Ocular Biometric Measurements In Emmetropic And Myopic Malaysian Children - A Population-Based Study

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SUMMARY

This is the first population based study on ocular biometric measurements (OBMs) conducted in Malaysia. Its objective is to measure and compare among children of different ethnicity who have myopia and emmetropia. Subsets of children aged between 7 and 8 years old who participated in a larger population based refractive error study had their axial length, anterior chamber depth, lens thickness and vitreous depth measured using A scan and vertical and horizontal corneal curvature measured using an auto-keratorefractometer. Eighty eight of the 870 children (10.1%) examined had myopia. Boys, Chinese and children with myopia had significantly longer axial length and vitreous depth compared to girls, Malay and Indian and children who were emmetropic respectively. Girls and children with myopia had steeper corneal curvature. The baseline OBMs in Malaysian children of different ethnicity are valuable for studies in myopia progression. Like other studies, children with myopia have longer axial length (P <0.001). and vitreous depth (P <0.001) compared to children who are emmetropia (without myopia).

KEY WORDS:
Myopia, emmetropia, ocular biometry, axial length, vitreous depth, corneal curvature

INTRODUCTION

Uncorrected refractive errors, especially myopia are significant global public health problems[1]. It can leads to poor performance in school and eventually low self-esteem and reduce employability. The global prevalence of myopia in the age group between 5 to15 years ranges from 3% to 35%, the prevalence of hyperopia ranges from 0.4% to 17% and the prevalence of astigmatism from 2.2% to 34% depending on the geographical area and urban/rural setting[1].

The prevalence of myopia among young children is high in Asia. In Hong Kong, 30% of children aged between 6 and 7 years[2], 20.2% of 7-year –old Taiwanese children[3] , 27.6% of 7- year-old Singaporean children and 34.6% of Singaporean 8-year-old children [4] have myopia. A number of studies have shown that the prevalence of myopia in Asian children increases with age[2,3,4]. A number of nationwide surveys on children aged 7 years in Taiwan over the last 3 decades have shown that myopia prevalence had increased from 4% in 1986 to 12% in 1995 and 20.2% in 2000[3].

There were 3 school-based refractive error studies conducted over the last 3 decades in Malaysia. The first study was conducted in 1987 on Malay children aged between 7 to 8 years old where the prevalence of myopia of 4.3%[5] was found. The second study was conducted in 1996 on Chinese children between 6 to 8 years old where the prevalence of myopia was 24%[6]. The third study, conducted in 2000 on Indian children, found that the prevalence of myopia was 16% among those aged between 6 to 12 years and 22 % among 13 to 16 years old[7]. However cycloplegic refraction was not done in these studies and thus diagnosis of myopia may be overestimated.

In 2003, Malaysia took part in a multi-country refractive error study in children (RESC) of different ethnicity aged between 7 to 15 years of age[8]. Based on cycloplegic retinoscopic refraction, the prevalence of myopia among the 7-year old children was 9.8% , on 8 year-old- children was 14.0%, and for 15 year-old was 34.4 %. These findings indicate that prevalence of myopia increases with age. That study also shown that prevalence of myopia was highest among Chinese children (45.3%), followed by Indian children (15.5%) and Malay children (13.9%) [8].

The aetiology of myopia is complex. It is believed that both the environmental and genetic factors have important roles[9,10]. A study compared the prevalence of myopia of the Chinese population in Singapore, Xiamen city and Xiamen countryside showed that prevalence of myopia in the three locations were significantly different [10]. As the genetic makeup of the Chinese populations from these three sites was similar, the difference in the rate of prevalence of myopia between these three sites was deemed to be related to environmental factors.

Among some of the possible environmental risk factors associated with myopia are near work [11,12 ,13], school achievement[13], outdoor activities[13], and ambient light[14]. The challenges in studying association of near work and myopia are the use of surrogates for amount of near work done such as number of books read, recall bias on duration spent on near work and reading distant. Difficulties arise in categorizing individual near work activity, behavioural aspect of reading such as reading distance and continuous reading. Thus, although earlier studies showed near work increased the risk of myopia[11,12 ,13] , more recent studies have thrown doubt in this [15] and proposed intensity of near work such as close reading distance and continuous reading as

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important factos[16]. Findings from the RESC in Malaysia showed that increasing age, female gender, higher parental education and Chinese ethnicity were risk factors associated with myopia[8].

