Original Article

# Myopia Progression Among Preschool Chinese Children in Hong Kong

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## Abstract

**Introduction: Myopia is the most common eye disorder especially in Asia. However, the information on myopic progression and ocular growth among preschool children, who undergo rapid changes, is limited. The aim of this study was to determine the prevalence, incidence of myopia and myopic progression among preschool children in Hong Kong. Materials and Methods: A kindergarten was randomly chosen in Hong Kong, China. Preschool children aged 2 to 6 years attending the selected kindergarten were invited to participate. One hundred and eight children completed the 5-year cohort study. Refractive error and axial ocular dimensions were the main outcome measures. Results: A total of 255 preschool children with a mean age of 4.96 (SD, 0.90) years were examined in the initial examination. Only 4.6% children had myopia of at least –0.50 D. The prevalence of myopia increased almost 10-fold to 43.5% after 5 years in the final examination. The annual incidence of myopia was 8.2%. The mean increase in axial length was 1.72 mm (SD, 0.80 mm) over the 5-year period (*P* <0.001). The lens thickness decreased significantly from 3.80 mm (SD, 0.37 mm) to 3.74 mm (SD, 0.51 mm) whereas the vitreous chamber depth increased significantly from 15.01 mm (SD, 0.68 mm) to 16.42 mm (SD, 0.88 mm) (both *P* <0.001). Children who were younger or were less hypermetropic at the initial examination was having greater myopic progression (*P* = 0.015, *P* <0.001 respectively). Conclusion: This is the first prospective study to investigate the myopic progression and ocular growth among preschool children. Hong Kong has a high prevalence of myopia even in preschool children. They also experience a significant myopic shift and ocular growth. Further studies on the prevention of myopic development or progression should be targeted on this population.**

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**Key words: Longitudinal study, Myopia, Myopic progression, Ocular biometry**

## Introduction

Myopia occurs when the image of distant objects, focused by the cornea and lens, falls in front of the retina. It is the commonest eye problem worldwide.[1-4] Its prevalence varies in different parts of the world – myopia occurs in 25% of the adult population in the United States,[5] while it may be present in up to 70% to 90% in some Asian populations.[6,7] The impact of myopia is also great. All myopes must endure with the physical encumbrance and the financial burden of spectacles or contact lens throughout their lives. The need for optical correction in school myopes has significantly affected the social activities of millions of individuals during their productive years. Moreover, sight-threatening complications often develop at their prime age. Myopia accounts for 12% to 55% of retinal detachment among patients.[8-11] It is the seventh leading cause of registered blindness in adults in the United States[12] and Europe.[13,14]

Hong Kong is currently facing a similar problem of myopia as its Asian counterparts such as Taiwan and Singapore do. In these countries, myopia is characteristically severe with high and increasing prevalences.[5,15-17] The reasons why Asian countries have such a myopia epidemic compared to the United States and Europe remain unclear. However, Hong Kong seems to have most of the features common among these countries. We are mainly populated with Chinese ethnic groups. Our lifestyle is highly competitive, and the environment is congested. Students have very heavy schoolwork. Education, prevention and healthcare planning will be possible and effective only when the prevalence and the risk factors of myopia with specific relevance to Hong Kong are known. Apart from

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having a high prevalence, myopia is also having earlier onset in Chinese population.[18] Previously reported studies on myopia prevalence and progression were concentrated on older school children. Moreover, these studies were often cross-sectional.[19] There is little information on myopic progression in preschool children, whose visual system has not matured yet. Therefore, we conducted a cohort study to investigate the prevalence, the incidence, and myopic progression among preschool children in Hong Kong.

## Materials and Methods

Over 95% of children aged 2 to 6 years were studying in kindergartens according to the Hong Kong census.[20] There were 771 kindergartens in Hong Kong. One kindergarten was randomly selected. Non-Chinese subjects and those with diagnosed eye diseases, such as glaucoma, cataract or squint, were excluded from the study. All children studying in the kindergarten were invited to participate after obtaining parental written consents. In order to encourage participation, the investigators arranged meeting with the principal, the students, and parents before the recruitment to explain the objectives and procedures of the project. The study was approved by the Ethics Committee of The Chinese University of Hong Kong, and the measurements followed the guidelines of Declaration of Helsinki. Written informed consents were obtained from parents and verbal consent from the preschool children.

