Prevalence, Incidence, and Progression of Myopia of School Children in Hong Kong

Dorothy S. P. Fan,[1] Dennis S. C. Lam,[1] Robert F. Lam,[1] Joseph T. F. Lau,[2] King S. Chong,[2] Eva Y. Y. Cheung,[1] Ricky Y. K. Lai,[1] and Sek-Jin Chew[3,4]

PURPOSE. To determine the prevalence, incidence, and progression of myopia of Chinese children in Hong Kong.

METHODS. A cross-sectional survey was initially conducted. A longitudinal follow-up study was then conducted 12 months later.

RESULTS. A total of 7560 children of mean age 9.33 (95% confidence interval [CI] = 9.11–9.45; range, 5-16) participated in the study. Mean spherical equivalent refraction (SER) was -0.33 D (SD = 11.56; range, -13.13 to $+14.25$ D). Myopia (SER ≤ -0.50 D) was the most common refractive error and was found in 36.71% $\pm$ 2.87% (SD) of children. Prevalence of myopia correlated positively with older age. Children aged 11 years were almost 15 times more likely to have myopia than were children younger than 7 years (Odds ratio [OR] = 14.81; 95% CI = 14.17–15.48). Incidence of myopia was 144.1 $\pm$ 2.31 (SD) per 1000 primary school children per annum. Increasing age was correlated with increased incidence of myopia, with highest risk in children ages 11 years (OR = 2.27; 95% CI = 2.11–2.44). The average annual change in SER for children with myopia (SER ≤ -0.50 D) was -0.63 D (SD = 3.44) compared with -0.29 D (SD = 2.96) for those who were not myopic at the beginning of the study ($P < 0.001$).

CONCLUSIONS. The results show that the prevalence and progression of myopia in Hong Kong children was much higher than those previously reported in Western countries. The long-term socioeconomic impact of these findings warrants further studies. (*Invest Ophthalmol Vis Sci.* 2004;45:1071–1075) DOI: 10.1167/iovs.03-1151

Myopia is the most common ocular disorder. All myopes must endure the physical and financial burden of spectacles and/or contact lenses throughout their lives. The need for optical correction in young myopes has affected career choices and social activities. Persons with a high degrees of myopia, particularly those with degenerative or pathologic changes, also have a higher chance of the development of permanent visual impairment or blindness from macular degeneration, retinal detachment, glaucoma, and cataract.[1–6] These myopia-related conditions also tend to occur at an earlier age than other common blinding disorders, such as diabetic retinopathy and age-related macular degeneration. The National Eye Institute[7] has estimated that costs of refractive eye examinations amount to $1 billion annually, with another $1.5 billion spent on eyeglasses each year.

Prevalence of myopia varies in different parts of the world. The Baltimore Eye Survey[8] and Beaver Dam Study[9] reported the prevalence in adults to be 22.7% and 26.2%, respectively. These rates seem low compared with recent data from East Asia. Japan[10] reported an overall prevalence of 50%. In the younger population, Taiwan[11] reported a prevalence of 84% in people by 16 years of age. Though there have been reports on prevalence of myopia, there is no population-based longitudinal study on the incidence of myopia and its progression among school children in Asia. In addition, reasons for myopia's being epidemic in East Asia but not in North America or Europe remain unclear. As myopia has an onset and progresses in childhood, it is important to focus research on these age groups. To date, no large-scale studies have been performed to address the prevalence, incidence, and severity of myopia in children of Hong Kong. However, we know Hong Kong children share most of the common features among other East Asian countries—namely, ethic Chinese living in highly congested environments with competitive lifestyles and heavy schoolwork. We sought to examine these important epidemiologic parameters and compare them with the published data. Prevention and healthcare planning for our next generation will be much facilitated when this important information is known. The study also has a component to investigate the risk factors of myopia and its progression, such as parental history of myopia, visual tasks, and astigmatism. We are in the process of finalizing the data analysis of this part of the study in preparation for another report.