Measurements of ocular components are essential in the study of myopia progression as changes in the size of the eye or its components are responsible for changes in the eye's refractive properties. Kurtz et al. successfully demonstrated that it was possible to obtain meaningful and precise measurements of the ocular components with A-scan ultrasonography in young children between the ages of 6 to 11 years[17]. The relationship between OBMs and the degree of myopia has been widely studied, both in countries with high prevalence of myopia such as Singapore[10] and Xiaman[10] and in country with low prevalence of myopia like Australia[18]. Findings from these studies showed that axial length and vitreous depth are significantly longer in myopic children[10,18].

This study aims to determine and compare OBMs in terms of axial length, anterior chamber depth, vitreous depth, lens thickness and corneal curvature among children with myopia and emmetropia in the subset of 7 to 8 years old Malay, Chinese, Indian, and children of other ethnicity who took part in the RESC study.

MATERIALS AND METHODS

The study is part of the large population-based refractive error study in children conducted on 5,528 children aged between 7 to 15 years old. It took a subset of children aged between 7 to 8 years old and excluded those who had hypermetropia, with any ocular co-morbidity or had past ocular surgeries. The study took place in Gombak District, Selangor from March 2003 to July 2003. The study was approved by the Medical Research Ethics Committee of the MOH and received MOH research grant.

The detail methodology has been reported elsewhere[8]. In brief, it followed the same protocol as that of RESC but carried out OBM using A scan and handheld auto-keratorefractometer on children aged between 7 and 8 years old who were found to be emmetropic or myopic by cycloplegic retinoscopic refraction done by trained optometrists. Cycloplegia was induced with 2 drops of gutt 1 % cyclopentolate hydrochloride, administered five minutes apart by ophthalmic assistants, with the third drop administered after 20 minutes. Pupil dilatation of 6 mm or more with the absence of light reflex was considered as complete cycloplegia.

Myopia was defined as spherical equivalent refraction (SER) of -0.50 D or worse while emmetropia was defined as SER between -0.50 D and +2.00 D. Myopia is classified into low myopia, defined as SER equal or worse than -0.5 D but better than -3.00 D; moderate myopia as defined as SER equal or worse than -3.0 D but better than -6.0 D and high myopia as defined as SER equal or worse than – 6.0 D.

OBMs were carried out after cycloplegic refraction. The axial length, anterior chamber depth, lens thickness and vitreous depth were measured with contact ultrasonography (Echoscan model US-800, probe frequency of 1mHz; Nidek Co, Ltd, Tokyo, Japan). Gutt proparacaine 0.5% was used for topical anaesthesia. An average of six measurements with good tracing and within the standard deviation (SD) of less than 0.12mm was taken. If the SD was 0.12mm or more, the data was not included and the measurements were repeated until SD was less than 0.12mm. The horizontal and vertical corneal curvature measurements were taken using the handheld auto-keratorefractometer (Retinomax K- plus; Nikon, Tokyo, Japan). The researchers who performed the ocular biometric measurements did not know the status of refraction so as to avoid operator bias.

A pilot study involving 60 children from 2 non-study clusters was conducted. Ocular biometric measurements were taken twice for each child. The first set of measurements was done by the researcher and the second set by a trained optometrist. The pilot study revealed repeatability of the keratometry and ocular biometric measurements between the two operators.

Data were analysed using Stata Statistical Software, Release 8.0 (College Station, TX: Stata Corp, 2003). Only data from the right eye were included in the analyses to avoid confounding effect from inter-ocular correlation. The demographic characteristic and status of myopia were analysed using descriptive statistics. Multifactorial ANOVA analysis was used to show difference of biometric measurements on gender, ethnicity and refractive status. A p-value of less than 0.5 was defined as being statistically significant.

RESULTS

Of the 1,182 children aged between 7 and 8 years old who participated in the RESC, 870 (73.6%) were examined. The remaining 312 (26.4%) either did not fulfil the inclusion criteria, had no parental consent or OBMs could not be performed on them. The demographic characteristics of those examined in this study were similar in terms of age and gender to participants in the larger RESC except that this study has more Malay children and fewer children from other ethnicity (Table I). We can thus infer that demographic characteristic of participants and non-participants in this study were similar to the RESC study and there is no extreme different between participants and non-participants in this study.

The proportions of 7-year (48.2%) and 8-year-old (49.3%) children were of equal. There were more boys (51.5%) than girls (48.5%). Majority of the participants were Malays (76.7%) (Table II).

Most of the children were emmetropic (782, 89.9%) and 88 (10.1%) were myopic. Prevalence of myopia in 8-year-old children (12.6%) was almost doubled that of 7- year-old (7.4%). Boys (10.5%) had higher prevalence of myopia compared to girls (9.7%). The prevalence of myopia among Chinese children (16.9%) doubled that of the Malay children (8.2%). The apparently high prevalence of myopia among Indian children may be due to the small sample size (Table II).

