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Family history, near work, outdoor activity, and myopia in Singapore Chinese preschool children

Wilson Low[1], **Mohamed Dirani**[2,3], **Gus Gazzard**[4], **Yiong-Huak Chan**[5], **Hui-Jun Zhou**[1], **Prabakaran Selvaraj**[1], **Kah-Guan Au Eong**[6,7,8,9], **Terri L Young**[10,11], **Paul Mitchell**[12], **Tien-Yin Wong**[1,2,3,9], and **Seang-Mei Saw**[1,3]

[1]Department of Epidemiology and Public Health, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

[2]Centre for Eye Research Australia, University of Melbourne, Melbourne, Australia

[3]Singapore Eye Research Institute, Singapore

[4]Glaucoma Research Unit, Moorfields Eye Hospital, London, UK

[5]Statistics Unit, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

[6]Department of Ophthalmology and Visual Sciences, Alexandra Hospital, Singapore

[7]Eye Clinic, Jurong Medical Centre, Singapore

[8]Singapore International Eye Cataract Retina Centre, Mount Elizabeth Medical Centre, Singapore

[9]Department of Ophthalmology, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

[10]Duke-National University of Singapore Graduate Medical School, Singapore

[11]Department of Ophthalmology, Duke University Medical Centre, Durham, North Carolina, USA

[12]Centre for Vision Research, University of Sydney, Sydney, Australia

Abstract

Aims—To investigate the risk factors for myopia, including near work and outdoor activity, in Singapore Chinese preschool children.

Methods—A cross-sectional study, with disproportionate random sampling by 6-month age groups, of 3009 Singapore Chinese children aged 6–72 months was performed. Information on family history, near work and outdoor activity was obtained. Spherical equivalent refraction (SEA) was assessed.

Correspondence to, Dr Seang-Mei Saw, Department of Epidemiology and Public Health, Yong Loo Lin School of Medicine, National University of Singapore 16 Medical Drive (MD3), Singapore 117597; ephssm@nus.edu.sg.

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Ethics approval Ethics approval was provided by the Institutional Review Boards of the Singapore Eye Research Institute (SERI) and the National Healthcare Group (NHG).

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Results—Children with two myopic parents were more likely to be myopic (adjusted OR=1.91; 95% CI 1.38 to 2.63) and to have a more myopic SER (regression coefficient=−0.35; 95% CI −0.47 to −0.22) than children without myopic parents. For each 1 cm taller height, the SER was more myopic by 0.01 dioptres. Neither near work nor outdoor activity was associated with preschool myopia.

Conclusions—A family history of myopia was the strongest factor associated with preschool myopia. In contrast, neither near work nor outdoor activity was found to be associated with early myopia. These data suggest that genetic factors may play a more substantial role in the development of early-onset myopia than key environmental factors.

INTRODUCTION

Myopia is a complex eye disease, in which both genetic and environmental factors contribute to its development.[1] Twin heritability, familial aggregation, pedigree segregation and linkage studies provide evidence to support a major genetic component influencing myopic development.[2–5] Additionally, environmental factors such as near work and outdoor activity appear to play an important role in the development of myopia.[6–8]

Our understanding of the risk factors for early-onset myopia remains limited. Most studies were undertaken in adults or children aged >6 years,[67] with few studies in children aged <6 years.[9–11] The Singapore Cohort Study of the Risk Factors for Myopia (SCORM) assessed Chinese children aged 7–9 years and found that children who read more than two books per week were more likely (OR=3.05; 95% CI 1.80 to 5.18) to develop higher myopia (spherical equivalent refraction (SER) at least −3.0 dioptres (D)) than those who read fewer than two books per week, and children with two myopic parents had a more myopic SER than children without myopic parents.[612] The Sydney Myopia Study (SMS) examined children aged 12–13 years and reported that continuous reading (>30 min) and close reading (<30 cm) were risk factors for myopia (OR=1.5; 95% CI 1.05 to 2.10 and OR=2.5; 95% CI 1.74 to 4.0, respectively), children who performed more outdoor activities were less likely to have myopia, and children with two myopic parents were more likely to be myopic (OR=7.9; 95% CI 5.0 to 12.4).[71314] However, whether near work and outdoor activity are significantly associated with myopia in very young children is presently unknown. Our study aimed to assess the roles of near work, outdoor activity and family history of myopia for early-onset myopia in Singapore Chinese children aged 6–72 months.

