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School grades and myopia

Seang-Mei Saw[1,2,3,5], Angela Cheng[2], Allan Fong[3], Gus Gazzard[4], Donald T. H. Tan[2,3,5] and Ian Morgan[6]

[1]Department of Community, Occupational and Family Medicine, National University of Singapore, 16 Medical Drive, Singapore 117597, [2]Singapore Eye Research Institute, Singapore, [3]Singapore National Eye Centre, Singapore, Singapore, [4]Institute of Ophthalmology, London, UK, [5]Department of Ophthalmology, National University of Singapore, Singapore, Singapore, and [6]ARC Centre of Excellence in Vision Science and Visual Sciences Group, Research School of Biological Science, Australian National University, Canberra, ACT, Australia

Abstract

Aim: To evaluate the association between school performance and myopia in Singapore children.
Methods: Children aged 10–12 years from two schools in the Singapore Cohort study Of the Risk factors for Myopia (SCORM) were included. Results of a Year 4 standard nation-wide examination were obtained. Cycloplegic autorefraction and A-scan ultrasound biometry measurements were performed in the schools.
Results: The odds ratio for myopia (defined as right eye spherical equivalent at least −0.5 D) was 2.5 (95% confidence interval 1.4–4.5) for children with average school examination scores in the fourth quartile compared with the first, after adjusting for confounders including reading in books per week and IQ test scores. Similar significant associations were found for English language ($p = 0.001$) and native language school examination scores ($p < 0.001$), while the associations with mathematics school examination scores were of borderline significance ($p = 0.055$).
Conclusion: School grades, a possible indicator of either cumulative engagement in near work activity or intelligence, were positively associated with myopia in Singapore children.

Keywords: academic achievement, epidemiology, myopia, refractive error, Singapore

Introduction

There is an epidemic of myopia in Asia, and a rate of myopia of 73.9% has been reported in 946 teenagers aged 15–19 years in Singapore (Quek *et al*., 2004). The exceptionally high rates of myopia in urban East Asian cities are associated with environmental changes, although a role for individual genetic predispositions cannot be excluded. The major environmental factor identified thus far from epidemiological studies is the number of years of schooling. More direct measures of near work such as the number of hours spent per day reading or the number of books read per week have also been assessed (Saw *et al*., 2002). These associations are often weak, however, possibly due to limited assessments of recent near work activity (Saw *et al*., 2002). A child's performance at IQ tests, a possible indicator of a child's general ability, has been linked to myopia (Rosner and Belkin, 1987; Williams *et al*., 1988; Saw *et al*., 2004). Performance in school may be a cumulative measure, which takes account of both ability and diligence. A previous study by Mutti *et al*. (2002) of 366 eighth grade children in the Orinda Longitudinal Study showed that children with myopia were more likely to have higher Iowa Test of Basic Skills (ITBS) Reading and Total Language scores ($p < 0.024$). We therefore aimed to examine the link between school grades and myopia in Singapore children.

Methods

A total of 740 children (50.3% boys and 49.7% girls) aged 10–12 years of 1018 (participation rate = 72.7%) from two schools enrolled in 1999 in the Singapore Cohort study Of the Risk factors for Myopia (SCORM) were included (Saw *et al*., 2002, 2004). Children were

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Correspondence and reprint requests to: Seang-Mei Saw.
Tel.: +65 6516 4989; Fax: +65 6779 1489.
E-mail address: cofsawsm@nus.edu.sg

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recruited into the SCORM study in 1999 if they were in grades 1–3 in either of the two schools. Children with chronic eye diseases such as congenital cataract and chronic medical disorders such as congenital heart disease were excluded. There were 550 Chinese, 136 Malays, 38 Indians and 16 of other backgrounds. A standard nation-wide examination comprising English language, mathematics and native language examinations was conducted for all Year 4 children in Singapore schools, and the results were obtained from the Ministry of Education. Data from the third school in SCORM (children enrolled in 2001) were not available because the Singapore government abolished the examination in 2003. The tenets of the Declaration of Helsinki were observed and the study was approved by the Singapore Eye Research Institute Ethics Committee. Informed written consent was obtained. The number of books read per week was determined by a parent-administered questionnaire that was translated in the Chinese and Malay languages (Saw *et al*., 1999), and the non-verbal Raven Matrix Test was administered by a team of psychologists in the schools. Three drops of 1% cyclopentolate hydrochloride (cyclogyl; Alcon-Couvrerur, Puurs, Belgium) were administered 5 min apart, and refraction measurements were obtained 30 min after the third drop using one of two table-mounted closed-field autorefractors (model RK5; Canon Inc. Ltd, Tochigiken, Japan). The average of five consecutive refraction measurements was obtained. One of two A-scan ultrasound biometry machines (Echoscan model US-800; Nidek Co., Ltd, Tokyo, Japan; probe frequency of 10 mHz) was used to obtain axial length, vitreous chamber depth, lens thickness and anterior chamber depth measurements. The average of six values was taken only if the standard deviation (S.D.) was less than 0.12 mm. If the S.D. of the six measurements was 0.12 mm or more, the six measurements were repeated until a S.D. of less than 0.12 mm was obtained.

