Indian J.Sci.Res. 6(1) : 1-9, 2015
ISSN : 0976-2876 (Print)
ISSN : 2250-0138 (Online)

COMPARISON OF OCULAR BIOMETRY AND CORNEAL CURVATURE AMONG MALAYSIAN EMMETROPES AND MYOPES

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ABSTRACT

A cross sectional study was conducted by including 47 Malaysian subjects aged 18-35 years. The purpose is to find out the variations in ocular biometry according to refractive state and rule out the most contributing factor for the degree of myopia among Malaysia subjects. Keratometer and A-scan ultrasonography were used to measure the corneal curvature and biometric parameters respectively. Comparison of ocular components for gender and onset of myopia were done by using independent t-test. One way ANOVA was done to compare biometric parameters with refractive states. Comparison of the axial length (p=0.49), anterior chamber depth (p=0.28), lens thickness (p=0.06) and cornea radius (p=0.94) showed no significant difference based on age groups and gender. Lens thickness (p<0.05) showed significant difference based on onset of myopia. Refractive state has a significant relation to axial length (p<0.001), lens thickness (p=0.03), corneal radius (p<0.001) and AL/CR ratio (p<0.001). Axial length was having more effect on high myopia group whereas corneal radius and AL/CR ratio showed more effect on emmetropia group. There was a significant difference in biometric parameter, corneal curvature and AL/CR ratio between emmetropia and myopia except anterior chamber depth. In addition, there was a significant difference in lens thickness exits based on the onset of myopia. Axial length was the main morphological factor related to myopia. AL/CR ratio is a better index for categorizing the refractive status of an individual than axial length alone.

KEYWORDS : Axial Length, Anterior Chamber Depth, Lens Thickness, Corneal Radius, AL/CR Ratio, Myopia.

Epidemiological studies indicated that uncorrected refractive errors are one of the important risk factor for visual impairments worldwide. Apart from genetic, racial and environmental risk factors, some other factor also have an influence on refractive error. The most contributing factor for refractive errors is its relationship to the ocular components. Numerous studies showed that the ocular components are influenced by age and variation of refractive errors with age may be due to changes in the ocular components (Yekta et al., 2010).The refractive state of the eye is determined by refractive components (corneal power, lens power, anterior chamber depth and axial length) which are interdependent and the growth of eye during the early years of life in such a manner that the refractive state tend towards emmetropia. The refractive state of the human eye is also dependent on the balance of change in overall eye size and refractive components-namely the cornea and crystalline lens (Eghosasere et al., 2011).Majority of eye growth takes place in the first 18 months of life. Overall the changes in axial length appears to be compensated by the progressive corneal flattening with age in normal eyes; the majority of axial length elongation takes place in the first three to six months of life and a gradual reduction of growth happens over the next two years, and by three years of age the adult eye size is attained (Eghosasere et al., 2011).

The prevalence of myopia is high among Asian countries such as China, Singapore, Taiwan and Malaysia (Zhao et al., 2000 and Saw et al., 2005). The progression of myopia can leads to various ocular pathologies and ocular component changes. High myopia above 6.0 diopters with an axial length of 26 mm or above, is connected with the process of degenerative myopia (Tarutta et al., 2011) and also a leading cause of blindness because of its association with retinal detachment, macular and choroidal degeneration, premature cataract and glaucoma (Young et al., 2009). Geographic variations in myopia prevalence are marked in both child and adult populations with the highest levels of myopia in East Asia, where approximately 80% of young adults are myopic. Compared to East Asian children the prevalence of myopia is lower in children from South Asia. The lowest prevalence appears to be in white children, with similarly low levels of myopia in children of African Caribbean origin (Alicja et al., 2010).