METHODS

Study Population and Sampling

A school-based prevalence survey on myopia was conducted in Hong Kong from September 1998 to August 2000. Approval from the Ethics Committee of The Chinese University of Hong Kong was granted before the study commenced, and all ophthalmic examinations followed the guidelines of the Declaration of Helsinki. All children aged 6 to 15 residing in Hong Kong must attend school by local law. The study population included primary schools children, grades 1 to 6. There were 797 primary schools throughout the 19 school districts in Hong Kong with the exclusion of international schools and special schools for handicapped children. We randomly selected one primary school from each of the 19 school districts in Hong Kong. Invitation letters were sent to the school principal detailing the study objectives and procedures. When a selected school refused to participate, another school in the same district was selected randomly. Four of the 19 invited schools declined our invitation. Another four schools from the respective districts were invited, and they all agreed to participate in the study. From each school, two to three classes were randomly selected

TABLE 1. Prevalence of Emmetropia and Different Types of Refractive Errors in Primary School Children of Hong Kong

	Boys (n = 3817) % (SD)	Girls (n = 3743) % (SD)	All (n = 7560) % (SD)
Emmetropia			
(>−0.50 D and <+2.00 D SER)	60.1 (2.9)	58.4 (2.9)	59.3 (2.9)
Hyperopia (≥+2.00 D SER)	3.9 (1.2)	4.2 (1.2)	4.0 (1.2)
Myopia (≤−0.50 D SER)	36.0 (2.9)	37.4 (2.9)	36.7 (2.9)
Astigmatism (≤−1.00 cylinder)	19.4 (0.7)	16.7 (0.6)	18.1 (0.4)
Anisometropia			
(SER difference ≥ 1.00 D)	8.6 (0.5)	9.7 (0.5)	9.2 (0.3)

for the study, and all children in the selected classes were invited. Written consents from their parents were obtained before ophthalmic examinations. Non-Chinese subjects and those diagnosed with eye diseases such as amblyopia, squint, or cataract were excluded from the study.

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 distant visual acuity testing, cycloplegic autorefraction, and measurements of ocular dimensions with ultrasound. Distant visual acuity of each eye was measured using the Early Treatment Diabetic Retinopathy Survey (EDTRS) chart at 6 m with standard lighting. Cycloplegia was achieved using 1 drop of combined 0.5% phenylephrine and 0.5% tropicamide eye drops (Mydrin P; 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) between 30 and 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. The ocular parameters measured included anterior chamber depth, lens thickness, vitreous chamber depth, and axial length. 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.

Cohort Study

All schools were revisited 12 months after the initial examination, and all children who had participated in the study were reinvited. Children originally in the most senior class were excluded from this part of the study because most of them would have been attending a different secondary school. Identical ophthalmic examinations under the same settings by the same personnel as the initial part of the study were repeated to determine the incidence and progression of myopia among these children.

Definitions and Data Analysis

Spherical equivalent refraction (SER) was calculated as the numerical sum of the sphere and half of the cylinder. The negative cylinder method was used. Myopia was defined as SER of −0.50 D or less. Mild, moderate, and severe myopia was defined as −0.50 to −2.99 D, −3.00 to −5.99 D, and −6.00 D or more, respectively. Hypermetropia was defined as SER of +2.00 D or more. Astigmatism was defined as cylinder of −1.00 D or less. Anisometropia was defined as difference of SER of 1.00 D or more between the two eyes. The examination was repeated in 50 randomly selected study subjects after 2 weeks to assess the reliability of the ophthalmic examination tests. The intraclass correlation coefficient of the right eye SER and axial length were 0.85 (95% confidence interval [CI] = 0.70-0.93) and 0.78 (95% CI = 0.58-0.89), respectively.