Table I : Comparison of children who participated in current study with the larger RESC study

	Current study n (%)	RESC study N(%)
Age		
7 years old	419 (48.2)	590(48.9)
8 years old	451(45.3)	616 (51.0)
Gender	%	
%		
Boys	51.5	50.8
Girls	48.5	49.2
Ethnicity		
Malay	76.7	70.3
Chinese	16.3	16.5
Indian	6.8	8.9
Others	0.3	4.3

Table II: Demographic characteristics by refractive status

	All children (N=870) N (%)	Myopia (n=88) n (%)	Emmetropia (n=782) n (%)
Age			
7 years old	419 (48.2)	31 (7.4)	388(92.6)
8 years old	451 (45.3)	57(12.6)	394(87.4)
Gender			
Boys	448 (51.5)	47(10.5)	401(89.5)
Girls	422 (48.5)	41 (9.7)	381(90.3)
Ethnicity			
Malay	667 (76.7)	54 (8.1)	613(91.9)
Chinese	142 (16.3)	24(16.9)	118(83.1)
Indian	59 (6.8)	10(16.9)	49(83.1)
Others	2 (0.3)	0	2 (100)

Table III: Measures of ocular biometric parameters in right eyes of children (n=870)

	Axial length, mm mean(SD)	Anterior chamber depth, mm mean(SD)	Lens thickness, mm mean(SD)	Vitreous depth, mm mean(SD)	Horizontal Corneal curvature, D mean(SD)	Vertical Corneal curvature, D mean(SD)
Gender						
Boys	22.88(0.03)	3.46(0.01)	3.43(0.01)	15.98(0.03)	42.81(0.06)	43.72(0.07)
Girls	22.47(0.03)	3.43(0.01)	3.45(0.01)	15.59(0.03)	43.51(0.07)	44.49(0.07)
Ethnicity						
Malay	22.64(0.02)	3.45(0.01)	3.44(0.01)	15.75(0.02)	43.12(0.05)	44.05(0.06)
Chinese	22.88(0.06)	3.45(0.02)	3.47(0.01)	15.96(0.06)	43.14(0.12)	44.15(0.12)
Indian	22.60(0.09)	3.42(0.02)	3.41(0.02)	15.77(0.09)	43.53(0.22)	44.52(0.20)
Others	23.07(0.60)	3.52(0.20)	3.37(0.07)	16.19(0.47)	42.44(0.69)	43.37(0.50)
Refractive status						
Emmetropia	22.62(0.02)	3.45(0.01)	3.44(0.01)	15.73(0.02)	43.11(0.05)	44.01(0.05)
Myopia	23.18(0.07)	3.43(0.02)	3.43(0.01)	16.32(0.07)	43.51(0.14)	44.88(0.16)

Among the 88 myopic children, 84(95.5%) had mild myopia, 3(3.4%) had moderate myopia and one (1.1%) had severe myopia.

Table III shows the mean values of axial length, anterior chamber depth, lens thickness, vitreous depth and horizontal and vertical corneal curvature in terms of gender, ethnicity, and refractive status. The mean axial length of boys was longer at 22.88 mm (SD 0.03) as compared to girls (22.47mm (SD 0.03)). Chinese children had longer axial length at 22.88mm (SD 0.06) compared to Malay (22.64 mm SD 0.02). Children with myopia had longer axial length (23.18mm (SD0.07)) when compared to emmetropic children (22.62mm (0.02)). Boys had deeper anterior chamber depth (3.46 mm SD 0.01). Chinese had thicker lens (3.47mm,SD 0.01). The vitreous depth in Chinese children and children with myopia were deeper compared to Malays, Indians and children of other ethnicity. Girls had steeper horizontal and vertical corneal curvature as compared to boys (Table III).

From the multifactorial ANOVA analysis, boys (P <0.001), Chinese (P =0.001) and children with myopia (P <0.001) had significantly longer axial length compared to girls, Malays, Indians and children of other ethnic groups and emmetropic children. Besides, boys (P <0.001), Chinese (P =0.02) and children with myopia (P <0.001) had significantly longer vitreous depth compared to girls, Malays, Indians and children of other ethnic groups and emmetropic childre . Boys had significantly deeper anterior camber depth compared to girls (P= 0.037). Chinese had significantly thicker lens compared to other ethnic groups (P=0.026). Girls and children with myopia had significantly steeper horizontal and vertical corneal curvature (P <0.001). Anterior chamber depth and lens thickness were not significantly difference between children with myopia or emmetropia (Table IV).

