia in children, the relative contributions of genetic and environmental factors is still unclear.

To investigate this important question, Zadnik et al.1 evaluated the correlation between eye size and parental history of myopia in a cohort of Caucasian children. Their results indicated that children with myopic parents had longer eyes, even when myopia was not present, suggesting the influence of parental history of myopia on axial length of the offspring. Because of the cross-sectional design of the study, the role of this factor in determining the pattern of eye growth in these children could not be assessed.

It is recognized that the prevalence of myopia among Chinese children is much higher than among children of European descent.2 Although the reasons for this difference are still unclear, it is likely that epidemiologic studies in different populations may provide important information. We therefore performed a study using the cross-sectional methodology of Zadnik et al.1 in a cohort of Chinese school children. We subsequently performed a longitudinal follow-up study on the original cohort to evaluate the effect of parental history of myopia in determining the ocular growth patterns of children.

METHODS

A school-based prevalence survey on myopia was conducted in Hong Kong from September 1998 to August 2000. A report on the sampling methodology, prevalence, incidence, and progression of myopia, in this cohort of Chinese children has been published.2 In brief, cluster sampling was used for the random selection of one primary school from each of the 19 school districts in Hong Kong, and from each selected school, two to three classes were randomly selected for the study. All children in the selected classes, with the exception of non-Chinese children and those with eye disease such as amblyopia, squint, or cataract, were invited for an ophthalmic examination.

All examinations were conducted in the schools during school hours, by optometrists from the Chinese University of Hong Kong. Examinations included best corrected distance visual acuity testing, cycloplegic autorefraction, and measurements of ocular dimensions with ultrasonic biomicroscopy. Distance visual acuity of each eye was measured with the Early Treatment Diabetic Retinopathy Survey (EDTRS) chart at 6 m with standard lighting. Cycloplegia was achieved by using 1 drop of combined 0.5% phenylephrine and 0.5% tropicamide eye drops (Mydrin PR; Santen, Osaka, Japan) instilled three times in the inferior conjunctival cul-de-sac, at intervals of 15 minutes. Automated refraction was performed with an autorefractometer (Topcon KR-7100 autorefractometer; Topcon Corp., Tokyo, Japan), 30 to 60 minutes after completion of the drug regimen. Three reliable readings were obtained in each eye, and the average of these values was used for analysis. Ultrasound biomicroscopy (Compuscan; Storz Ophthalmic Inc., St. Louis, MO) was performed after cycloplegia, and anterior chamber depth, lens thickness, vitreous chamber depth, and axial length were measured. Three reliable readings were obtained, and the average of these values was used for analysis. All the equipment was maintained...
in satisfactory working condition, and reliable performance was assured by routine quality control programs.

Questionnaires
To determine the genetic and environmental influences on myopia, we asked the parents to complete a questionnaire regarding their myopia status and educational level. A parent was considered myopic if he or she was using any form of optical correction for distance vision before the age of 16 years. Educational level was categorized as: college or above, secondary school, and primary school or below.

Parents and teachers were also asked to estimate quantitatively the amount of near work performed by the child during the 1-week study period, using a diary to minimize recall bias. Teachers were asked to fill out the diary at the end of each classroom period and parents on a half-hourly basis at home, while their child was awake. If their child received supplementary classes after school hours, parents were also asked to include the estimated near work during these times. The diary provided detailed information regarding the duration and distance at which a variety of common visual tasks including reading, writing, television watching and computer-related activities were performed by the child.

The concept of dioptric hours (DH) was previously suggested by Zadnik et al. as a weighted measure of near work. It is calculated by adding three times the number of hours spent reading + two times the number of hours spent playing video-type games + the number of hours spent watching television. The same definition of near work quantification was used in the present study.

Longitudinal Study
All schools participating in the original cross-sectional study were revisited 12 months after the initial examination. With the exception of children who were in the most senior class during the initial study, all children who had participated in the study were invited to participate in the longitudinal follow-up study (the children in the senior class had finished primary schooling and were now in different secondary schools and hence were not included in the follow-up study). Identical ophthalmic examinations were repeated to determine the progression of myopia and change in ocular parameters among these children.

Definitions and Data Analysis
Spherical equivalent refraction (SER) was calculated as the algebraic sum of the sphere and half the cylinder. Myopia was defined as an SER of \(-0.50\) D or less. The examination was repeated in 50 randomly selected study subjects after 2 weeks, to assess the reliability of the ophthalmic examination test results. The between-test correlation coefficients of the right eye SER and axial length data were 0.85 (95% confidence interval \([CI] = 0.70 - 0.93\)) and 0.78 (95% \(CI = 0.58 - 0.89\)), respectively.

Analysis of covariance was performed with commercial software (SAS ver. 8.01; SAS Institute Inc., Cary, NC), modeling refractive error and each of the ocular biometric values as a function of parental history of myopia, adjusting for age, gender, parental education, and near work performed by the child.

The study protocol complied with the tenets of the Declaration of Helsinki, and informed consent was obtained from the parents of all participating students. The institutional review board of the Chinese University of Hong Kong approved the study protocol.