Myopia is classified into two main categories according to the age of its appearance as early onset and late onset myopia or adult onset myopia (Sawet et al., 2005). Early onset of myopia occurs at birth, with a reported prevalence in the full-term newborn varying from 0.0 to 24.2 percent. This variability is due to technical difficulties in measuring refraction in newborns (Saw et al., 2005).The

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late onset myopia usually start sat the age of 14 years and stop or slow down its progression as soon as the general physical growth stage finished at the end of adolescence. This type of myopia is thought to occur because, the elongation of the eye is insufficiently compensated by the flattening of the cornea and crystalline lens (Saw et al., 2005). It has been demonstrated that an increase in the axial length of the eyeball is the main factor related to the progression of myopia among children and adults, and vice versa short axial length is the principal morphological factor related to hyperopia (Blanco et al., 2008). Another factor that could affect the refractive state is the depth of the anterior chamber. Anterior chamber depth is the distance between anterior surfaces of the cornea to anterior surface of the crystalline lens (Blanco et al., 2008). Thus, it seems anterior chamber depth is significantly greater in both subjects with juvenile or adult onset myopia than emmetropia. Further, in high myopias, which are usually of juvenile onset, the cornea seems to show a greater curvature and rendering a deeper anterior chamber. Notwithstanding, researchers have only been able to detect very weak correlation between anterior chamber depth and refraction which is 0.08 mm to 0.15 mm (Blanco et al., 2008).Hence, despite consensus that axial length is the main factor that determines the degree of refractive error, it is not yet clear what other morphological components affect this refractive defect. It has been not yet established that a change in the corneal radius exerts an emmetropizing effect or contribute to attaining higher myopia (Blanco et al., 2008).The purpose of this research is to find out the variations in the biometry of the ocular globe according to refractive state and rule out the most contributing factor for the degree of myopia.

METHODOLOGY

A cross sectional study was conducted by including 47 Malaysian subjects aged 18-35 years, regardless of gender and race, from both east and west Malaysia within a period of one year at Twintech vision care centre. A convenience sampling method was used. Written informed consent was obtained from all the subjects who were included in the study. Subjects that had best corrected visual acuity of 6/6 irrespective of emmetropia or myopia were included for this study and subjects having hyperopia, binocular vision disorder, eye movement disorder, prior history of any ocular surgery, ocular pathology, or systemic illness were excluded. Permission to conduct the study was obtained from the institute and all procedures were performed after following the declaration of Helsinki. Detailed history was obtained followed by the measurement of visual acuity, objective and subjective refraction, pupillary evaluation, phoria measurements, measurement of other accommodative and vergence parameters, slitlamp examination, and fundus examination. Refractive corrections were recorded as a spherical equivalent (SE) and the classified into emmetrope (SE between plano and -0.50D), low myope (SE between -0.75D and ≤3.00D), moderate myope (SE between -3.25 D and -6.00D), or high myope (SE>-6.00D) (Zhong et al., 2009). After successful completion of initial assessments, those who passed the inclusion criteria were included in the study and categorized into three age groups ((18-23, 24-29 and 30-35years).

During keratometry, the eyepiece or reticule was adjusted for the examiner's refractive status. The subject was seated comfortably before the instrument with forehead on the head rest and chin fitting snugly into the chin rest. The leveling sight pin was at the same level as the outer canthus of the eye to be assessed. At this point the instrument was switched on and the examiner viewed the mire through the eyepiece while patient was asked to fixate on the reflection of his/her own eye. The blurred mire was cleared by adjusting the focusing knob. The cross-hair was placed in the center of the focusing circle to ensure that the optical axis of the instrument was coincident with the visual axis of the patient to ensure accuracy of readings by adjusting the elevation knob. Once the exact position was obtained the lock knob was tightened so that the instrument does not rotate out of setting. The minus signs are superimposed by the vertical power drum and the plus signs by the horizontal power drum. Three measurements were taken and the average values for vertical and horizontal corneal curvature were recorded along the appropriate meridians (Eghosasere et al.,2011).

