Eye (2008) 22, 649–656

www.nature.com/eye

CLINICAL STUDY

Ethnic differences in refraction and ocular biometry in a population-based sample of 11–15-year-old Australian children

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Abstract

Purpose **To examine the prevalence of refractive error and distribution of ocular biometric parameters among major ethnic groups in a population-based sample of 11–15-year-old Australian children.**
Methods **The Sydney Myopia Study examined 2353 students (75.3% response) from a random cluster-sample of 21 secondary schools across Sydney. Examinations included cycloplegic autorefraction, and measures of corneal radius of curvature, anterior chamber depth, and axial length.**
Results **Participants mean age was 12.7 years (range 11.1–14.4); 49.4% were female. Overall, 60.0% of children had European Caucasian ethnicity, 15.0% East Asian, 7.1% Middle Eastern, and 5.5% South Asian. The most frequent refractive error was mild hyperopia (59.4%, 95% confidence interval (CI), 53.2–65.6), defined as spherical equivalent (SE) +0.50 to +1.99 D. Myopia (SE−0.50 D or less) was found in 11.9%, 95% (CI 6.6–17.2), and moderate hyperopia (SE⩾+2.00 D) in 3.5%, 95% (CI 2.8–4.1). Myopia prevalence was lower among European Caucasian children (4.6%, 95% CI 3.1–6.1) and Middle Eastern children (6.1%, 95% CI 1.3–11.0) than among East Asian (39.5%, 95%, CI 25.6–53.5) and South Asian (31.5%, 95%, CI 21.6–41.4) children. European Caucasian children had the most hyperopic mean SE (+0.82 D) and shortest mean axial length (23.23 mm). East Asian children had the most myopic mean SE (−0.69 D) and greatest mean axial length (23.86 mm).**
Conclusion **The overall myopia prevalence in this sample was lower than in recent similar-aged European Caucasian population samples. East Asian children in our sample had both a higher prevalence of myopia and longer mean axial length.**
Eye (2008) **22,** 649–656; doi:10.1038/sj.eye.6702701; published online 2 February 2007

Keywords: myopia; ocular biometry; population-based; epidemiology; Sydney myopia study; refraction

Introduction

Uncorrected refractive errors are a major cause of visual impairment in children worldwide, and are a priority area targeted by the World Health Organisation in the global initiative to eliminate avoidable blindness by the year 2020.[1] The recent population-based Refractive Error Study in Children surveys collected data from six countries[2–9] and reported high myopia prevalence rates in East Asian countries and in urban areas. Among children aged 12 years, the prevalence of myopia is higher in China (18–49.7%)[2,3] and Malaysia (24.8%),[4] than in Nepal (2%),[5] South Africa (4%),[6] India (10–10.6%),[7,8] and Chile (10%).[9] In other studies, the prevalence of myopia among school children in Taiwan, Hong Kong, and Singapore ranges from 26 to 55%.[10–12] Recent population-based studies of refractive error among European Caucasian children are scant.[13–15] In one study among children aged 12–13 years in Sweden, the prevalence of myopia was high (49.7%).[13] In the US, two studies have reported on the prevalence of myopia in children, although these rates have varied (9.2 and 28%).[14,15]

Given the high prevalence of myopia in East Asian countries and the observation that

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Received: 19 July 2006
Accepted in revised form: 30 November 2006
Published online: 2 February 2007

Proprietary Interest: None

myopic eyes generally have greater axial length than non-myopic eyes,[12,16] it could be postulated that ocular dimensions may differ between ethnic groups. Studies comparing ocular components by ethnicity are few,[17,18] despite recent large ocular biometry data sets published for children in Singapore, Taiwan, Malaysia, Vanuatu, and the US.[10,17–20] Although the IOLMaster, a commercial biometry instrument using partial coherence interferometry is more precise than clinical ultrasound in measurement of axial length,[21] few studies of ocular biometry in children, however, have utilised this tool to date.[22,23]

In this paper, we aimed to (1) report the prevalence of refractive errors; and (2) use the IOLMaster to examine ocular biometric components in children from ethnic groups found in a large sample of Year 7 school children (predominantly aged 12 years) residing in Sydney, Australia.