The adjusted prevalence and incidence of myopia was weighted by the number of students in different school districts and school grades. The study population was selected randomly from a census provided by the Educational Department of Hong Kong, which recorded a total of 476,682 and 491,851 primary school children in the year 1998 and 1999, respectively. Two-sample *t*-tests were performed, and general linear models and logistic regression models were fitted with age and sex as covariates (SAS, ver. 8.01, SAS Institute Inc., Cary, NC).

RESULTS

Prevalence of Myopia

Initially 9904 primary school children were invited, 196 of them were excluded because of eye diseases other than refrac-

TABLE 2. Refractive Error among Primary School Children of Hong Kong

	Subjects (n)	Myopia			Refractive Error (SER)			
		Prevalence (%)	Odds Ratio	95% CI	Mean	*Coefficient	SE	P
Sex								
Female	3743	37.4	Reference	Reference	−0.29	Reference	Reference	Reference
Male	3817	36.0	0.96	0.939-0.976	−0.36	0.00	0.05	0.9397
Age (y)								
Below 7	1035	17.0	Reference	Reference	0.67 D	Reference	Reference	Reference
7	1194	28.9	2.55	2.44-2.67	0.44 D	−0.45	0.09	<0.0001
8	1210	37.5	4.31	4.12-4.50	0.00 D	−0.76	0.09	<0.0001
9	1134	43.1	7.12	6.82-7.45	−0.34 D	−1.25	0.09	<0.0001
10	1267	48.2	9.11	8.72-9.51	−0.77 D	−1.60	0.08	<0.0001
≥11	1720	53.1	14.81	14.17-15.48	−1.26 D	−2.17	0.09	<0.0001

Data are estimates of coefficient and standard error of a multivariate model; age and sex are covariates in the model.
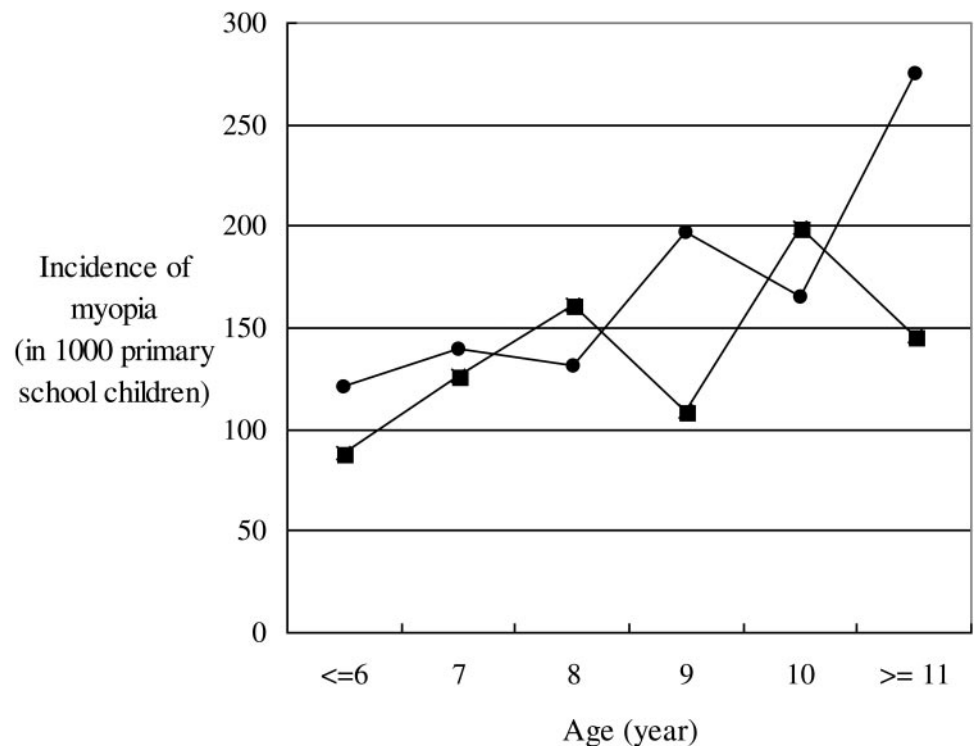* Coefficient, estimate of coefficient.