RESULTS
In the initial cross-sectional study, 9904 primary school children were selected within the sampling frame, and of those, 196 were excluded because of eye diseases other than refractive errors (143 strabismus, 48 amblyopia, 5 cataract, and 2 glaucoma). Among the remainder, 7560 children varying in age from 5 to 16 years (mean, 9.3 ± 1.2 [SD]) participated in the study, including 5743 (49.5%) girls and 3817 (50.5%) boys. The response rate was 76.3%. There was no statistically significant difference in age between the participants and the nonparticipants (\(P = 0.359\)). Among those taking part in the study, a high correlation between SER of the right and left eyes was found (Spearman \(ρ = 0.935\)) and data from right eyes was chosen for analysis. In the longitudinal study, one school did not participate in the follow-up test, because of its having been relocated. The number of eligible children was 5885. A subset of 4468 children from the original cohort was re-examined 1 year later, for a response rate of 75.9%.

Children with two myopic parents and one myopic parent were, on average, \(-0.95\) and \(-0.40\) D more myopic, respectively, than children with no myopic parents (\(P < 0.001\); Table 1). The effect of parental history of myopia was assessed by comparing the axial lengths and the dimensions of various ocular components between children with different numbers of myopic parents (Table 1).

AL before the Onset of Myopia
A separate analysis (Table 2) was performed on the data from children without myopia. In this premyopia subgroup, children with two myopic parents (mean SER = 0.43 D) were the least hyperopic, compared with children with one (mean SER = 0.67 D) and no (mean SER = 0.68 D; \(P = 0.007\)) myopic parents. However, although the mean AL of children with two myopic parents (23.11 mm) was longer than that of children with one myopic parent (23.07 mm), children with no myopic parents (23.15 mm) had the longest AL (Table 2). There were no significant differences in the vitreous chamber depth (\(P = 0.324\)), anterior chamber depth (\(P = 0.100\)), and lens thickness (\(P = 0.747\)) among children with a different number of myopic parents.

The comparison between the ALs of all children and premyopic children with different numbers of myopic parents is shown in Figure 1.

Table 1. Mean Refractive Errors and Dimensions of Ocular Components of Myopia of All Children, Grouped by Parental History of Myopia

<table>
<thead>
<tr>
<th>Myopic Parents</th>
<th>Children (n)</th>
<th>Refractive Error (SER) (D)</th>
<th>Anterior Chamber Depth (mm)</th>
<th>Lens Thickness (mm)</th>
<th>Vitreous Chamber Depth (mm)</th>
<th>AL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>2846</td>
<td>-0.98</td>
<td>3.56</td>
<td>3.64</td>
<td>16.46</td>
<td>23.65</td>
</tr>
<tr>
<td>One</td>
<td>2560</td>
<td>-0.43</td>
<td>3.57</td>
<td>3.65</td>
<td>16.28</td>
<td>23.51</td>
</tr>
<tr>
<td>None</td>
<td>2154</td>
<td>-0.05</td>
<td>3.57</td>
<td>3.65</td>
<td>16.25</td>
<td>23.47</td>
</tr>
<tr>
<td>(P^*)</td>
<td>&lt;0.001</td>
<td>0.524</td>
<td>0.211</td>
<td>0.010</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

\* Trend statistic (adjusted for age, gender, parental education, and near work performed by the child).
Eye-Growth Rate and Parental History of Myopia

The average rate of myopia progression as measured by cycloplegic autorefraction was $0.40 \pm 0.30$ D per year. We found a strong positive dose–response relationship between parental history of myopia and progression of myopia in children who were initially nonmyopic in the cross-sectional study ($P < 0.001$; Table 3). Children with two myopic parents had the greatest annual myopia progression (mean $0.22$ D) and AL growth (mean $0.37$ mm), followed by children with one myopic parent (mean myopia progression $0.07$ D; mean AL growth $0.26$ mm) and children with no myopic parents (mean myopia progression $-0.02$ D; mean AL growth $0.20$ mm; all $P < 0.001$). Vitreous chamber data showed the same pattern ($P < 0.001$).

DISCUSSION

Though it is the leading cause of low vision among Chinese school-aged children, much of the pathophysiology of myopia remains a mystery. The stimuli for myopization, the receptors in the eye, and the processes involved in eye growth are still being evaluated. Zadnik et al. previously proposed three possible mechanisms for excessive eye growth in myopia—the eye that is destined to be myopic may be normal in size at birth, but elongates rapidly during growth, resulting in myopia. The eye may be elongated initially and undergoes a normal pattern of growth during the onset of myopia; a combination of these two growth patterns results in myopia.