Materials and methods

The Sydney Myopia Study is a population-based survey of eye health in school children resident in Sydney, Australia, and forms part of the Sydney Childhood Eye Study. Findings for 6-year-old children have been reported previously.[23] Approval for the study was obtained from the Human Research Ethics Committee of the University of Sydney, the New South Wales Department of Education and the Catholic Education Office. The study adhered to the tenets of the Declaration of Helsinki.

Secondary schools across the Sydney metropolitan region were stratified by socio-economic status and 21 schools, including a proportional mix of public and private/religious schools, were selected to provide a representative sample of Sydney children.[24] All children in Year 7 were invited to participate. After informed written consent from their parents, children underwent a detailed eye examination, which included cycloplegic autorefraction (RK-F1 autorefractor, Canon, Tokyo, Japan) and ocular biometry (IOLMaster,™ Carl Zeiss-Meditec, Jena, Germany).

Five reliable readings of refraction were generated by the autorefractor for each eye; the mean reading was used for analysis. Ocular biometry measurement included corneal radius of curvature (measured along the flattest and steepest meridians and axial length), anterior chamber depth (measured as the distance from the anterior corneal surface to the anterior lens surface), and axial length (measured as the distance from the anterior corneal vertex to the retinal pigment epithelium along the fixation line). Lens power was calculated using Bennett's formula.[25]

Amethocaine 0.5% (Minims™, Chauvin Pharmaceuticals, England) was used for corneal anaesthesia at 0 min, followed by cyclopentolate 1% (one drop) at 2 min for cycloplegia. Tropicamide 1% (one drop) at 3 min and phenylephrine 2.5% (one drop) at around 10 min were also used in some children to obtain adequate mydriasis. A minimum pupillary diameter of 6 mm was achieved in all children before refraction. Tropicamide was used in 53.0% and phenylephrine was used in 10.6% of students. Dilating eye drops were refused by 11 children (0.5%) who consented to non-cycloplegic autorefraction and completed all other examinations. Autorefraction was performed approximately 25 min after the last drop.

Socio-demographic information including ethnicity, highest level of parental education, and occupation were collected in questionnaires completed by parents. Ethnicity of the child was determined only if both parents shared that ethnic origin. Otherwise, children were placed in the mixed ethnicity category. Ethnicity was classified on the basis of self-identification by the parents, combined with information about the place of birth of the child. Ethnic categories (European Caucasian, East Asian, South Asian, Middle Eastern, Pacific Islander, Indigenous Australian, African, South American) were consistent with the Australian Standard Classification of Cultural and Ethnic groups (available at www.abs.gov.au, document number 1249.0), which takes into consideration the similarity in the cultural and social characteristics to determine ethnic groupings. The term East Asian covers people originating from China, Malaysia, Singapore, Indonesia, Philippines, Japan, Korea, Myanmar, Thailand, Laos, Cambodia, and Vietnam. The broad classification of East Asian was used rather than separate Northeast Asian and Southeast Asian categories because of the difficulty in classifying people derived from both of these branches. South Asian included people originating from India, Pakistan, and Nepal.

Myopia was defined as spherical equivalent (SE) refraction (sphere $+\frac{1}{2}$cylinder) -0.50 D or less, emmetropia as SE -0.49 to $+0.49$ D, mild hyperopia as SE $+0.50$ to $+1.99$ D, and moderate hyperopia as SE $+2.00$ D or greater.

Data were analysed using Statistical Analysis System software (SAS Institute, Cary, NC, USA). Overall distributions of refraction and ocular biometric parameters were described in terms of central tendency and spread (mean and SD). Mixed models and generalised estimating equations were used to examine associations and subgroup differences, adjusting for the effects of cluster sampling. Where cluster effects were not significant, *t*-tests and χ^2 tests were used. All confidence intervals (CIs) are 95%. Average corneal radius of curvature was the average of the steepest and flattest meridians. Axial length/corneal radius (AL/CR) ratio was defined using the average corneal radius of curvature.