The study commenced in May 1995 and completed in May 2000. The children underwent ocular examination twice, one at the beginning in the kindergarten and the other at the end of the 5-year study period in our clinic. Since all children graduated from kindergarten, the participants were contacted through telephone calls and mails. The examinations in the initial and final examinations were carried out by the same optometrist. When she was carrying out the final examinations, she was masked with the initial examination results. Both eyes of all the subjects were examined. The examination included visual acuity measurement, cover and uncover test to determine strabismus, and ophthalmoscopy to exclude ocular anomalies. The pinhole visual acuity was tested by Sheridan Gardiner test in the first visit and by Snellen chart in the second visit. Best-corrected visual acuity would be measured when the visual acuity was less than 6/9. The participants received topical 1.0% tropicamide (Mydriacyl, Alcon-Couvreur, Puurs, Belgium) and topical 1.0% cyclopentolate (Cylopentolate Thilo, Dr Thilo & Co, Gmbh, Freiburg) eye drops 10 minutes apart thrice. Cycloplegic refraction would be determined by autorefractometer (Topcon KR-7100, Topcon, Tokyo, Japan) 30 minutes after the last drop. Three reliable readings were obtained from each eye, and the average values were used for analysis. Ultrasound biomicroscopy (Storz Compuscan, Storz Ophthalmic Inc., St Louis, United States) was performed after instilling one drop of paracaine 1% eye drops (Alcaine, Alcon-Couvreur, Puurs, Belgium). The ocular parameters recorded included anterior chamber depth, lens thickness, vitreous chamber depth and axial length. Three reliable readings were obtained, and average values were used for analysis.

The ocular and medical histories of the children were explored from questionnaire completed by parents. Children with best-corrected visual acuity worse than 6/9, systemic and ocular diseases other than minor external eye inflammation or allergies were excluded. The refractive error was taken as the spherical equivalent refraction (SER) in diopters, and calculated as the power of the sphere plus half of the cylindrical power. Eyes with a SER from –0.49 D to +2.00 D were classified as emmetropic, –0.50 D or less as myopic, and more positive than +2.00 D as hypermetropic.[21] Myopic progression was defined as the difference between the final SER in 2000 and the initial SER in 1995. Paired *t*-test was used to compare the SERs and ocular dimensions between initial and final examinations. Association of SER, ocular dimension and age were assessed by Pearson correlation. Statistical significance was accepted for tests with *P* values of less than 0.05 (2-tailed).

## Results

Two hundred and fifty-five children out of the 307 students (83.1%) participated in the study in 1995. One hundred and eight children (42.4%) completed the 5-year cohort study. The reasons for refusal of follow-up included children having moved to another region, their receiving eye care from other clinics and refusal of cycloplegics. There was no significant difference in SER in the initial examination between those who participated and those who did not participate in the study ($P$ = 0.38). Their mean age in 1995 was 4.96 years [standard deviation (SD), 0.88], with a range of 3.42 to 7.25 years. Fifty-one children (47.2%) were boys and 57 children (52.8%) were girls.

### *Refraction and Ultrasound Biometry Result at Initial Examination*

The mean SER, measured by cycloplegic autorefraction, of the right eyes of 255 children participated in the initial examination was +0.77 D (SD, 0.80 D), with a range of –0.88 D to +4.88 D (Table 1), while that of the left eye was +0.85 D (SD, 0.81 D), with a range of –0.88 D to +5.00 D. There was no significant difference between the SERs of the 2 eyes ($P$ = 0.13). The mean axial length of the right eyes at the initial examination was 21.99 mm (SD, 0.77 mm), with a range of 20.10 mm to 23.99 mm (Table 2), whereas the figure for the left eye was 21.90 mm (SD, 0.98 mm), with a range of 18.04 mm to 23.70 mm. There was no statistical difference between the axial lengths of the 2 eyes ($P$ = 0.200). Since the findings of the right and left eyes were similar and showed no statistical difference, the data of the right eye were chosen for analysis.[22]

The distribution of SER was shown in Figure 1. Most of the children were emmetropia (91.7%). Hypermetropia accounted for 3.7% of the subjects. Five children (4.6%) were having myopia. There was no difference between the SERs of boys and girls (*t*-test, $P$ = 0.209). The SER was significantly correlated with the axial length of the eyes (r = –0.341, $P$ <0.001).

