[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

Original Article

Axial Length/Corneal Radius of Curvature Ratio and Refractive Status in an Adult Nigerian Population

SA Badmus, AI Ajaiyeoba[1], BO Adegbehingbe, OH Onakpoya, AO Adeoye

Department of Surgery, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Osun State, [1]Department of Ophthalmology, College of Medicine, University of Ibadan, Oyo State, Nigeria

Abstract

Aim/Background: Associations between axial length (AL) to corneal radius of curvature (CR) ratio and refractive status in a healthy Nigerian adult population were studied. **Materials and Methods:** Healthy students and members of staff of Obafemi Awolowo Teaching Hospitals Complex, Ile-Ife, South West Nigeria, free of obvious ocular diseases except possible refractive errors were recruited. Consecutive consenting volunteers were recruited by simple random sampling and a proportionate sample of each population based on its representative fraction in the hospital community was recruited. The study was conducted between June and August 2011. Noncycloplegic objective refraction was done and spherical equivalent refraction (SER) of the right eyes was used for calculation. The AL, CR, and keratometric readings were measured with the IOL Master. The AL/CR ratio was calculated. The data were analyzed with statistical software package STATA 13. **Results:** Three hundred and fifty volunteers aged 18–60 years were studied. The mean ± standard deviation of AL/CR and SER were 3.04 ± 0.10 and −0.38 ± 1.42D, respectively. AL in myopia was significantly higher than in emmetropia and hypermetropia. There were no significant differences between CR in the refraction groups. Myopes had significantly higher AL/CR than nonmyopes. On controlling for age and gender, 1 mm increase in AL increased SER by −0.77D (95% confidence interval [CI] −0.91–−0.64D) while a unit increase in AL/CR increased SER by −8.89D (95% CI −10.00–−7.78D). Whereas AL accounts for 39% of variability in SER ($P < 0.001$), AL/CR accounts for 51% of the variability observed in SER ($P < 0.001$). **Conclusion:** This study has further confirmed that the AL remains a strong determinant of refraction, but a derived factor AL/CR accounts for more variation in final refractive status than AL in isolation.

Date of Acceptance: 14-Jun-2017

Keywords: *Axial length, axial length/corneal radius of curvature ratio, Nigerian adults, refraction*

Introduction

The final refractive status of the eye has been variously described as determined by the ocular biometric variables. There have been many studies on the relationship between refractive error and ocular axial length (AL), anterior chamber depth, corneal radius of curvature (CR), keratometric readings as well as other ocular biometric variables such as lens thickness and vitreous chamber depth.[1-4] Although the AL has been found to be the most important singular biometric variable affecting final refractive status of individuals,[2,5-8] the relationship between CR and refractive status has been inconsistent.[4,8] While some researchers have reported flatter cornea to be associated with increasing myopia,[4] others have found it to be

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_183_16

Address for correspondence: Dr. SA Badmus, Department of Surgery, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. E-mail: saratbadmus@gmail.com

This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Badmus SA, Ajaiyeoba AI, Adegbehingbe BO, Onakpoya OH, Adeoye AO. Axial length/corneal radius of curvature ratio and refractive status in an adult Nigerian population. Niger J Clin Pract 2017;20:1328-34.

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

associated with hypermetropia.[8] In either case, the relationship has been very weak.[4,8]

When the AL/corneal radius ratio is generated, it is found to be a stronger determinant of refractive status than the AL or CR in isolation.[3,4,9-11] The extent to which these factors affect the final refractive outcome is shown in the work of Baker and Tasman.[12] They demonstrate that retinopathy of prematurity patients with myopia had shorter AL for the level of myopia when compared to their full-term counterpart with the same degree of myopia although later in life, the AL/CR were similar for refractive status in both groups.[12] The extent to which the ocular biometric variables affect the final refractive status has also been found to vary among different racial groups.[9,10]

The current study seeks to determine the relationship between AL, CR, AL/CR ratio, and refractive status in healthy Nigerians.