Results

Population characteristics

Overall, 2353 children were examined (75.3% response); participants and non-participants were similar in gender and ethnic background (Table 1). The mean age of participants was 12.7 years, ranging from 11.1 to 14.4 years, with 49.4% girls. Among participants, most were of European Caucasian ethnicity (60.0%), other ethnicities included East Asian (15.0%), Middle Eastern (7.1%), South Asian (5.5%), and Oceanian (3.3%). Mixed ethnicity accounted for 7.6%, and other ethnicities (African, indigenous, South American) each comprised less than 1%.

Table 1 Demographic characteristics of participants ($n = 2353$) and non-participants ($n = 777$)

	Participants n (%)[a]	*Non-participants* n (%)
Gender		
Girls	1163 (49.4)	376 (48.4)
Boys	1190 (50.6)	401 (51.6)
Ethnicity		
European Caucasian	1407 (60.0)	527 (67.8)
Other[b]	938 (40.0)	250 (32.2)
School type		
Public	1971 (83.8)	630 (82.8)
Private	382 (16.2)	131 (17.2)

[a]Age of participants included 11–12 years (4.3%), 12–13 years (69.9%), 13–14 years (25.6%), and 14–15 years (0.2%).
[b]Other ethnic groups of participants included East Asian (15%), Middle Eastern (7.1%), South Asian (5.5%), Oceanian (3.3%), and mixed ethnicity (7.6%). African, Indigenous and South American ethnic groups each comprised <1%.

Refractive error and refraction

Overall, the vast majority of children had mild hyperopia (59.4%, Table 2), which was followed by emmetropia (25.3%) and myopia (11.9%), including 8.0% who had myopia of SE less than −1.00 D. Moderate hyperopia was found in 3.5%. The mean SE for the whole group was emmetropic (+0.49 D; Table 3).

Children in the European Caucasian and Middle Eastern subgroups had lower prevalence rates of myopia (4.6 and 6.1%, respectively) than children of East Asian and South Asian ethnicity (39.5 and 31.5%, respectively). Mean SE was more myopic among the East Asian (−0.69 D) and South Asian groups (−0.35 D) compared to the European Caucasian (+0.82 D) and Middle Eastern groups (+0.71 D, Table 3). Children of European Caucasian ethnicity had significantly more hyperopic SE (+0.82 D) than children from other ethnic backgrounds combined (+0.04 D, $P < 0.0001$) after adjusting for age, gender, and height. Girls had a significantly higher prevalence of myopia than boys (14.1 *vs* 9.7%), with less hyperopic mean SE (+0.39 D *vs* +0.58 D).

Corneal radius of curvature and axial length

Mean corneal radius was steeper in children of European Caucasian ethnicity and South Asian ethnicity than in children of other ethnic groups (Table 3). Mean axial length was shorter in the European Caucasian and the Middle Eastern subgroups (Table 3). Boys had slightly flatter corneas (7.84 *vs* 7.73 mm, $P < 0.0001$) and longer eyes (23.72 *vs* 23.30 mm, $P < 0.0001$) than girls.

Table 2 Proportion (95% CI) of children with refractive error, stratified by gender and ethnicity,[a] adjusting for the effects of cluster-sampling