Ocular biometry provides information on how the known risk factors such as parental myopia cause myopia in the growing eye, as well as the relative contributions of each ocular component in myopia’s development. In a cohort of Caucasian children, Zadnik et al. found that premyopic children with two myopic parents had longer eyes and less hyperopic refractive errors than did children with only one or no myopic parents, suggesting that the premyopic eyes in children with parental history of myopia resembled the elongated eye seen in myopia, even before the onset of myopia. On the other hand, our study of preschool children found no relationship between parental myopia and the AL of the child. Because of the cross-sectional design of both studies, the pattern of growth of these eyes and the subsequent occurrence of myopia could not be ascertained. The age groups of the subjects in the study by Zadnik et al. and the present study were similar, allowing a direct comparison of results. The proportion of excluded myopic subjects was higher, however, in the present study (45.7%, 3454/7560) than the study by Zadnik et al. (7.5%, 54/716).

The present study design permitted a longitudinal follow-up to determine the effect of parental myopia on eye growth during childhood. Before the onset of myopia, Chinese children with two myopic parents were less hyperopic than were children with either one or no myopic parents (Table 2).

### Table 2. Mean Refractive Errors and Dimensions of Ocular Components with Myopic Children Excluded, Grouped by Parental History of Myopia

<table>
<thead>
<tr>
<th>Myopic Parents</th>
<th>Nonmyopic Children, n (% of All Children)</th>
<th>Refractive Error (SER) (D)</th>
<th>Anterior Chamber Depth (mm)</th>
<th>Lens Thickness (mm)</th>
<th>Vitreous Chamber Depth (mm)</th>
<th>AL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>796 (28.0)</td>
<td>0.43</td>
<td>3.49</td>
<td>3.67</td>
<td>15.95</td>
<td>23.11</td>
</tr>
<tr>
<td>One</td>
<td>1385 (54.1)</td>
<td>0.67</td>
<td>3.52</td>
<td>3.68</td>
<td>15.88</td>
<td>23.07</td>
</tr>
<tr>
<td>None</td>
<td>1925 (89.4)</td>
<td>0.68</td>
<td>3.53</td>
<td>3.66</td>
<td>15.95</td>
<td>23.15</td>
</tr>
<tr>
<td>$P^*$</td>
<td></td>
<td>0.007</td>
<td>0.100</td>
<td>0.747</td>
<td>0.324</td>
<td>0.429</td>
</tr>
</tbody>
</table>

* Trend statistic (adjusted for age, gender, parental education, and near work performed by the child).

![Figure 1](http://iovs.arvojournals.org/pdfaccess.ashx?url=/data/journals/iovs/933445/)
However, their ALs (23.11 mm) were only intermediate between children with one (23.07 mm) and no (23.15 mm) myopic parents (Fig. 1). In our longitudinal study, we found a positive dose–response relationship between AL growth and parental history of myopia in these children, with an average annual growth of 0.37, 0.26, and 0.20 mm in children with two, one, and no myopic parents, respectively ($P < 0.001$, Table 3). Vitreous chamber data showed a similar positive dose–response relationship.

In summary, parental history of myopia showed a positive correlation with refractive state, refractive error change and AL change in the nonmyopia group in the present cohort. The association between parental history of myopia and AL in the nonmyopia group was statistically nonsignificant, compared with the previous finding by Zadnik et al.1 Although we are unable to explain this difference, we find it interesting and believe that similar studies in different populations may be warranted.

Our study also had limitations. First, a high proportion of children, especially children with two myopic parents, became myopic after 1 year of follow-up and were therefore excluded from the longitudinal analysis. This finding is consistent with the high annual incidence rate of myopia in the same cohort of 10% to 20% reported in our previous study.2 We believe insofar as there is an adequate number of nonmyopic children remaining in the longitudinal study to provide sufficient statistical power, the exclusion of this proportion of children should not invalidate our subsequent analysis. The sample size in the present study was relatively large, and even when 72% (2846) of children with two myopic parents were excluded, there were still 796 children remaining in the analysis, compared with the entire cohort of 662 children in the study described by Zadnik et al.1 Second, our biometric data and refractive error changes in students from 3 to 17 years of age. 


### Table 3. Change over 1 Year in Mean Refractive Errors and Dimensions of Ocular Components of Nonmyopic Children in the Cross-sectional Study, Grouped by Parental History of Myopia

<table>
<thead>
<tr>
<th>Myopic Parents</th>
<th>Children (n)</th>
<th>Refractive Error Change (SER) (D)</th>
<th>Anterior Chamber Depth Change (mm)</th>
<th>Lens Thickness Change (mm)</th>
<th>Vitreous Chamber Depth Change (mm)</th>
<th>AL Change (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>324</td>
<td>−0.22</td>
<td>0.19</td>
<td>−0.03</td>
<td>0.18</td>
<td>0.37</td>
</tr>
<tr>
<td>One</td>
<td>702</td>
<td>−0.07</td>
<td>0.19</td>
<td>−0.03</td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>None</td>
<td>1602</td>
<td>−0.02</td>
<td>0.18</td>
<td>−0.02</td>
<td>0.02</td>
<td>0.20</td>
</tr>
<tr>
<td>$P^*$</td>
<td></td>
<td>&lt;0.001</td>
<td>0.622</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

$^*$ Trend statistic (adjusted for age, gender, parental education, and near work performed by the child).