Measurements of axial length, anterior chamber depth, and lens thickness were obtained using A-scan ultrasonography (CIMA Technology, USA). The subject was comfortably seated with the head upright and eyes in the primary position of gaze. The probe was sterilized with 70% alcohol and allowed to air-dry. A drop of topical anesthetic (Tetracaine Hydrochloride 0.1%) was instilled into subject's eye. The probe was carefully aligned perpendicularly to and highly applanating the cornea. The axial length is displayed on the color liquid crystal display (LCD) screen. At least three readings were taken and the average calculated as the measured axial length (Eghosasere et al., 2011). Calibration of A-scan biometry was performed following the standards of use advised by the manufacturer (Mohamed Hosny et. al., 2000). The AL/CR ratio for each subject was obtained by dividing the axial length with the corneal radius of curvature (Eghosasere et. al., 2011). Data analysis was carried out by using SPSS 16.0 software. The normality of the data was checked by using Shapiro-wilk test. Comparison of ocular components for gender and onset of myopia were done by using independent t-test whereas rest of the comparison done by using one way ANOVA where more than two groups were involved. To avoid the type 1 error the banferroni correction was considered while performing the post hoc analysis. A p value of < 0.05 is considered significant.

RESULTS

This study had a total of 47 subjects out of which 14 were male (29.78%) and 33 were females (70.20%). These subjects were categorized into three races out of which 55.3% were Chinese, 38.3% were Malay and 6.38% were Indian. The refractive error includes 47.87% of emmetropia and 52.13% of myopia. Out of 52.13% of myopia 17.02% was low myopia, 25.53% was moderate myopia and 9.58% was high myopia. Comparison of biometric parameters and corneal curvature based on gender, age group and refractive error was shown in Table no. 1, 2 and 3 respectively. When the biometric parameters

Table 1 : Comparison Ocular Parameters Between Genders

Ocular components (mm)	Gender	Mean±SD	P(<0.05)
AL	Female Male	24.20±0.85 24.44±0.82	0.39
ACD	Female Male	3.50±0.20 3.58±0.27	0.35
LT	Female Male	3.59±0.20 3.67±0.35	0.44
CR	Female Male	7.81±0.21 7.84±0.24	0.61

* A p Value of < 0.05 is Considered Significant

Table 2 : Comparison Ocular Parameters Among Age Groups

Ocular parameters (mm)	Age groups (Years)	Mean± SD	P (<0.05)
AL	18 to 23 24 to 29 30 to 35	24.35±0.87 24.17±0.82 23.68±0.13	0.49
ACD	18 to 23 24 to 29 30 to 35	3.56±0.18 3.49±0.29 3.33±0.07	0.28
LT	18 to 23 24 to 29 30 to 35	3.58±0.19 3.62±0.31 3.99±0.30	0.06
CR	18 to 23 24 to 29 30 to 35	7.81±0.22 7.83±0.23 7.79±0.04	0.94

* A p Value of < 0.05 is Considered Significant

Table 3 : Comparison of Ocular Parameters Among Refractive Errors

Ocular parameters (mm)	Refractive error	Mean±SD	P (<0.05)
AL	Emmetropia	23.78±0.61	0.00
	Low myopia	24.12±0.70	(<0.001)
	Moderate myopia	24.82±0.65	
	High myopia	25.50±0.42	
ACD	Emmetropia	3.49±0.18	0.37
	Low myopia	3.51±0.31	
	Moderate myopia	3.52±0.22	
	High myopia	3.52±0.22	
LT	Emmetropia	3.67±0.25	0.03
	Low myopia	3.52±0.21	
	Moderate myopia	3.57±0.21	
	High myopia	3.50±0.15	
CR	Emmetropia	7.95±0.20	0.00
	Low myopia	7.81±0.21	(<0.001)
	Moderate myopia	7.69±0.12	
	High myopia	7.61±0.10	
AL/CR	Emmetropia	2.99±0.06	0.00
	Low myopia	3.09±0.07	(<0.001)
	Moderate myopia	3.23±0.07	
	High myopia	3.35±0.07	

* A p Value of < 0.05 is Considered Significant

and corneal curvature were compared based on gender (p>0.05) and age group (p>0.05), no clinically significant difference was observed but there was a clinically significant difference exists for refractive error (p<0.05) except for the measurement of anterior chamber depth (p>0.05). Post hoc analysis showed a significant difference exists within emmetropia, moderate myopia and high myopia for axial length, corneal curvature but no significant difference exists for anterior chamber depth and lens thickness. On the other hand a significant difference exists within emmetropia, low myopia, moderate myopia and high myopia for the measurement of AL/CR ratio as shown in Table no.4. Comparison of biometric parameter and corneal curvature showed no clinically significant difference for onset of myopia except the lens thickness (p=0.03) as shown in table no 5.