DISCUSSION

This is the first population- based study that describes the distribution of ocular biometric parameters among Malaysian children between 7 to 8 years of different ethnic groups for children with myopia and emmmetropia.

The prevalence of myopia in this study (7 to 8 years old combined, 10.1%, 7-year-old, 7.4%, 8-year-old, 12.6%) was lower than that published in RESC study (7-year–old, 10.0%, 8-year–old, 14.0%).This may be due to a smaller sample size in this study. The myopia prevalence among Malaysian

Table IV : Multifactorial ANOVA analysis showing difference of mean outcome based on gender, ethnicity and refractive status

Ocular parameter	Factor		Adjusted mean (95% CI)	F-stat (df)	p-value
Axial length	Gender	Boy	23.15(22.94,23.36)	104.34 (1)	<0.001
		Girl	22.75(22.54,22.97)		
	Ethnicity	Malay	22.86(22.79,22.93)	5.36 (3)	0.001a
		Chinese	23.05(22.95,23.16)		
		Indian	22.77(22.61,22.92)		
		Others	23.13(22.33,23.93)		
	Refractive status	Emmetropia	22.69(22.48,22.89)	65.60 (1)	<0.001
		Myopia	23.21(22.98,23.45)		
Corneal Curvature(h)	Gender	Boy	42.96(42.45,43.46)	56.75 (1)	<0.001
		Girl	43.66(43.14,44.17)		
	Ethnicity	Malay	43.30(43.14,43.47)	1.40 (3)	0.243
		Chinese	43.28(43.03,43.52)		
		Indian	43.67(43.30,44.03)		
		Others	42.98(41.07,44.89)		
	Refractive status	Emmetropia	43.11(42.62,43.60)	6.48 (1)	0.011
		Myopia	43.51(42.95,44.06)		
Corneal Curvature(v)	Gender	Boy	44.08(43.56,44.60)	65.51 (1)	<0.001
		Girl	44.86(44.33,45.38)		
	Ethnicity	Malay	44.42(44.25,44.59)	1.40 (3)	0.240
		Chinese	44.45(44.19,44.70)		
		Indian	44.81(44.44,45.19)		
		Others	44.19(42.23,46.15)		
	Refractive status	Emmetropia	44.03(43.53,44.54)	29.58 (1)	<0.001
		Myopia	44.90(44.33,45.48)		
Anterior chamber depth	Gender	Boy	3.46(3.39,3.53)	4.34 (1)	0.037
		Girl	3.44(3.37,3.51)		
	Ethnicity	Malay	3.44(3.42,3.47)	0.44 (3)	0.73
		Chinese	3.44(3.41,3.48)		
		Indian	3.42(3.37,3.47)		
		Others	3.50(3.24,3.80)		
	Refractive status	Emmetropia	3.46(3.39,3.52)	0.30 (1)	0.58
		Myopia	3.44(3.37,3.52)		
Lens thickness	Gender	Boy	3.41(3.36,3.46)	2.50 (1)	0.114
		Girl	3.42(3.37,3.48)		
	Ethnicity	Malay	3.43(3.42,3.45)	3.11 (3)	0.026[a]
		Chinese	3.46(3.44,3.49)		
		Indian	3.40(3.37,3.44)		
		Others	3.36(3.17,3.56)		
	Refractive status	Emmetropia	3.43(3.38,3.48)	1.63 (1)	0.203
		Myopia	3.41(3.35,3.46)		
Vitreous depth	Gender	Boy	16.28(16.06,16.50)	94.85 (1)	<0.001
		Girl	15.89(15.67,16.11)		
	Ethnicity	Malay	15.98(15.91,16.05)	3.28 (3)	0.02[a]
		Chinese	16.15(16.04,16.25)		
		Indian	15.95(15.79,16.10)		
		Others	16.28(15.45,17.10)		
	Refractive status	Emmetropia	15.81(15.60,16.02)	69.70 (1)	<0.001
		Myopia	16.37(16.13,16.61)		

[a] Post-hoc Multiple comparison with Bonferroni correction was applied.

children in this study of 10.1% is lower than that found in Singapore (27.6% of 7 year–old[4], 34.6% of 8-year–old [4], 12.3% of children between 6-7 year old10), Hong Kong (30% of children aged between 6 and 7 years)[2] and Taiwanese (20.2% of 7-year-old)[3] . These differences may be due to the fact that majority (76.7%) of participants in this study was Malay as compare to the other studies where the majority were Chinese. Findings from a study on ethnicity- specific prevalence of myopia in Malaysian and Singaporean children age between 7 to 9 years old shown that prevalence of myopia among Malaysian Chinese (30.9%) and Singaporean Chinese (40.1%)[19] are higher than that of Malaysian Malays (9.2%)[8] and Singaporean Malays (22.1%)[19].