FIGURE 1. Incidence of myopia in primary school children of Hong Kong by age and gender. (■) Boys; (●) girls.

tive errors. Among them 143 had strabismus, 48 amblyopia, 3 cataract, and 2 glaucoma. A total of 7560 children participated in the study, including 3743 girls (49.51%) and 3817 boys (50.49%), aged 5 to 16 years (mean = 9.33 ± 1.18 [SD]). The response rate was 77.9%. There was no statistical difference in age between the participants and nonparticipants ($P = 0.359$).

A high correlation between SER of the right and left eyes was found ($\rho = 0.935$) and the refractive status of the right eye was chosen for analysis. The mean refractive error in the right eye of these children was −0.33 D (SD = 11.56; range, −13.13 to +14.25 D). The prevalence of emmetropia, hypermetropia, and myopia are shown in Table 1. Myopia was the most common type of refractive error. It was found in 36.71% ± 2.87% (SD) of the children. The average refractive error of these myopic eyes was −2.33 D (SD = 9.62 D). Mild myopia (−0.50 to −2.99 D) was found in 26.27% of children, moderate myopia (−3.00 to −5.99 D) in 9.47%, and severe myopia (≤ −6.00 D) in 1.19%. Astigmatism was the second most common refractive error, present in 18.1% ± 0.4% (range, −1.00 to −5.75 D) of the study subjects. The frequency of anisometropia was 9.2% ± 0.3% (range, 1.00–9.25 D).

Age and Gender Effects

A positive correlation between the prevalence of myopia and age was evident, with more than half of the children (54.52%) older than 11 years being myopic. Compared with children younger than 7 years, the average refractive errors for all other age groups were significantly more myopic (all $P < 0.0001$; Table 2). Boys on average had more myopic refractive error than girls, but the difference was insignificant ($P = 0.9397$). In multivariate models controlling for age and gender, increasing age was associated with increased risk of having myopia (Table 2). Children aged 11 years were almost 15 times more likely to have myopia than were children younger than 7 years ([OR] = 14.81; 95% CI = 14.17–15.48). Boys had a lower odds ratio of having myopia than girls (OR = 0.96; 95% CI = 0.94–0.98). The prevalence of myopia among boys was 37.1% compared

with 37.9% in girls after controlled for age. The odds ratio was close to 1.

Incidence of Myopia and Myopic Progression

Another part of the study is a 1-year longitudinal cohort study. Among the children who participated at the beginning of the study, 6443 were reinvited. One school, which moved to another district and included new students from the new district, was excluded from this part of the study. There were no statistically significant differences in the SER and axial length between participants at this school and other schools ($P = 0.283$ and 0.348, respectively). The final eligible study pool was 5885 children, among whom 4973 were successfully reexamined 1 year later. The response rate was 84.5%. There was no statistically significant difference in baseline SER between the participants and nonparticipants ($P = 0.136$).

Of the 3149 children who were not myopic at the initial examination, 454 were myopic in the second examination. The incidence of myopia was therefore 144.1 ± 2.31 per 1000 primary school children per annum. Incidences of individual gender and age groups are shown in Figure 1. Highest incidences were found in 10-year-old boys and 11-year-old girls, with annual incidence of 199.5 and 275.6 per 1000, respectively. Multivariate analysis showed that boys had a lower incidence of myopia than girls (OR = 0.86; 95% CI = 0.83–0.88). Increasing age was positively correlated with increased incidence of myopia, with highest risks in children aged 10 and 11 (OR = 1.93 and 2.27, respectively; Table 3).

The average rate of myopic progression as measured by cycloplegic autorefraction was −0.40 D per year (SD = 3.30 D). The average annual change in SER for children who were myopic (SER ≤ −0.50 D) was −0.63 D (SD = 3.44 D) compared with −0.29 D (SD = 2.96 D) for those who were not myopic at the beginning of study. This difference was statistically significant ($P < 0.001$). A higher degree of myopia at the beginning of the study was directly related to higher myopic progression (all $P < 0.001$, Table 4).