Materials and Methods

This observational cross-sectional study was carried out on apparently healthy volunteers from the staff and student population of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife in South West Nigeria, who visited the Eye Care Center of the teaching hospital. Ethical clearance for the study was obtained from the Ethical and Research Committee of the Hospital, and the study was advertised in the hospital community. The study was carried out between June and August 2011. Consenting volunteers were recruited by simple random sampling (by balloting), and a proportionate sample of each population based on its representative fraction in the hospital community was recruited. Informed consent was obtained from all the participants, and the Declaration of Helsinki was adhered to. Sample size was calculated using the formula for estimating a single proportion at a specified precision.[13]

$n = Z\alpha^2 pq/d^2$

Where,

n = Minimum sample size

$Z\alpha$ = Standard normal deviate corresponding to a significance level of 5% (1.96%)

p = prevalence of outcome of interest (refractive error) 65%[14]

q = 1 − prevalence

d = Level of precision set at 0.05 with an error margin of 10%

$n = (1.96)^2 (0.65) (1 - 0.65)/(0.05)^2$

n = 349.6˜350.

A total of 240 workers and 110 students were recruited for the study.

All individuals with a past history of significant ocular trauma or surgery and current eye diseases except possible refractive errors were excluded from the study. The gender and age of the participants (18 years and above) were documented in a pro forma designed for the study. Distant visual acuity was measured by a registered nurse unaided and with pinhole using an illuminated Snellen chart at a distance of 6 m in a well-lit room, one eye at a time. Only participants with visual acuity of 6/6 unaided or significant improvements with pinhole acuity were included in the study. One 5th year ophthalmic resident carried out all the ocular examination, objective refraction, and ocular biometry for all the participants. Noncycloplegic objective refraction of each participant was determined using a Grand Seiko® autorefractor (Kagawa, Japan). The anterior segment was examined with bright pen torch and the slit lamp biomicroscope (Haag-Streit, Switzerland), while the posterior segment was examined with direct ophthalmoscope (Welch Allyn) by the same investigator. The magnitude of the errors for astigmatism was presented as spherical equivalent, that is, the sum of the sphere and half of the cylinder in diopters. Myopia was defined as spherical equivalent refraction (SER) less than or equal to −0.50D and hypermetropia as greater than or equal to +0.50D.[15] Emmetropia was defined as SER from −0.49D to +0.49D.[15]

The AL, CR, and keratometric readings were measured with the IOL Master (Carl Zeiss Meditec AG, 07740 Jena Germany). Five measurements per eye were taken for the AL and the mean values used in calculation. The average of three keratometric readings in the greatest and least meridians of corneal radial curvature (K_1, K_2, respectively) was determined for each eye, and the average keratometric reading (K) was finally calculated in diopters. The greatest and least corneal radii of curvature were measured for each eye, and the average was recorded as the average CR in millimeters. Only measurements in the right eyes were used for analysis because of high correlation between the right and left eyes. The correlations between AL, CR, K, and SER in the right and left eyes were 0.95, 0.85, 0.98, and 0.87, respectively.

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

Data obtained were analyzed using STATA 13 statistical software (Texas, USA). Skewness/kurtosis test was used to determine normality of distribution. Correlations between variables were determined using Pearson's and Spearman correlations for parametric and nonparametric variables, respectively. Bartlett's test of equal variances was also employed. Differences between means were examined using the *t*-test or analysis of variance methods for parametric variables and Kruskal–Wallis test for nonparametric variables. A multivariate regression model was fitted to explore the influence of AL and AL/CR on SER after controlling for age and gender. Level of statistical significance was set at 5% ($P < 0.05$).

Results

Three hundred and fifty healthy controls were enrolled in this study. One hundred and twelve participants (32.0%) were students while the remaining (68.0%) were workers. One hundred and sixty-seven (47.7%) of the participants were males and 183 (52.3%) were females. Participants' age ranged between 18 and 60 years with a mean of 34.8 ± standard deviation (SD) 11.2 years while the median age was 33 years. There was no significant difference in the age distribution of the males relative to the females ($P = 0.96$). All participants were Nigerians, and measurements were complete for both eyes in all participants.