MATERIALS AND METHODS

Study population

The STrabismus, Amblyopia and Refractive error in Singaporean children (STARS) study is a population-based survey of Chinese children aged 6–72 months old residing in the government apartments in the south-western and western regions of Singapore. Disproportionate stratified random sampling of 6-month age groups (6–11.9 months, 12–23.9 months, 24–35.9 months, 36–47.9 months, 48–59.9 months and 60–72 months) was performed to sample identical numbers of children within each age strata and compute age-specific prevalence rates. Children with chronic medical conditions or those not living at the

household address for the past 6 months were excluded. A total of 3009 children (response rate=72.3%) underwent eye examinations between May 2006 and November 2008 at either of two examination sites: the Singapore National Eye Centre or the Jurong Medical Centre, Singapore. The STARS methodology is similar to that used by Multi-Ethnic Paediatric Eye Disease Study (MEPEDS)[15] and Baltimore Paediatric Eye Disease Study (BPEDS).[16]

Approval for STARS was obtained from the Institutional Review Boards of the Singapore Eye Research Institute and the National Health-care Group. The study complied with the tenets of the Declaration of Helsinki. Informed written consent was obtained from the children's parents after a verbal explanation of the study.

Eye examinations

The eye examinations were performed by trained eye professionals (one ophthalmologist, two optometrists and one orthoptist). After the administration of one drop of 0.5% proparacaine, cyclopegia was induced with one drop of 2.5% phenylephrine and three drops of 1% cyclopentolate (0.5% for children aged <12 months) instilled at 5 min intervals. Thirty minutes after pupillary dilation, children aged 12–23.9 months and 24–72 months underwent autorefraction using a hand-held Retinomax K-PLUS 2 (Right Medical, Virginia Beach, Virginia) and a table-mounted autorefractor Canon RK-F1 (Canon, Tokyo, Japan), respectively, to obtain five consecutive readings. If the children were aged <12 months or failed autorefraction, streak retinoscopy (Welch Allyn, Chessy, France) was performed. Both autorefractors were calibrated daily prior to testing. Our pilot study in 51 children showed a better validity comparing the streak retinoscopy with the table-mounted autorefractor than with the hand-held Retinomax autorefractor.[17]

Questionnaire

A comprehensive English- and Chinese-language questionnaire was administered by two trained interviewers. A range of data were collected, including demographic information and family ocular history. Parents gave details about the age at which they started to wear spectacles or contact lenses. If the parent used spectacles or contact lens for looking at far objects, the parent was classified as myopic.

Near work activities were recorded in number of hours per day. Activities included reading, colouring and drawing, watching television, playing television games, playing hand-held video games and using computers. Additionally, data on reading habits such as the age the child started reading, whether the child read for leisure, number of books read per week, amount of time spent reading before taking a break and frequency of close (<30 cm) reading, and child's preschool status were collected.

The outdoor activity questionnaire was similar to that used by SMS.[7] In summary, outdoor activity was separated into sporting activities and leisure activities, and was recorded in number of hours per week and number of hours per day, respectively. The presence of nearby park or garden and whether the children played in the park or garden were ascertained.

Height measurements

Height was measured in children aged >24 months using the height-measuring scale, Seca model 220 (Seca, Hamburg, Germany). For children aged <24 months, recumbent length was obtained using an infantometer (Kiddimetre; Raven Equipment, Dunmow, UK).

Definitions

As the SERB of the right and left eyes were highly correlated (Spearman correlation coefficient 0.95 and 0.98, respectively, p<0.001), only the right eye data were analysed. SER was defined as 'sphere plus half negative cylinder' Myopia was defined as an SER of at least −0.5 D.