Table 1. Spherical Equivalent Refraction and Axial Length of the Right Eye of the 108 Children

| Spherical equivalent refraction | Initial examination | Final examination | *P* value |
|---|---|---|---|
| Mean (SD) | +0.77 D (0.80 D) | –0.44 D (1.72 D) | <0.001 |
| Range | –0.88 D to 4.88 D | –5.13 D to 3.50 D | |

SD: standard deviation

Table 2. Change in Ultrasound Biometry

| | Initial examination Mean (SD) | Final examination Mean (SD) | *P* value |
|---|---|---|---|
| Anterior chamber depth | 3.18 mm (0.36 mm) | 3.18 mm (0.36 mm) | 0.072 |
| Lens thickness | 3.80 mm (0.37 mm) | 3.74 mm (0.51 mm) | <0.001 |
| Vitreous depth | 15.01 mm (0.68 mm) | 16.42 mm (0.88 mm) | <0.001 |
| Axial length | 21.99 mm (0.77 mm) | 23.69 mm (0.92 mm) | <0.001 |

SD: standard deviation

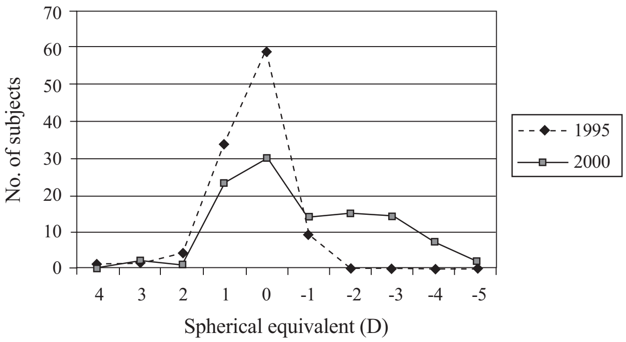


Fig. 1. Distribution of spherical equivalent refraction.

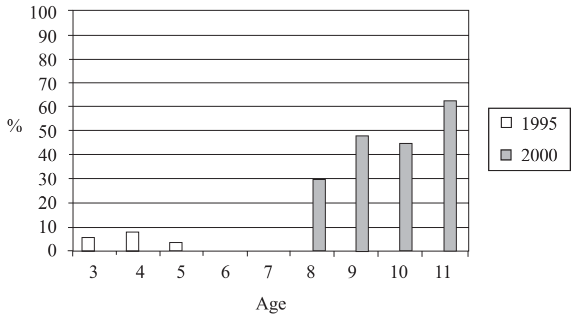


Fig. 2. Prevalence of myopia with age.

### *Refraction and Ultrasound Biometry Result at the End of the Study*

The mean SER of the right eye after 5 years was –0.44 D (SD, 1.72 D) with a range of –5.13 D to +3.50 D (Table 1). The distribution of SER shifted towards myopia (Fig. 1). Change in SER during the follow-up interval ranged from –5.25 D to +1.13 D, with a mean of –1.20 D (SD, 1.39 D). There was a significant change between the SERs at the initial and the final examinations (*P* <0.001).

The prevalence of myopia (SER ≤–0.50D) increased almost 10-fold to 43.5% at the end of the study (Fig. 2), whereas the percentage of emmetropia dropped to 54.6% and that of hypermetropia to 1.9%. The incidence rate was defined as the number of new cases during a specified period divided by the population at risk.[23] Forty-two children became myopic during the study period. The incidence of myopia over the 5-year period was 40.8%, which resulted in an annual rate of 8.2%.

The mean axial length of the right eye was 23.69 mm (SD, 0.92 mm), with a range of 21.64 mm to 26.1 mm in 2000. The mean change in axial length in the 5-year study was 1.72 mm (SD, 0.8 mm) with a range of 0.03 mm to 4.35 mm. This increase was statistically significant (*P* <0.001). The growth in component of the eye was summarised in Table 2. Over the 5-year period, the mean lens thickness reduced from 3.8 mm (SD, 0.37 mm) to 3.74 mm (SD, 0.51 mm) (*P* <0.001). Vitreous depth was the only ocular component that had significantly increased in length during the study period (*P* <0.001). The growth of the eyeball was mainly attributed to the increase in vitreous cavity. Moreover, there was a negative correlation between the changes in SER and axial length (r = –0.615, *P* <0.001).