Statistical methods

Spherical equivalent (SE) was defined as sphere plus half negative cylinder, and myopia was defined as SE of at least −0.5 D. English language, mathematics, native language scores and the average of all three scores were evaluated in quartiles. Multivariate logistic (myopia as the dependent variable) and linear regression models (refractive error as the dependent variable) were constructed using STATA version 8.0 (StataCorp 2001, College Station, TX, USA).

Results

The prevalence of myopia was 62.2%. Children with scores (average, English language, mathematics and native language) in the highest quartile had significantly higher IQ scores and read more books per week compared with the lowest quartile (*Table 1*).

Children with average examination scores in the highest quartile were 2.5 times more likely to be myopic compared with the lowest quartile, after adjusting for age, gender, race, school, parental myopia, father's education, reading in books per week and IQ test scores (*Table 2*). Consistent trends in odds ratios across quartiles of English language and native language scores were also found (all p's for trend < 0.001). Performance in mathematics was also associated with myopia, but this relationship did not reach statistical significance ($p = 0.055$). Similar results were found when the analyses were repeated in Chinese children only, except that mathematics scores in quartiles were not significantly associated with myopia (p for trend = 0.54). The multivariate-adjusted odds ratios of myopia for Chinese children with average scores, English language scores and native language scores in the fourth compared with first quartile were 1.94 [95% confidence interval (CI) 0.99–3.12], 1.89 (95% CI 0.95–3.76) and 2.50 (95% CI 1.37–4.57) respectively. The results were also repeated for 136 Malays only. In Malays, the multivariate analysis of trends of odds ratios for average scores (p for trend = 0.056), English language scores (p for trend = 0.054) and mathematics scores (p for trend = 0.080) were of borderline significance, and native language scores were not associated with myopia (p for trend = 0.15). There were only 38 Indians and multivariate analysis of trends of odds ratios of myopia were of borderline significance for average (p for trend = 0.068) and mathematics scores ($p = 0.036$), significant for English language scores (p for trend = 0.036), but not for native language scores ($p = 0.53$).

In multivariate analyses controlling for similar confounders, more negative refractions and longer axial lengths were significantly associated with examination scores (average, English language, native language) in quartiles. Higher mathematics scores were associated with more negative refractions ($p = 0.014$), but the association with axial length was only of borderline significance ($p = 0.085$).

Discussion

Singapore children who perform better in school tend to be myopic, even after adjusting for current reading and IQ test scores. This school-based study assessed academic achievement using standard nation-wide examination scores, and adjustments for possible confounding by reading or IQ score were performed. Although this is a cross-sectional study and temporal bias may exist, it is unlikely that because the child has

Table 1. Relationship of school examination scores with IQ test scores and the number of books read per week ($n = 740$)

School examination scores	*n*	Median IQ test scores (range)	Mean number of books read per week (S.D.)
Average scores			
Lowest quartile	186	38 (6–55)	2.1 (2.5)
Second lowest quartile	186	43 (13–54)	2.4 (2.1)
Second highest quartile	188	46 (28–58)	2.9 (4.3)
Highest quartile	180	49 (31–59)	2.9 (2.2)
p (trend)		<0.001	0.001
English language			
Lowest quartile	188	39 (6–53)	2.0 (2.1)
Second lowest quartile	195	43 (12–55)	2.5 (2.7)
Second highest quartile	178	45 (13–55)	3.0 (4.2)
Highest quartile	179	49 (30–59)	2.9 (2.1)
p (trend)		<0.001	<0.001
Mathematics			
Lowest quartile	188	37 (6–54)	2.2 (2.5)
Second lowest quartile	193	43 (13–55)	2.6 (2.4)
Second highest quartile	189	45 (28–58)	2.7 (4.0)
Highest quartile	170	49 (31–59)	2.9 (2.5)
p (trend)		<0.001	0.03
Native language			
Lowest quartile	190	40 (6–55)	2.0 (2.2)
Second lowest quartile	187	43 (12–58)	2.6 (2.4)
Second highest quartile	201	46 (20–56)	2.8 (4.1)
Highest quartile	161	47 (13–59)	3.0 (2.6)
p (trend)		<0.001	<0.001

Table 2. Multivariate odds ratios of myopia (spherical equivalent at least −0.5 D) for different quartiles of examination scores