Statistical analysis

The association between myopia prevalence and risk factors was identified by t test for quantitative variables or a χ^2 test for categorical variables. The interaction terms, age*gender, agetheight, age*parental myopia, height*gender, height*parental myopia and gender*parental myopia were not significant, p=0.99, p=0.47, p=0.91, p=0.39, p=0.96 and p=0.69, respectively. Logistic models were constructed, with myopia as the outcome variable and age, gender, height, parental myopia, time spent outdoors and reading words or pictures as the explanatory variables, with adjustment for familial clustering. Linear regression models were constructed with adjustment for the same factors to assess variables that predicted SER. Data analysis was performed using SPSS (version 17.0; SPSS, Chicago, Illinois) and Stata (version 10; Stata, College Station, Texas). Statistical significance was assumed as p<0.05.

RESULTS

A total of 3009 children aged 6–72 months (mean age=40.5 months) were examined, of which 1570 (52.2%) were boys, and 1439 (47.8%) were girls. SER were recorded in 2639 (87.7%) children (1375 (52.3%) boys and 1264 (47.9%) girls) aged 6–72 months. The mean SER for all children was 0.69 D (SD: 1.15 D). There was no significant difference between participants (n=3009) and non-participants (n=1155) for age (p=0.98) and gender (p=0.67). However, a greater proportion of participants lived in study areas closer to the clinical examination sites than non-participants (p<0.001).

Table 1 shows the risk factor prevalences of myopic and non-myopic children. The myopia prevalence in children who had one or two myopic parents was higher than in those without myopic parents (p<0.001). No significant difference in children's myopia prevalence was found for father's education (p=0.85), frequency of close reading (p=0.4), average duration of reading a book before taking a break (p=0.93), time spent on outdoor sports (p=0.56), living near a garden (p=1.0) or whether children played in the garden (p=0.34).

After adjusting for age, gender, height, time spent reading words or pictures alone, and outdoor activity, and myopia defined as an SER of at least −0.5 D, children with two myopic parents had an almost twofold higher risk of myopia compared with children with no myopic parents (table 2).

After adjusting for age, gender, height, time spent reading words or pictures alone and outdoor activity, for each increase in age by 1 month, the SER increased by 0.01 D ($p<0.001$). The SER also decreased by 0.01 D for each 1 cm taller height ($p=0.01$). The SER was significantly lower by 0.35 D ($p<0.001$) in children with two myopic parents versus no myopic parents (table 3). The SER for children with one myopic parent versus no myopic parents decreased by 0.11 D ($p=0.054$), but this association was only of borderline significance.

DISCUSSION

In this study of Chinese children aged <6 years, a family history of myopia was significantly associated with both myopia and a more myopic SER. Height was associated with a more negative SER. However, importantly, no significant association of near work or outdoor activity with myopia was found. These data suggest that genetic factors may play a more important role than environmental factors in determining early-onset myopia in Chinese preschool children.

Many studies have examined the risk factors for myopia, but these have been performed mostly in children aged >6 years. The SCORM evaluated risk factors for myopia in children aged 7–9 years[612] while the SMS examined children aged 6 years and 12 years.[7131418] However, active emmetropisation occurs during the young age while the eye undergoes rapid growth in the first 18 months of age.[19] Therefore, the risk factors for early-onset myopia may intrinsically be expected to differ between children aged <6 years and >6 years.

However, few studies have analysed the risk factors for early-onset myopia in children aged <6 years[9–11] A Hong Kong study that examined 514 Chinese children aged 2.3–6.4 years from two kindergartens did not demonstrate any associations either of family history of myopia or of near work with myopia.[9] A study[10] of 128 Singapore children aged 3–7 years from one kindergarten found no relationship between near work and myopia, while another Singapore study[11] of 414 children aged 4–6 years from two kindergartens reported an association between near work and myopia. The kindergarten studies were limited by a relatively small sample size and were conducted only in certain kindergartens.