There was high correlation between the ocular biometric values in the right and the left eyes. The correlations between AL, CR, K, and SER in the right and left eyes were 0.951, 0.851, 0.980, and 0.871, respectively. One hundred and twenty-four (35.43%) were myopic, 149 (42.57%) were emmetropic, and 77 (22%) were hypermetropic. Two hundred and eighty-nine (82.6%) participants had astigmatism ranging from −0.25DC to −4.25DC. The mean astigmatism was −0.51 ± 0.50DC. The SER in all participants ranged between −7.75D and +2.50D. Only 15 (4.3%) participants had myopia (SER) of more than −3.00DS.

Table 1 shows the mean, SD, and median values of AL, average CR, average keratometric reading, AL/CR, and SER values of the participants. The AL, CR, and K were normally distributed. On the other hand, AL/CR was significantly positively skewed (skewness = 1.246, kurtosis = 6.956) while SER was negatively skewed (skewness = −1.950, kurtosis = 9.761).

Table 2 shows the ocular biometric indices and SER by gender. There was significant difference between the AL, average keratometric reading, and average CR in the males and females, but no statistically significant difference in the SER by gender.

Table 3 shows the correlation between ocular biometric variables and SER. Significant correlations were found between AL and all variables examined. The CR was highly correlated with K. Both the corneal radius and average keratometric reading were not significantly correlated with SER.

Table 4 depicts the distribution of AL, average CR, average keratometric reading, AL/CR, and SER in myopia, emmetropia, and hypermetropia in the participants. There is a significantly higher AL in myopes compared to emmetropes and hypermetropes. Although the CR is higher in myopes (myopes have flatter corneas), the difference is not statistically significant. The association between the average keratometric reading and refraction groups is similar to that of CR and refraction groups in which there were no statistically significant differences between the groups. For the AL/CR, there was significant difference between myopia and emmetropia as well as between myopia and hypermetropia, but the difference between emmetropia and hypermetropia was not statistically significant. *P* values and other details are as shown in Table 4.

One hundred and fifty-one (43.14%) of the participants were 30 years old or younger. Among the participants who were 30 years old or younger, there were 83 myopes (54.97%), 58 emmetropes (38.41%), and only 10 hypermetropes (6.62%). The distribution of AL, average CR, average keratometric reading, AL/CR, and SER in myopia, emmetropia, and hypermetropia, in these participants is depicted in Table 5. In the participants 30 years and younger, the correlation between AL and SER was −0.33 ($P < 0.001$) while in participants older than 30 years, the correlation was −0.43 ($P < 0.001$).

Regression analysis controlling for age and gender revealed that 1 mm increase in AL increased SER by −0.77D (95% confidence interval [CI] −0.91–−0.64D); $R^2 = 0.39$ ($P < 0.001$) indicating that AL accounts for 39% of variability in SER in the participants. On the other hand, a unit increase in AL/CR increased SER by −8.89D (95% CI −10.00–−7.78D); $R^2 = 0.51$ ($P < 0.001$) suggesting that AL/CR accounts for 51% of the variability observed in SER.

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

Table 1: Values of ocular biometrics

Variable	Mean±SD	Median
AL (mm)	23.78±0.91	23.77
CR (mm)	7.81±0.28	7.82
K (D)	43.24±1.56	43.16
AL/CR	3.04±0.10	3.04
SER (D)	−0.38±1.42	−0.25

Mean, SD, and median values of AL, CR, K, AL/CR, and SER values of the participants. SER=Spherical equivalent refraction; AL=Axial length; CR=Average corneal radius of curvature; K=Average keratometric reading; SD=Standard deviation; AL/CR=Axial length/corneal radius of curvature ratio

Table 2: Mean ocular biometric variables and spherical equivalent refraction by gender

Variable	Mean±SD		*P*
	Male (*n*=167)	Females (*n*=183)	
AL (mm)	24.07±0.87	23.52±0.87	<0.01
K (D)	42.92±1.51	43.54±1.54	<0.01
CR (mm)	7.86±0.31	7.76±0.27	<0.01
SER (D)	−0.23±1.45	−0.02±1.28	0.16