	n	*Moderate hyperopia*	*Mild hyperopia*	*Emmetropia*	*Myopia*
Whole group	2340	3.5 (2.8–4.1)	59.4 (53.2–65.6)	25.3 (22.1–28.4)	11.9 (6.6–17.2)
Girls	1154	3.3 (2.2–4.4)	59.1 (52.1–66.1)	23.5 (19.7–27.3)	14.1 (8.4–19.8)
Boys	1186	3.6 (2.6–4.7)	59.7 (53.3–66.1)	27.0 (23.0–31.0)	9.7 (4.5–14.9)
European Caucasian	1402	4.4 (3.6–5.3)	69.9 (66.6–73.2)	21.0 (18.0–24.1)	4.6 (3.1–6.1)
East Asian	349	1.1 (0.2–2.1)	25.2 (19.0–31.4)	34.1 (24.3–43.9)	39.5 (25.6–53.5)
South Asian	127	0.0 (–)	33.9 (21.1–46.7)	34.6 (25.2–44.1)	31.5 (21.6–41.4)
Middle Eastern	163	6.1 (1.5–10.7)	63.8 (59.5–68.1)	23.9 (18.9–29.0)	6.1 (1.3–11.0)
Mixed ethnicity	112	1.7 (0.0–3.6)	57.0 (48.0–65.9)	30.2 (22.9–37.4)	11.2 (5.3–17.0)

D, dioptre; SE, spherical equivalent refraction.
[a]Data not presented for smaller ethnicities including Oceanian, African, Indigenous, and South American. East Asian includes the following ethnicities: China, Malaysia, Singapore, Indonesia, Philippines, Japan, Korea, Myanmar, Thailand, Laos, Cambodia, and Vietnam. South Asian includes India, Pakistan, and Nepal.
Moderate hyperopia: SE $\geq$ +2.00 D; mild hyperopia: +0.50 D $\leq$ SE < +2.00 D; emmetropia: −0.50 D < SE < +0.50 D; myopia: SE $\leq$ −0.50 D.

Table 3 Spherical equivalent refraction and ocular biometric parameters in children aged 12 years, stratified by gender and ethnicity

	n	*Mean (±SD)*	P-*value*[a]
Spherical equivalent (D)			
Whole group	2340	0.48 (±1.34)	—
Boys	1190	0.58 (±1.16)	Referent
Girls	1163	0.39 (±1.49)	0.04
European Caucasian	1402	0.82 (±1.00)	Referent
East Asian	349	−0.69 (±1.92)	<0.0001
South Asian	127	−0.35 (±1.53)	<0.0001
Middle Eastern	163	0.71 (±1.09)	0.03
Average corneal radius (mm)			
Whole group	2327	7.78 (±0.25)	—
Boys	1181	7.83 (±0.25)	Referent
Girls	1146	7.73 (±0.24)	<0.0001
European Caucasian	1385	7.77 (±0.25)	Referent
East Asian	350	7.79 (±0.27)	0.008
South Asian	129	7.76 (±0.28)	0.9
Middle Eastern	165	7.82 (±0.26)	0.009
Axial length (mm)			
Whole group	2311	23.38 (±0.85)	—
Boys	1174	23.58 (±0.78)	Referent
Girls	1137	23.18 (±0.86)	<0.0001
European Caucasian	1376	23.23 (±0.75)	Referent
East Asian	348	23.86 (±1.07)	<0.0001
South Asian	128	23.65 (±0.94)	<0.0001
Middle Eastern	164	23.39 (±0.70)	0.002

D, dioptre; mm, millimetre; SD, standard deviation.
[a]Adjusted for cluster-sampling, age, and height.

Anterior chamber depth and lens power

Mean anterior chamber for the whole group was 3.67 mm, and was deeper in European Caucasian children compared to East Asian children (3.67 *vs* 3.62 mm, $P = 0.047$), adjusting for age, gender, and height. However, anterior chamber depth in European Caucasian children was similar to that in South Asian children and Middle Eastern children (both $P > 0.05$). Boys had deeper chambers than girls (3.73 *vs* 3.61 mm, $P < 0.0001$).

Calculated lens power was 22.15 D for the whole group, and was weaker in children of East Asian ethnicity than in children of European Caucasian ethnicity (22.03 *vs* 22.18 D, $P = 0.02$). Lens power in the European Caucasian group was similar to that in South Asian children and in Middle Eastern children (both $P > 0.05$). Boys had weaker lens power than girls (21.67 *vs* 22.65 D, $P < 0.0001$).