TABLE 3. Risk of Myopia Development in the Cohort Study among Primary School Children of Hong Kong

		Myopia		
	Subjects (*n*)	Mean Incidence Rate*	Odds Ratio	95% CI
Sex				
Female	2421	150.0	Reference	Reference
Male	2552	139.0	0.855	0.83–0.88
Age (y)				
Below 7	650	106.2	Reference	Reference
7	886	131.3	1.30	1.24–1.37
8	985	148.4	1.44	1.37–1.51
9	1111	149.6	1.51	1.44–1.59
10	1090	197.7	1.93	1.84–2.03
≥11	251	209.4	2.27	2.11–2.44

Data are odds ratios and 95% CI of a multivariate model; age and sex are covariates in the model.

* Mean incidence rate per 1000 primary school children per annum.

DISCUSSION

To our knowledge, this is the largest cross-sectional and longitudinal study examining the prevalence and incidence of myopia in school children. Few epidemiologic studies addressing similar issues had a comparable population size. Our children were selected randomly from all over Hong Kong and were of different academic and socioeconomic backgrounds. The response rates for the initial prevalence and the latter cohort study were good: 77.9% and 84.5%, respectively. We believed the children participated in the study were representative of the targeted population.

Our results showed that Hong Kong has one of the highest prevalences of myopia in the world (Table 5). Taking into account of the differences in myopic definition, study, and measurement methodology and age group compositions, Hong Kong still had a high percentage of myopic children. Our prevalence was three times that of the United States,[12] more than 10 times that reported from the Middle East, and nearly twice that in South America.[13,14] Our results, however, were comparable to our East Asian neighbors, such as Taiwan and Singapore where Chinese population predominated.[15–17]

A positive correlation between the prevalence of myopia and age within the range from 5 to 11 years was found. Our prevalence rates for children aged 7, 8, and 9 years (Table 2) were highly comparable to those recently reported in Singapore (27.6%, 34.6%, and 43.2%, respectively).[18] We found a lower prevalence and incidence of myopia among boys, with odds ratios of 0.96 (95% CI = 0.94–0.98) and 0.86 (95% CI = 0.83–0.88), respectively, compared with their age-matched counterparts. Lin et al.[14] also reported a lower prevalence and

less myopic refractive error among boys in Taiwan. A Finnish study[19] reported slower myopic progression in boys. One possible explanation would be that girls tend to read and write more, at least at primary school level. The subsequent increase in near-work predispose them to myopia development. Further studies are warranted to confirm such proposition.

Our 1-year cohort study found the incidence of myopia to be 144.1 per 1000 primary school children per annum, an increase from a previous study in Hong Kong in which the incidence was 118 per 1000 among children of age 6 to 17. The cohort was much smaller, with 142 school children using noncycloplegic refraction.[20] The average change in SER for children who were myopic (SER ≤ −0.50 D) was −0.63 D (SD = 3.44 D) compared with −0.29 D (SD = 2.96 D) for those who were not myopic at the beginning of study ($P < 0.001$). Similar difference in favor of nonmyopes was previously reported using noncycloplegic subjective refraction (−0.46 D vs. −0.17 D, respectively).[20] A Singaporean study[21] in children aged 6 to 12 reported the average annual change for children with SER more than −2.00 D and SER −2.00 D or less to be −0.56 and −0.65 D, respectively ($P < 0.0001$). Caution must be exercised when interpreting results from this latter study, because it recruited children participating in a clinical trial on control of myopia progression, rather than children in the general population.[21] Nonetheless, most reports so far support the hypothesis that myopic children have a greater myopic shift than do those without myopia.[22,23]

Mean rates of childhood myopia progression among white children in the United States[24–26] and the United Kingdom[27] were generally quoted in the range of −0.10 to −0.30 D per year, much lower than rates reported by Asian studies. This may be the result of the complex interaction between genetic and environmental factors unique to Asian children, such as genetic susceptibility, living in a congested environment, and highly competitive education systems. Further studies comparing children of different ethnicities living in identical environment with children of same ethnicity living in different environments would help to explore the observed differences.