Mean and SD of AL, K, CR, and SER in the males and female participants. AL=Axial length; K=Average keratometric reading; CR=Average corneal radius of curvature; SER=Spherical equivalent refraction; SD: Standard deviation

Table 3: Correlation between the various ocular biometrics and spherical equivalent refraction

Variable	AL	CR	K	AL/CR
CR	0.576, *P*<0.001			
K	−0.645, *P*<0.001	−0.890, *P*<0.001		
AL/CR	0.333, *P*<0.001	−0.421, *P*<0.001	0.396, *P*<0.001	
SER	−0.351, *P*<0.001	−0.078, *P*=0.147	0.093, *P*=0.081	−0.310, *P*<0.001

Correlation between ocular biometric variables and SER in all participants. AL=Axial length; CR=Corneal radius of curvature; K=Average keratometric reading; AL/CR=Axial length/corneal radius of curvature ratio; SER=Spherical equivalent refraction

Table 4: Distribution of ocular biometric variables and refractive status

Ocular variable	Refractive group	Mean±SD			
		All participants	Difference between myopia and emmetropia	Difference between myopia and hypermetropia	Difference between emmetropia and hypermetropia
AL	Myopia	24.20±1.03	0.53	0.86	0.32
	Emmetropia	23.67±0.70	*P*<0.001	*P*<0.001	*P*=0.026
	Hypermetropia	23.34±0.79			
CR	Myopia	7.85±0.29	0.03	0.09	0.06
	Emmetropia	7.82±0.26	*P*=0.614	*P*=0.067	*P*=0.299
	Hypermetropia	7.76±0.28			
K	Myopia	43.05±1.63	0.18	0.53	0.35
	Emmetropia	43.23±1.47	*P*=0.627	*P*=0.065	*P*=0.283
	Hypermetropia	43.58±1.56			
AL/CR	Myopia	3.08±0.12	−0.06	−0.07	−0.02
	Emmetropia	3.03±0.07	*P*<0.001	*P*<0.001	*P*=0.36
	Hypermetropia	3.01±0.08			
SER	Myopia	−1.68±1.52			
	Emmetropia	−0.05±0.23			
	Hypermetropia	+1.07±0.58			

Distribution of AL, CR, K, AL/CR, and SER in myopia, emmetropia, and hypermetropia. AL=Axial length; CR=Average corneal radius of curvature; K=Average keratometric reading; SER=Spherical equivalent refraction; AL/CR=Axial length/corneal radius of curvature ratio; SD=Standard deviation

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

Table 5: Distribution of axial length and average corneal radius of curvature by refractive status in participants 30 years old and younger and participants older than 30 years

Ocular variable	Refractive group	30 years and younger				Older than 30 years			
		Mean±SD	Difference between myopia and emmetropia	Difference between myopia and hypermetropia	Difference between emmetropia and hypermetropia	Mean±SD	Difference between myopia and emmetropia	Difference between myopia and hypermetropia	Difference between emmetropia and hypermetropia
AL	Myopia	24.11±1.06	0.47	1.11	0.63	24.37±0.96	0.69	0.98	0.29
	Emmetropia	23.64±0.75	*P*=0.018	*P*=0.003	*P*=0.156	23.69±0.66	*P*<0.001	*P*<0.001	0.062
	Hypermetropia	23.01±1.07				23.39±0.74			
CR	Myopia	7.88±0.29	0.04	0.13	0.09	7.78±0.29	0.02	0.02	0.04
	Emmetropia	7.84±0.29	*P*=0.759	*P*=0.402	*P*=0.637	7.80±0.25	*P*=0.951	*P*=0.901	*P*=0.648
	Hypermetropia	7.76±0.28				7.76±0.28			

Distribution of AL and CR in myopia, emmetropia, and hypermetropia in participants 30 years old and younger and participants older than 30 years. AL=Axial length; CR=Average corneal radius of curvature; SD=Standard deviation