Axial length in emmetropia and myopia, differences in two major ethnic groups

The distribution of axial length among emmetropic children was similar between European Caucasian and East Asian children, with similar mean axial length (23.49 mm for European Caucasian and 23.45 mm for East Asian children, respectively, shown in Figure 1). Among myopic children, there was a wide distribution and overlap of axial length in both European Caucasian and East Asian subgroups; differences between these two ethnic groups included a higher proportion of children with greater axial lengths and a tendency towards longer axial length among the East Asian subgroup. In children with myopia, mean axial length was slightly longer in the East Asian subgroup (24.66 mm) than in the European Caucasian subgroup (23.99 mm). Considerable overlap in the distribution of axial length was noted between emmetropic and myopic children.

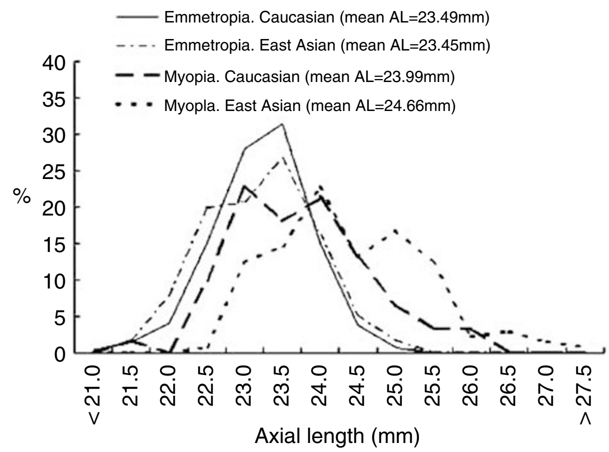

Figure 1 Distribution of axial length among children with emmetropia ($-0.50\,D < SE < 0.50\,D$) and myopia ($SE \leqslant -0.50\,D$), in children of European Caucasian and East Asian ethnicity. *X*-values represent minimum value of each interval. SE, spherical equivalent refraction; AL, axial length; D, dioptres.

Discussion

Prevalence of SE errors

In this large population-based sample of Sydney children with a mean age of 12.7 years, the prevalence of myopia was 11.9%, whereas the prevalence of moderate hyperopia was 3.5%. The mean SE (+0.49 D) was just within the emmetropic range.

Comparison of refractive error prevalence rates with other studies is difficult due to the use of different definitions, instrumentation, variable use of cycloplegia, plus differences in other population characteristics such as ethnicity, gender, and age distribution. In studies of predominantly European Caucasian children, the reported prevalence for myopia ranges from 11.6 to 49.7%.[13–15,26] Junghans and Crewther[26] reported only a slightly higher prevalence of myopia (14.7%) in urban Australian children, using non-cycloplegic retinoscopy.

This method, however, increases measurement variability and is likely to underestimate hyperopia,[2] emphasising the importance of cycloplegia. In studies among predominantly European Caucasian children in the US, Zadnik[15] reported a prevalence of myopia of around 20% for children aged 12 years and Kleinstein *et al*[14] reported a prevalence of 11.6% for children aged 5–17 years in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error. Among 12–13-year-old children in Sweden, Villarreal *et al*[13] reported a myopia prevalence of 49%. These values are consistently higher than the low prevalence of myopia in 12-year-old European Caucasian children reported in this study (4.6%).

The overall prevalence of myopia in the current study was very substantially lower than that reported for similarly aged East Asian children (36.7–78.4%),[2,3,11,27] using the same definition for myopia (SE −0.50 D or less). The overall prevalence of myopia in this study was, however, higher than that reported for children in Chile, Nepal, India, and South Africa (Table 4).[5–9]