Our study also had limitations. First, not all children in Hong Kong were included in the sampling frame. Children studying in international schools and special schools were excluded. Thus, our study results reflect only the prevalence and incidence of myopia in ethnic Chinese children studying at conventional Chinese primary schools in Hong Kong. Second, although we tried to improve the participation rate by conducting all examinations in schools, holding prestudy education seminars, and giving out information sheets to parents, 20% of all invited children still refused to participate. Third, even though the present study was the largest of its kind, our incidence and myopic progression rates were calculated based on only 1 year of follow-up. A longer follow-up would provide better knowledge on how incidence of myopia changes with

TABLE 4. Annual Change in SER among Primary School Children of Hong Kong

	Annual Change in SER			
SER at Beginning of Cohort Study	Mean (D)	*Coefficient	SE	*P*
Emmetropia (>−0.50 to <2.00 D)	−0.29 D	Reference	Reference	Reference
Low myopia (−0.50 to −2.99 D)	−0.63 D	−0.36	0.02	<0.001
Moderate myopia (−3.00 to −5.99 D)	−0.64 D	−0.37	0.03	<0.001
High myopia (≤−6.00 D)	−0.71 D	−0.44	0.09	<0.001

Data are estimates of coefficient and standard error of a multivariate model; age and sex are covariates in the model.

* Coefficient, estimate of coefficient.

TABLE 5. Comparisons with Studies of Other Regions

Country	Age (y)	Myopia Definition	Method	Prevalence (%)
Hong Kong	5-16	≤−0.50 D SE	Cycloplegic autorefraction	36.71
Chile[14]	5-15	≤−0.5 D SE	Cycloplegic retinoscopy	3.4-19.4
Sultanate of Oman[13]	6-12	≤−1.0 D SE	Cycloplegic retinoscopy	0.56-5.16
Taiwan[15]	6-12	≤−0.25 D SE	Cycloplegic autorefraction	12-56
Orinda, CA[12]	6-12	≤−0.5 D Sph	Noncycloplegic retinoscopy	<5-20

time, as well as the impact of a rapid growth spurt on the growth of the eyeball and progression of myopia.

In conclusion, Hong Kong has one of the highest prevalences of myopia in the world, and it is likely that both the rate and severity of myopia will increase over time. Similar epidemics are observed in our East Asian neighbors, creating important medical, social, and public health issues. With the availability of these basic epidemiologic parameters, we are now in a better position to explore the risk factors associated with myopia. Some postulations have already been made regarding the etiology of myopia—namely, increased near-work activity and intense schooling. More studies on the interaction between genetic and environmental factors are warranted.

References

1. Hochman MA, Seery CM, Zarbin MA. Pathophysiology and management of subretinal hemorrhage. *Surv Ophthalmol*. 1997;52:195-213.

2. Fan DS, Li KW, Lam DS. Retinal complications after cataract extraction in patients with high myopia. *Ophthalmology*. 1999;106:688-691.

3. Banker AS, Freeman WR. Retinal detachment. *Ophthalmol Clin North Am*. 2001;14:695-704.

4. Mastropasqua L, Lobefalo L, Mancini A. Prevalence of myopia in open angle glaucoma. *Eur J Ophthalmol*. 1992;2:33-35.

5. Galassi F, Sodi A, Ucci F. Ocular haemodynamics in glaucoma associated with high myopia. *Int Ophthalmol*. 1998;22:299-305.

6. Lim R, Mitchell R, Cumming RG. Refractive associations with cataract: The Blue Mountain Eye Study. *Invest Ophthalmol Vis Sci*. 1999;40:3021-3026.