When comparing Malaysian Chinese children in this study to Chinese from other countries of the similar age group, prevalence of myopia among Malaysian Chinese (16.3%) was lower than that of Hong Kong[1] (30%) , Taiwan[2] (20.2%) and Singapore[14] (27.6%) but higher than children inXiamen city[10] (9.1% of children aged between 6 and 7 years old), Xiamen countryside (3.9%)10 and Sydney, Australia(1.4%)[18] .

Findings from this study support the findings that myopia increases with age. Prevalence of myopia among the 8 year olds (12.6%) was almost doubled that of 7 year-olds (7.4%) in this study. While a study in Singapore showed that prevalence was 27.6 % among 7 year olds and increased to 34.6% among 8 years old children[4]. In Hong Kong, children aged 11 years were almost 15 times more likely to have myopia compared to children younger than 7 years[2], and in Taiwan myopia increased from 20% among 7-years-old to 61 % among 12-year-old children[3].

This study shows that boys aged between 7 and 8 years are more likely to be myopic than girls, because they have significantly longer axial length, deeper anterior chamber and longer vitreous depth. The same explanation is also for Chinese children who are more likely to be myopic compared to children of other ethnic groups, as they too have significantly longer axial lengths, lens thickness and vitreous depth than children of other ethnic groups.

Like other studies, children with myopia have a significantly longer axial length[10,19] and deeper vitreous chamber [10] when compared to children who are emmetropia. Comparing to results from study done by Zhang *et al* [10] on 6 to7 year-old Chinese children from Singapore, Xiamen city and Xiamen countryside, the mean values for axial length for myopic children between 6 to 7years old in Singapore (23.7mm) is longer than Xiamen Countryside (23.5mm) and Xiamen city (22.9mm), and Malaysian children in this study of 7-8 year old (23.2mm). The mean values for vitreous depth were also longer among myopic children from Singapore (16.6mm) when compared to Xiamen Countryside (16.4mm), Xiamen city (16.1mm) and Malaysian children (16.3mm).

Malaysian Chinese and Singaporean Chinese share similar genetic background as they migrated from the same localities in South China, primarily Fujian and Guangzhou provinces and thus both groups should be genetically similar to Xiamen Chinese. We compare our results to OBMs study on Singaporean Chinese and Xiamen Chinese[10], Malaysian Chinese (23.1mm) and Singaporean Chinese (22.8mm) have longer mean axial length compare to Xiamen Chinese in city (22.5mm) and countryside (22.3mm). This is supported by lower prevalence of myopia in Xiamen countryside, (3..9%)[10] and Xiamen city (9.1%)[10] as compared to Malaysia (10.1%) and Singapore (12.3%)[10].

The steeper corneal curvature especially in the vertical meridian observed in this study suggested that myopia among Malaysian school children had an association with 'with-the-rule' astigmatism. This fact was supported by Arini *et al.* who reported 'with-the-rule' astigmatism was the commonest type of astigmatism (71.9%) among the 4634 children aged between 7 to 15 years who participated in the RESC study[20]. Lin et al in their study conducted in the year 2000 found that the corneal curvature remained unchanged during the progression of myopia among Taiwanese children[3].

The strengths of this study is that it was a population-based study using a random sampling strategy, thus avoiding the bias that might be present in school-based studies previously done in Malaysia. Besides, all children underwent cycloplegic refraction to determine their refractive status. A pilot study was conducted prior to the actual study to ascertain the repeatability and reliability of keratometry and ocular biometric measurements among operators.

This study also has several limitations. The use of contact ultrasound biometry such as the A scan may indent the cornea causing shorter anterior chamber depth and axial length. Ocular biometric measurements obtained by non-contact optical coherence approaches (IOL Master; Carl Zeiss Meditec) would provide more precise measurement[22, 23].

CONCLUSION

This study provided, for the first time, baseline data on ocular biometric measurements on a large group of Malay, Chinese and Indian children in Malaysia. The findings are consistent with other studies that axial length and vitreous depth are longer in children with myopia than those with emmetropia. These data can support future study on the association of eye growth and ocular biometric measurements with myopia progression.

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