Ethnic differences in the prevalence of myopia

In this study, children of European Caucasian ethnicity had both a lower prevalence of myopia and a more hyperopic SE than children of East Asian ethnicity. A new finding was that children of South Asian ethnicity had a similar myopia prevalence and myopic SE as children of East Asian ethnicity. Ethnic differences in myopia have also been reported in other studies among children in school-based settings.[12,14] Kleinstein *et al*[14] reported a higher prevalence of myopia among Asian children (18.5%) than White children (4.4%), aged 5−17 years. Each ethnic sample (African American, Asian, Hispanic, and White) was predominantly drawn from relatively different environments; therefore, these differences in myopia prevalence cannot be attributed to ethnicity alone. A study of children aged 7−9 years from two schools in Singapore[12] showed that the prevalence of myopia among Chinese children (37.0%) was higher than among non-Chinese children (19.9%). Ethnic associations with myopia may not necessarily indicate a purely genetic influence, but could reflect enduring patterns of behaviour and cultural attitudes that may result in a more myopigenic environment, such as higher levels of more intense near-work and lower levels of outdoor activity.

The prevalence of myopia in East Asian children in the current study is lower than that in other studies among East Asian children in urban areas, where the prevalence of myopia ranges from 48.2 to 60.0% (Table 4). These differences in myopia prevalence among children of East Asian ethnicity suggest that a high prevalence of myopia is not inherently universal. The association of an urbanised environment with myopia development could be mediated by factors such as higher educational attainment and greater levels of near-work, with possible differences in duration and intensity of study between children of urban and rural areas.

Gender differences in myopia

The higher prevalence of myopia in girls reported in the current study was also described in our 6-year-old cohort,[23] and is consistent with a number of studies

Table 4 Prevalence of refractive errors among children aged 12 years from selected studies with age-specific data available

	Country	*Sample size*	*Prevalence (%)*	
			Myopia ($SE \leqslant -0.5$ D)	*Moderate hyperopia ($SE \geqslant +2.0$ D)*
Villareal *et al*[13]	Sweden	1045	49.7	8.4[a]
He *et al*[3]	China (urban)	454	49.7	2.0
Zhao *et al*[2]	China (semirural)	704	12.0–23.0	1.0–2.0
Fan *et al*[11]	Hong Kong	1267	48.2	—
Lin *et al*[27]	Taiwan	920	60.0[b]	—
Maul *et al*[9]	Chile	435	4.0–9.0	11.0–13.0
Goh *et al*[4]	Malaysia	534	24.8	0.6
Murthy *et al*[7]	India (urban)	560	9.7	5.0
Dandona *et al*[8]	India (rural)	534	4.8	0.8
Pokharel *et al*[5]	Nepal	481	1.0–2.0	<1.0
Naidoo *et al*[6]	South Africa	476	4.4	3.2
Current study	Australia	2353	11.9	3.5

D, dioptres; SE, spherical equivalent refraction.
[a]Moderate hyperopia defined as $\geqslant$1.0 D.
[b]Myopia defined as SE$\leqslant -0.25$ D.

among Asian,[2,4,10,11] rural Indian,[8] and Caucasian childhood populations.[20] No gender differences, however, were found in studies of children in urban India,[7] South Africa,[6] Nepal,[5] and Chile.[9]

The higher rate of myopia and lower rate of moderate hyperopia in girls in our study is consistent with their lower mean SE; however, the reasons for these findings are unclear. One possible explanation is that girls may perform more near-work than boys; however, recent papers have raised some doubt over the relative importance of near-work as a risk factor for myopia.[28] Another suggestion is that earlier pubertal changes in girls are responsible; however, in our findings we have shown that mean axial length was shorter in girls than boys, making a hormonal cause for myopia less likely.

Hyperopia

Hyperopia is an important condition because of its association with amblyopia, strabismus, and anisometropia in children.[29] Although the prevalence of moderate hyperopia varies among different countries (Table 4), these differences are typically less dramatic than the differences in myopia prevalence. The prevalence of moderate hyperopia in our sample was comparable to that in urban India,[7] but was higher than rates reported for East Asian countries,[2–4,11,27] rural India,[8] and South Africa.[6]

Populations with a high prevalence of myopia generally have a relatively low prevalence of hyperopia (Table 4). This suggests that the decrease in prevalence of moderate hyperopia with age may be due to an overall myopic shift in the population, which, in turn, are associated with age-related physiological changes in ocular biometry. However, in locations such as Nepal, rural India, and South Africa, where the prevalence of myopia is very low, factors other than age-related myopic shift may also contribute to a low prevalence of hyperopia.