7. National Advisory Eye Council, Strabismus and Amblyopia Panel. *Vision Research*: *A National Plan*; *1983-1987*. Washington DC: National Institutes of Health; 1987.

8. Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. *Invest Ophthalmol Vis Sci*. 1997;38:334-340.

9. Wang Q, Klein BE, Klein R, Moss SE. Refractive status in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci*. 1994;35:4344-4347.

10. Hosaka A. Population studies–myopia experience in Japan. *Acta Ophthalmol Suppl*. 1988;185:37-40.

11. Lin LL, Chen CJ, Hung PT, Ko LS. Nation-wide survey of myopia among school children in Taiwan, 1986. *Acta Ophthalmol Suppl*. 1988;185:29-33.

12. Maul E, Barroso S, Munoz SR, et al. Refractive error study in children: results from La Florida, Chile. *Am J Ophthalmol*. 2000;129:445-454.

13. Lithander J. Prevalence of myopia in school children in the Sultanate of Oman: a nation-wide study of 6292 randomly selected children. *Acta Ophthalmol Scand*. 1999;77:306-309.

14. Lin LL, Shih T, Tsai C et al. Epidemiology study of ocular refraction among schoolchildren in Taiwan in 1995. *Optom Vis Sci*. 1999;76:275-281.

15. Robinson BE. Factors associated with the prevalence of myopia in 6-years-old. *Optom Vis Sci*. 1999;76:266-271.

16. Zhan MZ, Saw SM, Hong RZ,et al. Refractive errors in Singapore and Xiamen, China: a comparative study in school children aged 6 to 7 years. *Optom Vis Sci*. 2000;77:302-308.

17. Zadnik K, Satariano WA, Mutti DO, Sholtz RI, Adams AJ. The effect of prenatal history of myopia on children's eye size. *JAMA*. 1994;271:1323-1327.

18. Saw SM, Chua WH, Hong CY, et al. Nearwork in early-onset myopia. *Invest Ophthalmol Vis Sci*. 2002;43:332-333.

19. Goldschmidt E. On the etiology of myopia: an epidemiological study. *Acta Ophthalmol*. 1968;98(suppl):1-172.

20. Lam CSY, Edwards M, Millodot M, Goh WSH. A 2-year longitudinal study of myopia progression and optical component changes among Hong Kong school children. *Optom Vis Sci*. 1999;76:370-380.

21. Saw SM, Nieto FJ, Katz J, et al. Factors related to the progression of myopia in Singaporean children. *Optom Vis Sci*. 2000;77:549-554.

22. Chew SJ, Ritch R, Leong YK, et al. The age of onset of myopia is a predictor of adult myopia severity. In: Shimizu K, ed. Current aspects in ophthalmology. *Proceedings of the XIII Congress of the Asia-Pacific Academy of Ophthalmology*. Kyoto, 12-17 May 1991, Vol 1. Amsterdam: Experpta Medica; 1992:680-685.

23. Watanabe S, Yamashita T, Ohba N. A longitudinal study of cycloplegic refraction in a cohort of 350 Japanese schoolchildren: cycloplegic refraction. *Ophthalmic Physiol Opt*. 1999;19:22-29.

24. Zadnik K, Mutti DO, Friedman NE, Adams AJ. Initial cross-sectional results from the Orinda longitudinal study of myopia. *Optom Vis Sci*. 1993;70:750-758.

25. Hirsch MJ. The changes in refraction between the ages of 5 and 14: theoretical and practical considerations. *Am J Optom Arch Am Acad Optom*. 1952;29:445-459.

26. Hirsch MJ. Relationship between refraction on entering school and rate of change during the first six years of school: an interim report from the Ojai longitudinal study. *Am J Optom Arch Am Acad Optom*. 1962;39:51-59.

27. Sorsby A, Leary GA. *A Longitudinal Study of Refraction and Its Components during Growth*. London: Her Majesty's Stationary Office; 1970.