School examination scores	*n*	Crude odds ratios (95% confidence interval)	*p* (trend)	Multivariate-adjusted* odds ratios (95% confidence interval)	*p* (trend)
Average scores					
Lowest quartile	186	1.0 (referent)	<0.001	1.0 (referent)	0.001
Second lowest quartile	186	2.1 (1.4–3.1)		1.6 (1.0–2.5)	
Second highest quartile	188	3.1 (2.0–4.8)		2.1 (1.2–3.4)	
Highest quartile	180	4.5 (2.8–7.0)		2.5 (1.4–4.5)	
English language					
Lowest quartile	188	1.0 (referent)	<0.001	1.0 (referent)	0.001
Second lowest quartile	195	2.2 (1.5–3.3)		1.8 (1.1–2.8)	
Second highest quartile	178	3.0 (2.0–4.7)		1.9 (1.1–3.2)	
Highest quartile	179	3.8 (2.5–5.9)		2.0 (1.1–3.5)	
Mathematics					
Lowest quartile	188	1.0 (referent)	<0.001	1.0 (referent)	0.055
Second lowest quartile	193	2.4 (1.6–3.7)		1.7 (1.1–2.7)	
Second highest quartile	189	2.6 (1.7–3.9)		1.4 (0.8–2.4)	
Highest quartile	170	4.2 (2.6–6.5)		1.9 (1.0–3.6)	
Native language					
Lowest quartile	190	1.0 (referent)	<0.001	1.0 (referent)	<0.001
Second lowest quartile	187	1.9 (1.3–2.8)		1.6 (1.0–2.5)	
Second highest quartile	201	2.5 (1.7–3.8)		2.1 (1.3–3.4)	
Highest quartile	161	3.5 (2.2–5.5)		2.6 (1.5–4.5)	

*Multivariate-adjusted odds ratios obtained from four logistic regression models of myopia as the dependent variable, with (1) average scores, (2) English language, (3) mathematics scores and (4) native language, adjusted for age, gender, race, school, parental myopia, father's education, reading in books per week and IQ test scores.

myopia, a child would perform better in examinations. Our findings are consistent with previous cross-sectional findings in the Orinda Longitudinal Study (Mutti *et al.*, 2002), in which myopic children had higher national reading, local reading and total language scores compared with non-myopic children.

School grades are a cumulative product of general academic ability and intelligence. School grades, especially for language-related subjects, may reflect the amount of cumulative near work, including time spent on schoolwork during the pre-school years. Children who spend more time reading or writing on school-related work may perform better in school tests. In addition, performance in school tests may reflect the total amount of time spent reading or writing from an early age. School grades may be influenced by the child's interest toward academic subjects. Parental interest and time devoted to helping their children with schoolwork may also influence a child's school performance. While there is a strong association between increased myopia and higher educational outcomes, associations between estimated near work and other measures such as numbers of books read account for $<10\%$ of the variance in refraction (Saw *et al*., 2004). This suggests that a more cumulative measure of educational intensity may be required. Nation-wide examination scores are aggregate measures of educational intensity and may capture elements of total near work activity related to education, possibly not quantified comprehensively in prior questionnaire-based assessments of recent near work. Reading in books per week was associated with high myopia in the SCORM study, but not reading in hours per week (Saw *et al*., 2002). Although it may appear that reading in hours per week may better capture reading activity, the parents of young children may find it more difficult to quantify a child's reading habits in hours per day and parents may have a better idea of the number of books their children read in a week. In the Orinda Longitudinal study, Diopter hours quantified as $3\times$ (hours spent studying or reading for pleasure), $2\times$ (hours spent playing video games or working on the computer) $+$ $1\times$ (hours spent watching television) was associated with increased odds of myopia (odds ratios 1.020; 95% CI 1.008–1.032) (Mutti *et al*., 2002).

On the other hand, children who are more intelligent perform better in school. Our findings thus also support the IQ score and myopia theory whereby children with higher IQ scores are more likely to be myopic. In another longitudinal study of New Zealand children, children who were myopic had higher verbal and performance IQs (Williams *et al*., 1988). Previous research has suggested that there may even be intrinsic differences in the IQ of myopic children when compared with hypermetropes that are not fully explained by differences in family background.

Interestingly, the associations of myopia with language examinations scores were stronger than with Mathematics examination scores. Children who performed better at language-based examinations were also slightly more likely to read more books per week, compared with children who performed well in Mathematics. This suggests that excellence in academic language performance may be partially due to increased reading activity.

Ethnic-specific analyses were conducted although this was not the primary aim of the study and the sample sizes for Malays only ($n = 136$) and Indians only ($n = 38$) were small. The trends of multivariate-adjusted odds ratios for myopia for quartiles of average examination scores were significant for Chinese only, and of borderline significance for Malays only and Indians only. The relationship between average scores and myopia was consistent within different ethnic populations.

In summary, our findings complement previous positive links between reading in books per week, IQ test scores and myopia in the SCORM study. In Singapore children, there is a positive association between school academic achievement and myopia, independent of associations with reading in books per week and IQ test scores. Further investigations, including analysis of the incidence of myopia from longitudinal data, need to be conducted to determine the causal relationships involved in these associations.

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