Ocular biometry

Age-specific ocular biometric data for children have been published for older children in the US[17,20] and Taiwan.[10] These reports used ultrasound measurements and provided gender-stratified data but not overall data for each age year, making comparison with our ethnic subgroups difficult. The mean axial length in boys (23.58 mm) and girls (23.18 mm) obtained by IOLMaster in our study were actually comparable to those reported by Zadnik *et al*[20] for similarly aged children (23.55 and 23.27 mm in boys and girls, respectively). Lin *et al*[10] reported similar findings for Taiwanese girls (23.6 mm) but slightly longer mean axial length (24.1 mm) in Taiwanese boys, both aged 12 years. Mean axial length for children of East Asian ethnicity in our study was 23.86 mm.

Among studies of children with myopia, mean axial length was generally longer. In the Correction of Myopia Evaluation Trial study,[17] which only included children with myopia, axial length in those aged 11 years was 24.62 mm in boys and 24.23 mm in girls. In younger Singaporean children (ages 7–9 years), axial length measurements obtained using ultrasound for those with low myopia (23.76 mm) or high myopia (24.81 mm) were greater than that found in 12-year-old children (23.38 mm) in the current study.

Our finding that boys generally had a more hyperopic refraction and longer eyes with deeper anterior chambers than girls is consistent with previous studies using ultrasound measurements.[10,17] Some studies have also reported weaker lens power[20] and thinner lens[10] among boys. Although there were highly statistically significant gender differences in mean corneal radius and axial length, the actual differences were quite small (0.1 and 0.4 mm, respectively) and translated into only a small difference in SE (0.19 D) between boys and girls. Therefore, in clinical terms, the differences of ocular biometry between boys and girls may be considered relatively inconsequential.

Strengths and limitations

We used random cluster sampling to obtain a large representative sample of children in the Sydney metropolitan region. Both satisfactory response rate, and the use of cycloplegic refraction and standardised measurement protocols contributed to the strengths of this study. By examining a large sample of children within one school year, we are able to control the influences of schooling to a certain extent and make valid comparisons of ocular dimensions between boys and girls, and between ethnic groups. We assigned ethnicity for the child by using data from both parents to increase accuracy and excluded children of mixed race from ethnic comparisons. Ocular biometry measurements were obtained by the IOLMaster, which are considered to be more precise and repeatable than those obtained using ultrasound.[21] As previous reports have shown that axial length measurement by non-immersion ultrasound are shorter,[30] IOLMaster measurements were internally adjusted for comparison.

A limitation of this study was the use of calculated lens power. This was based on the Gullstrand–Emsley schematic eye, and assumed a theoretical relationship between ocular components in the adult eye. Measurement of vitreous chamber depth was not performed with the IOLMaster. With a cross-sectional design, data on development and progression of myopia are outside the scope of this study. Comparing the current findings in 12-year-old children with our previously published data for 6-year-old children, however,[23] the older children had a higher prevalence of myopia, longer axial length, longer anterior chamber depth, weaker lens power, and a more myopic SE than the younger children. There was no apparent change in the corneal radius between the two samples.

In summary, in this study of 12-year-old children, we report a relatively low prevalence of myopia by international standards in age-matched cohorts. There were substantial ethnic differences in the prevalence of different refractive errors and in ocular dimensions within this sample of children from diverse ethnic backgrounds. Among the four major ethnic groups, myopia prevalence ranged from European Caucasian (lowest), Middle Eastern, South Asian, and East Asian (highest) with corresponding range of increasing axial length.

Acknowledgements

The Sydney Myopia Study is supported by the Australian National Health & Medical Research Council (Grant No. 253732); the Westmead Millennium Institute, University of Sydney; and the Vision Co-operative Research Centre, University of New South Wales, Sydney, Australia.

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