The association of parental history with myopia and a more myopic SER in very young children in our study is consistent with previous studies in older children.[1214] The SMS assessed 2353 children aged 12–13 years, and found that children with two myopic parents were substantially more likely to be myopic (OR=7.9; 95% CI 5.0 to 12.4).[14] Among 1453 Chinese children aged 7–9 years from the SCORM, having two myopic parents was reported to be associated with a more negative SER.[12] However, family history of myopia could represent the effects of shared genes or shared environments. Parents who read more may encourage their children to read to the same degree. Nevertheless, Mutti *et al*[20] did not find any evidence to support a theory of inherited near work environment in the Orinda Longitudinal study suggesting that family history of myopia was due to heredity.

Few studies have examined height as a risk factor for myopia in children. The SMS of 1765 schoolchildren aged 6–7 years and the Tanjong Pagar Survey of 951 Singaporean Chinese

adult aged 40–81 years reported that height was not associated with SER.[1821] In contrast, our study showed that height was associated with a more negative SER, which parallelled the pattern found in the study of 1453 Chinese children from the SCORM.[12] This suggests that the developmental mechanisms responsible for the effects of height on SER appear conserved from very young Chinese preschool children to older Chinese school children.

Our study did not find that near work activity was independently associated with myopia in children aged <6 years. In contrast, near work appears to be an important risk factor for myopia in the older children.[613] In 1005 children aged 7–9 years from the SCORM, those who read more than two books per week had a greater risk (OR=3.05; 95% CI 1.80 to 5.18) of higher myopia (SER of at least −3.0 D) than those who read fewer than two books.[6] Continuous reading (>30 min) and close reading distance (<30 cm) increased the risk of myopia by 1.5-fold (95% CI 1.05 to 2.10) and 2.5-fold (95% CI 1.74 to 4.0), respectively, in 2353 children aged 12–13 years from the SMS.[13] Children aged <6 years may perform fewer near work activities because of a less intensive preschool curriculum compared with elementary school. Children in our study spent less time per week (12.46 vs 23.54 h) on mean total near work activities (the sum of reading, writing, computer use and crafts outside school) than older children from the SCORM.[22] Besides, the current literature suggests that the effect of near work on myopia appears most significant on children aged >6 years.[10112023–25] Mutti *et al*[20] studied 366 American children (mean age of 13.7 years) and found that the multivariate OR of myopia for each dioptre-hour per week was 1.02 (95% CI 1.008 to 1.032). Among 1378 Greek children aged 15–18 years, 43,1% of the myopic children studied >5 h per day compared with 28.6% of the non-myopic children (χ^2=37.36, p<0.001).[24] In 340 children aged 5–14 years from Newfoundland, Canada, the SER became more myopic by 0.43 D with each hour increase in near work after controlling for age, sex and education.[25]

As outdoor activity was recently shown to be another major environmental factor, it is possible that increased outdoor activity may protect against myopia.[78] Engaging in more outdoor activity was found to protect against myopia in 1249 Singapore children aged 11–20 years (OR=0.90; 95% CI 0.84 to 0.96).[8] Similarly, among 2367 children aged 12–13 years from the SMS, those spending the greatest time outdoors were less likely to be myopic.[7] However, we did not find any protective role in outdoor activity for myopia in children aged <6 years. A possible explanation is that these children may engage in less cumulative outdoor activity than older children who participate in compulsory physical education lessons, outdoor sports and school games.

The principal strength of STARS was its large population-based design coupled with a high response rate (72.3%). However, it had some limitations. Parental estimates of their children's near work or outdoor activity were subjected to misclassification bias. Non-participants could have differed from participants such that the risk factors for myopia may be distorted. Because this was a cross-sectional study, the temporal relation between myopia and its risk factors cannot be ascertained.

In conclusion, our study found an association of family history of myopia and height with myopic refraction in Singaporean Chinese preschool children aged 6–72 months. However,

key lifestyle factors such as near work and outdoor activity were not significantly associated with myopia in this study. These data suggest that the cumulative effects of near work and outdoor activity may only influence the development of myopia in older children during school years, so that genetic factors may play a more substantial role in the development of early-onset myopia.