Discussion

The ocular biometric variables are the determinants of final refractive status of the eye. Findings from this study showed that ocular biometric variables (AL, CR, and average keratometric reading) in all participants examined in this study were normally distributed, the SER is negatively skewed, and the derived variable AL/CR is positively skewed. This pattern of distribution is similar to previous findings in literature.[2,10,16] These findings may suggest that some relationship may exist between some of the unexamined variables that influence and possibly determine the final refractive outcome. The mean AL, CR, and AL/CR (23.74 mm, 7.84 mm, and 3.03, respectively) in our study are also similar to findings by Iyamu *et al*.[10] in Benin City in Southern Nigeria although their sample size was smaller (n = 70). Similarly, our findings are also comparable to other studies on adult Arabs also recruited from workplaces.[2,3] The AL has remained a very important ocular biometric index around which many of the other ocular biometric indices revolve.

The significant positive correlation between AL and CR indicates that longer globes are associated with flatter cornea. In the same vein, longer globes are associated with lower corneal power as indicated by the significant negative correlation between AL and average keratometric reading. It seems there is an interplay between these variables, a mechanism in the relationship between these variables that tends to achieve emmetropia. The highest correlation which was found between average keratometric reading and CR may suggest that most of the refractive power of the cornea can be attributed to its curvature. Although it is generally believed that the cornea contributes about two-thirds of the total focusing power of the eye, it does not vary much between refraction groups. Previous studies have also shown no significant relationship between SER and CR.[11,16,17] While Iyamu *et al*.[10] in another location in Nigeria, reported a significantly steeper cornea in myopes, we found that the myopes in our study have flatter cornea although the relationship is not statistically significant. The reason for this discrepancy may need to be verified by further studies bearing in mind that the ocular biometric values reported in the study are similar to ours.

The main difference between myopia and hypermetropia appears to be the AL. This is in agreement with earlier reports on studies carried out both in children and adults in which refraction was found to be closely related to AL.[8,15,18,19] It should however be borne in mind that other factors which may not be reflected in this study such as the lens thickness and power may play more prominent role in the final refraction in selected individuals.

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

The AL/CR ratio in emmetropes is closest to the recorded mean in this study [Tables 1 and 3]. It may be deduced that the closer to the mean the AL/CR is, the more likely the refractive status is to be emmetropic. The myopes had significantly higher AL/CR than the emmetropes and the hypermetropes (most marked between myopes and hypermetropes). The difference between AL/CR in myopia and emmetropia is more marked than is evident between emmetropia and hypermetropia in this study. This may be accounted for by the fact that a higher range of myopia was recorded relative to hypermetropia.

Division of the group into participants 30 years and younger and participants older than 30 years did not reveal any significant difference in the variables examined among the two groups. This suggests that in this adult population, age is not likely to be a determinant of the indices examined.

This study showed that the contribution of AL to the variability of SER was found to be approximately 39%, while AL/CR accounted for about 51% of the variation in SER. This increase in the effect of AL in combination with the seemingly insignificant CR is similar to previous studies, suggesting that AL/CR is more closely related to SER than AL or CR alone.[3,4,9,10] The absolute values observed in this study however differ from values observed in earlier studies.[4,9,20] While Hashem *et al*.[9] in Iran attributed 35% and 60% of the variation in SER to AL and AL/CR, respectively; Grosvenor *et al*.[4] was able to attribute a variation of 84% of SER to AL/CR. Perhaps, this may connote some racial variation which further studies may be required to confirm. The corresponding increase in SER of −8.89D with each unit of AL/CR reported in our study is lower than −12.1D reported by researchers in the Middle East[9] and −10.77D reported among Chinese children.[20]

It is of note that in this study, very high refractive error was not common. This finding may probably be because the participants were selected from healthy volunteers. Further studies may be necessary to determine the role of the studied variables in the determination of very high refractive error.