DISCUSSION

The prime focus of this study was to investigate the association of biometric parameters (axial length, anterior chamber depth, lens thickness) and corneal curvature with refractive state, gender and age group. This study showed no statistically significant difference in ocular components like AL (p=0.39), ACD (p=0.35), LT (p=0.44), CR (p=0.61) between male and female. This finding contradicts the Blanco et.al and Twelker et.al study findings where they found out a significant difference in axial length (p<0.05, p<0.001) between genders (Blanco et al., 2008 and Twelker et.al; 2009). Zadnik et.al in their study showed a significant difference in ACD (p<0.05) but no significant difference for lens thickness (p>0.05) between gender (Zadnik et al., 2003). The possible reason for the discrepancy between this study and previous study is due to the inclusion of different age group. In another study by Donald et.al also contradicts this study finding for lens thickness where they found significant difference between gender (p<0.05) (Donald et al., 2004).

This study comprises three age groups (18-23, 24-29, 30-35). When biometric parameters were compared within this three age groups, we didn't find any significant difference in axial length (p=0.49), anterior chamber depth (p=0.28), lens thickness (p=0.06) and corneal radius

Table 4 : Comparison of Ocular Parameters Between Groups of Refractive Error

	Refractive Error	p value	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
AL	Emmetropia- Low myopia	0.39	-0.820.15	
	Moderate myopia	0.00	-1.47	-0.62
	High myopia	0.00	-2.33	-1.11
	Low myopia – Emmetropia	0.39	-0.150.82	
	Moderate myopia	0.00	-1.25	-0.17
	High myopia	0.00	-2.08	-0.69
	Moderate myopia– Emmetropia	0.00	0.62	1.47
	Low myopia	0.00	0.17	1.25
	High myopia	0.04	-1.33	-0.03
	High myopia–Emmetropia	0.00	1.11	2.33
	Low myopia	0.00	0.69	2.08
	Moderate myopia	0.04	0.03	1.33
ACD	Emmetropia- Low myopia	1.00	-0.20	0.15
	Moderate myopia	1.00	-0.19	0.12
	High myopia	0.48	-0.36	0.08
	Low myopia – Emmetropia	1.00	-0.15	0.20
	Moderate myopia	1.00	-0.20	0.19
	High myopia	1.00	-0.37	0.13
	Moderate myopia – Emmetropia	1.00	-0.12	0.19
	Low myopia	1.00	-0.19	0.20
	High myopia	1.00	-0.34	0.13
	High myopia – Emmetropia	0.48	-0.08	0.36
	Low myopia	1.00	-0.13	0.37
	Moderate myopia	1.00	-0.13	0.34
LT	Emmetropia - Low myopia	0.11	-0.02	0.33
	Moderate myopia	0.44	-0.05	0.25
	High myopia	0.22	-0.05	0.39
	Low myopia – Emmetropia	0.11	-0.33	0.02
	Moderate myopia	1.00	-0.25	0.14
	High myopia	1.00	-0.24	0.27
	Moderate myopia – Emmetropia	0.44	-0.25	0.05
	Low myopia	1.00	-0.14	0.25
	High myopia	1.00	-0.17	0.30
	High myopia – Emmetropia	0.23	-0.39	0.05
	Low myopia	1.00	-0.27	0.24
	Moderate myopia	1.00	-0.30	0.17