### *Risk Factors for Myopic Progression*

The change in SER (*P* = 0.938) and axial length (*P* = 0.378) showed no differences between boys and girls. Younger children were having greater myopic progression (r = –0.193, *P* = 0.045) and axial length change (r = –0.216, *P* = 0.028).

Myopic progression (*P* = 0.002) and the increase in axial length (*P* = 0.015) in children with SER less than or equal to zero were significantly higher than those with SER greater than zero at the beginning of the study (Table 3). In addition, when the age was controlled, the final SER was also positively correlated with the initial SER at the beginning of the study (*P* <0.001).

## Discussion

It has been recognised that infants, on average, are hypermetropic, and this gradually decreases during development. The process of emmetropia occurs largely by the

Table 3. Comparison of Spherical Equivalent and Axial Length Between Children with Spherical Equivalent ≤0.00 D and >0.00 D

| | Spherical equivalent (≤0.00 D) | | Spherical equivalent (>0.00 D) | |
|---|---|---|---|---|
| Number of cases | | 15 | | 93 |
| Mean SE in 1995 (SD) | –0.33 D | (0.35 D) | 0.95 D | (0.71D) |
| Mean SE in 2000 (SD) | –1.70 D | (1.58 D) | –0.23 D | (1.66 D) |
| Mean axial length in 1995 (SD) | 22.40 mm | (0.70 mm) | 21.93 mm | (0.76 mm) |
| Mean axial length in 2000 (SD) | 24.22 mm | (0.75 mm) | 23.60 mm | (0.92 mm) |

SD: standard deviation; SE: spherical equivalent

age of 2 years but may continue until 4 years of age.[24,25] The refractive errors in preschool children have been reported in various studies.[26-28] However, those studies were limited by their cross-sectional nature. Our study is the first prospective study to investigate myopic progression and also ocular dimension changes in preschool children. The average age of children recruited in our study was 4.96 years. Although most of the children were emmetropic, a significant percentage (4.6%) of them were having myopia of at least –0.50 D. This figure is higher than that reported in the United States (3%).[27] The mean SER in our study population was 0.77 D, which also indicated that our population was also less hypermetropic than those in other reports.[27] The population of Hong Kong, both children and adults, suffers a higher prevalence of myopia compared to other populations.[1-6] Our results showed that this is also true for preschoolers. In summary, children in Hong Kong are not only at a higher risk of developing myopia, but they also develop it at an earlier age.

The annual incidence of myopia (8%) among preschool children was found to be high. In addition, a significant myopic shift was observed among them. The average spherical equivalent refraction was –0.44 D 5 years after the initial examination. Emmetropisation was reported to be finely regulated and completed by about 4 years of age. However, our subjects, whose average age was 4.96 years, still experienced a significant mean refractive error change of –1.20 D. These changes were accompanied by significant increase in ocular growth. The mean change in axial length in the 5-year study was 1.72 mm. Over this period, there was a significant reduction in lens thickness from 3.80 mm to 3.74 mm. On the other hand, vitreous depth increased significantly from 15.01 mm to 16.42 mm. To the best of our knowledge, our study is the first study to investigate ocular dimension changes in preschool children. This might provide information on the ocular growth of normal preschool children, and facilitate quantitative comparison of children with diseases and help diagnose abnormal refraction in young children. On the other hand, only 42.4% of the children in the original cohort participated in the 5-year follow-up study. This is a drawback of the study. However, we found that there was no statistical significant difference in initial SER between those who participated and those who did not participate in the study.

In summary, emmetropia was present in 91.7% of preschool children. As age increased, there was a steady shift in the distribution of refractive error from hypermetropia towards myopia. The prevalence of myopia increased almost 10-fold from 4.6% to 43.5% over 5 years. The mean myopic progression was –1.20 D, and the average ocular growth was 1.72 mm. Though the study was limited by the small sample size, it reflected the importance of myopia and myopic progression among preschool children in Hong Kong. In addition, myopic progression was more severe in children of younger age and also in children with higher myopic refraction. The study also found that myopic progression was related to the initial refractive error. The greater the myopic refraction at the beginning, the larger the myopic progression. Future studies should be directed towards preventing myopia development and myopic progression in preschool children at such a young age.

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