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Table 1

Comparison of children with or without myopia by risk factors

		Myopic* (≤−0.5 D, n=301)		Non-myopic* (>−0.5 D, n =2338)		
	N	n		n		p Value
Father's education						
No/primary school (reference)	269	30	11.2%	239	88.8%	
Secondary school/N- or 0-Level	773	86	11.1%	687	88.9%	
Diploma/ITE/Certificate/A-level	707	77	10.9%	630	89.1%	
University education	826	101	12.2%	725	87.8%	0.85‡
No of myopic parents						
0	757	67	8.9%	690	91.1%	
1	1003	96	9.6%	907	90.4%	
2	874	138	15.8%	736	84.2%	<0.001‡
Hours of total near work activities per day	2629	299	4.00 (2.74)	2330	4.70 (2.86)	<0,001†
Reading activities						
Age of start reading (years)	1798	171	2.20 (1.04)	1627	2.60 (1.20)	<0.001†
No of books read per week	1720	165	5.90 (7.74)	1555	4.87 (7.44)	0.10†
Reads words alone						
Yes	994	156	15.7%	838	84.3%	
No	1613	139	8.6%	1474	91.4%	<0.001‡
Reads picture books alone						
Yes	581	100	17.2%	481	82.8%	
No	2037	196	9.6%	1841	90.4%	<0.001‡
Preschool activities						
Attends preschool						
Yes	166	21	12.7%	145	87.3%	
No	1744	157	9.0%	1587	91.0%	0.12‡
Age of starting preschool (years)	1749	158	2.55 (0.83)	1591	2.73 (0.87)	0.01†

		Myopic* (≤−0.5 D, n=301)		Non-myopic* (>−0.5 D, n =2338)		
	N	n		n		p Value
Hours of preschool per day	1752	158	4.81 (3.23)	1594	5.43 (3.23)	0.02†
Tuition outside school						
Yes	2224	267	12.0%	1957	88.0%	
No	415	34	8.2%	381	91.8%	0.03‡
Hours of tuition outside school per day	415	34	2.80 (3.41)	381	2.20 (2.05)	0.11†
Hours of leisure activities per day	2621	299	0.14 (0.35)	2322	0.18 (0.47)	0.04†
Hours of total outdoor activity per day	2634	300	0.77 (1.06)	2334	0.86 (1.22)	<0.17†
Hours of outdoor sports per day	683	65	0.35 (0.38)	618	0.33 (0.37)	0.56†
Plays in nearby garden						
Yes	832	103	12.4%	729	87.6%	
No	960	105	10.9%	855	89.1%	0.34‡

A-Level, advanced level; ITE, Institute of Technical Education; N-Level, normal-level; 0-Level, ordinary-level.

*Mean (SD) for continuous variables, percentages for categorical variables.

†t test.

‡χ^2 test.

Table 2

Risk factors associated with myopia among Singapore Chinese preschool children

	Myopia at least −0.5 D			
	Multivariate OR*	95% CI		p Value
Age (month)	0.97	0.95	0.99	0.01
Girl versus boy	1.02	0.79	1.31	0.91
Height (cm)	1.02	0.98	1.05	0.34
One myopic parent versus no myopic parents	1.04	0.75	1.46	0.81
Two myopic parents versus no myopic parents	1.91	1.38	2.63	<0.001
Time spent outdoors (h/day)	0.95	0.85	1.07	0.44
Read words or pictures (yes vs no)	0.80	0.56	1.15	0.23

* Model has adjusted for familial clusters and all other factors in the table.

Table 3

Risk factors associated with spherical equivalent refraction among Singapore Chinese preschool children

	Spherical equivalent retraction			
	Regression coefficient*	**95% CI**		**p Value**
Age (month)	0.01	0.00	0.02	<0.001
Girl versus boy	0.07	−0.02	0.16	0.12
One myopic parent versus no myopic parents	−0.11	−0.22	0.00	0.054
Two myopic parents versus no myopic parents	−0.35	−0.47	−0.22	<0.001
Height (cm)	−0.01	−0.02	0.00	0.01
Time spent outdoors (h/day)	0.03	0.00	0.07	0.07
Read words or pictures (yes vs no)	−0.06	−0.20	0.09	0.47
R^2	0.022			

*Model has adjusted for familial cluster and all other factors in the table.