CR	Emmetrope - Low myopia	0.05	0.00	0.28
	Moderate myopia	0.00	0.15	0.39
	High myopia	0.00	0.16	0.51
	Low myopia – Emmetrope	0.05	-0.28	-0.00
	Moderate myopia	0.19	-0.03	0.28
	High myopia	0.05	-0.00	0.40
	Moderate myopia – Emmetrope	0.00	-0.39	-0.15
	Low myopia	0.19	-0.28	0.03
	High myopia	1.00	-0.11	0.26
	High myopia – Emmetrope	0.00	-0.51	-0.16
	Low myopia	0.05	-0.40	0.00
	Moderate myopia	1.00	-0.26	0.11
AL/CR	Emmetropia - Low myopia	0.00	-0.15	-0.05
	Moderate myopia	0.00	-0.28	-0.19
	High myopia	0.00	-0.42	-0.30
	Low myopia – Emmetropia	0.00	0.05	0.15
	Moderate myopia	0.00	-0.19	-0.08
	High myopia	0.00	-0.33	-0.19
	Moderate myopia – Emmetropia	0.00	0.19	0.28
	Low myopia	0.00	0.08	0.19
	High myopia	0.00	-0.19	-0.05
	High myopia – Emmetropia	0.00	0.30	0.42
	Low myopia	0.00	0.19	0.33
	Moderate myopia	0.00	0.05	0.19

Table 5: Comparison Ocular Component Based on Onset of Myopia

Ocular components (mm)	Onset of myopia	Mean±SD	P (<0.05)
AL	Early onset	24.740.85	0.65
	Late onset	24.600.69	
ACD	Early onset	3.560.20	0.70
	Late onset	3.520.30	
LT	Early onset	3.450.19	0.03
	Late onset	3.640.22	
CR	Early onset	7.700.14	0.63
	Late onset	7.740.22	

* A p Value of < 0.05 is Considered Significant

(p=0.94). Davaatseren et.al in their study found out that there is significant difference in axial length between 20-29 and 30-39 years (p=0.03) (Davaatseren et al., 2005). The possible reason behind the discrepancy between this study and Davaatseren et.al finding is difference in ethnicity. In another study, Yekta et.al also showed that there is significant difference in ACD (p<0.001), LT (p<0.001) and CR (p=0.007) between age groups where this study didn't show any significant difference among age groups (Yekta et al., 2010). The possible reason for contradicting the previous study finding is because of smaller age range and exclusion of the younger and older age groups. Furthermore it was explained by Zadnik et al in their study that anterior chamber depth elongated by an average of 0.19mm within 6 to 14 years and lens thickness decreased by an average of 0.07 mm within 6 to14 years (Zadnik et al., 2004).When we classified this data according to the age of myopia onset, no significant relationship established between onset of myopia and biometric component except lens thickness. Blanco et.al in their study found out a significant difference in AL ($p<0.05$) and ACD ($p<0.05$) whereas this study showed no significant difference in AL ($p=0.67$), ACD ($p=0.70$) and CR ($p=0.63$) (Blanco et al., 2008).The discrepancy in both studies is because of the difference in classification of onset of myopia where early onset was chosen before 16 years of age for Blanco et.al study and 14 years of age for this study (Blanco et al., 2008).Growth of axial length during childhood is accompanied with some variation in the corneal power, so that ametropia is created. When ametropia is induced, axial length is usually abnormal but it does not always affect alone, and imbalance among the refractive elements of the eye is accounted to be the principal factor for inducing refractive errors. The previous studies showed that axial length is the most important ocular component that increases in the myopia. In this study showed that refractive error and axial length is having a significant association with each other. When axial length was compared with different types of refractive errors, it was noted that AL had more affect in high myopia group compared to emmetropia, low myopia and moderate myopia. The reason for this perhaps is 0.4 mm of axial length change equals approximately 1D of refractive error change. The previous study of Yekta et.al, Eghosasere et.al and Blanco et.al showed significant difference in axial length ($p<0.001$, $p<0.001$ and $p<0.05$) between refractive error which support this study where we also found out significant difference ($p<0.001$) in axial length between refractive error (Yekta et al., 2010; Eghosasere et al., 2011 and Blanco et al., 2008).This study showed no significant differences ($p=0.37$) in anterior chamber depth among refractive errors which is supported by study of Blanco et.al where they also showed no significant differences ($p>0.05$) in ACD within refractive errors (Blanco et al., 2008). These study findings are contradicted by the study of Yekta et.al and Zhong et.al, where they observed a significant difference ($p<0.001$ and $p<0.024$) (Yekta et al., 2010 and Zhong et al., 2009). The possible reason for the discrepancy between this two study is inclusion of larger age group because with increasing age, anterior chamber depth significantly decreased ($P<0.001$). It is also documented that anterior chamber depth gets 0.09 millimeter shorter per year with increase in age (Yekta et al., 2010).In respect of lens thickness, it must also be pointed out that some studies showed that lens is thinner in the myopes. This study showed significant difference ($p=0.03$) between the myopes and emmetrope in LT, but there was no significant difference within myopia which is supported by the study of Yektaet.al and Zhong et.al where they showed a significant difference ($p=0.029$, $p<0.05$) in lens thickness and refractive error but Blanco et al study contradict this study finding where they showed no significant difference ($p>0.05$) in lens thickness between refractive errors (Yekta et al., 2010, Zhong et al., 2009 and Blanco et al., 2008).The possible reason for discrepancy between the findings of Blanco et al. study and this study is due to inclusion of different age group and ethnicity. The axial length has been found to be one of the key variables used in assessing the refractive status of the eye, and the interaction between it and corneal radius of curvature play a major role in the emmetropization process. This study showed that refractive error and corneal radius is having a significant ($p<0.001$) association with each other. When corneal radius compared with different types of refractive errors, it was noted that CR had more affect in emmetrope group as compare to low myopia, moderate myopia and high myopia. Zhong et.al in their study found out a significant difference ($p<0.05$) in corneal radius between refractive error which supports this study (Zhong et al., 2009). Eghosasere et al was reported that myopes having steeper cornea than emmetrope which supports this study too (Eghosasere et al., 2011). AL/CR ratio is important predictor for emmetropia. Eghosasere et al claimed that myopes had significantly higher AL/CR ratio than emmetrope (Eghosasere et al., 2011). A change of 1.00D in spherical equivalent refractive error will alter the AL/CR ratio by approximately 0.06. When we stratified our data according to the refractive error of the subjects, the

AL/CR ratio showed correlation with refractive error. We found out that AL/CR ratio showed greater affect on emmetrope group as compare to other groups. Eghosasere et.al in their study found out a significant difference ($p<0.001$) in AL/CR ratio across refractive groups which supports this study where the similar significant difference ($p<0.001$) in AL/CR ratio between refractive error where obtained (Eghosasere et al., 2011) . This study concluded that a significant difference in biometric parameter, corneal curvature and AL/CR ratio between emmetropia and myopia except anterior chamber depth. In addition, there is a significant difference in lens thickness exits based on the onset of myopia. On other hand, there was no significant difference in biometric parameter, corneal curvature based on age groups and gender. A greater axial length of the eye was observed in all the types of myopia examined. Hence, axial lengthening is the main morphological factor related to myopia. There was a statistically significant correlation between AL/CR ratio and spherical refractive error exists. AL/CR ratio is a better index for categorizing the refractive status of an individual than axial length alone. It is our recommendation that researchers interested in this study should have few different approaches to conduct the research. This study was concentrated on relationship of ocular components and refractive states, we did not include the larger age groups and races factor to our calculation. Therefore it is recommended that future study should include larger age group and ethnicity to find out the influence on ocular components by taking into consideration of all the contributing factors.

ACKNOWLEDGEMENT

I would like to thank all my colleagues for their valuable guidance and advice throughout the research. I am grateful to our Dean and Vice chancellor of our university for giving me the opportunity to conduct this research. Special thanks to all subjects who had participated to make this research complete.

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