Conclusion

This study confirmed the relationship between AL and refractive status in a healthy Nigerian adult population. It has also buttressed the fact that rather than being independent, ocular biometric variables are interdependent. This study also established that AL/CR ratio is a stronger predictor of refractive status than AL alone. Although the relationship established between these ocular variables and refraction will hold for the majority, some selected individuals may have dissimilar ocular biometric indices responsible for their final refractive outcome. This should be borne in mind when considering the usefulness of the AL/CR in refractive surgeries.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Brown NP, Koretz JF, Bron AJ. The development and maintenance of emmetropia. Eye (Lond) 1999;13(Pt 1):83-92.
2. Mallen EA, Wolffsohn JS, Gilmartin B, Tsujimura S. Clinical evaluation of the Shin-Nippon SRW-5000 autorefractor in adults. Ophthalmic Physiol Opt 2001;21:101-7.
3. Osuobeni EP. Ocular components values and their intercorrelations in Saudi Arabians. Ophthalmic Physiol Opt 1999;19:489-97.
4. Grosvenor T, Scott R. Role of the axial length/corneal radius ratio in determining the refractive state of the eye. Optom Vis Sci 1994;71:573-9.
5. Eysteinsson T, Jonasson F, Arnarsson A, Sasaki H, Sasaki K. Relationships between ocular dimensions and adult stature among participants in the Reykjavik Eye Study. Acta Ophthalmol Scand 2005;83:734-8.
6. Fotedar R, Wang JJ, Burlutsky G, Morgan IG, Rose K, Wong TY, *et al.* Distribution of axial length and ocular biometry measured using partial coherence laser interferometry (IOL Master) in an older white population. Ophthalmology 2010;117:417-23.
7. Kuzin AA, Varma R, Reddy HS, Torres M, Azen SP; Los Angeles Latino Eye Study Group. Ocular biometry and open-angle glaucoma: The Los Angeles Latino Eye Study. Ophthalmology 2010;117:1713-9.
8. Strang NC, Schmid KL, Carney LG. Hyperopia is predominantly axial in nature. Curr Eye Res 1998;17:380-3.
9. Hashemi H, Khabazkhoob M, Miraftab M, Emamian MH, Shariati M, Abdolahi-Nia T, *et al.* Axial length to corneal radius of curvature ratio and refractive errors. J Ophthalmic Vis Res 2013;8:220-6.
10. Iyamu E, Iyamu J, Obiakor CI. The role of axial length-corneal radius of curvature ratio in refractive state categorization in a Nigerian population. ISRN Ophthalmol 2011;2011:138941.
11. Kimura S, Hasebe S, Miyata M, Hamasaki I, Ohtsuki H. Axial length measurement using partial coherence interferometry in myopic children: Repeatability of the measurement and comparison with refractive components. Jpn J Ophthalmol 2007;51:105-10.
12. Baker PS, Tasman W. Myopia in adults with retinopathy of prematurity. Am J Ophthalmol 2008;145:1090-4.
13. Araoye MO. Sample size for comparison groups. In: Research Methodology with Statistics for Health and Social Sciences. Ilorin, Nigeria: Nathadex Publishers; 2003. p. 117-20.
14. Ezelum C, Razavi H, Sivasubramaniam S, Gilbert CE, Murthy GV, Entekume G, *et al.* Refractive error in Nigerian adults: Prevalence, type, and spectacle coverage. Invest Ophthalmol Vis Sci 2011;52:5449-56.
15. Foster PJ, Broadway DC, Hayat S, Luben R, Dalzell N, Bingham S, *et al.* Refractive error, axial length and anterior chamber depth of the eye in British adults: The EPIC-Norfolk Eye Study. Br J Ophthalmol 2010;94:827-30.

[Downloaded free from http://www.njcponline.com on Tuesday, December 5, 2017, IP: 165.255.188.110]

16. Ojaimi E, Rose KA, Morgan IG, Smith W, Martin FJ, Kifley A, *et al.* Distribution of ocular biometric parameters and refraction in a population-based study of Australian children. Invest Ophthalmol Vis Sci 2005;46:2748-54.
17. Llorente L, Barbero S, Cano D, Dorronsoro C, Marcos S. Myopic versus hyperopic eyes: Axial length, corneal shape and optical aberrations. J Vis 2004;4:288-98.
18. Wu HM, Gupta A, Newland HS, Selva D, Aung T, Casson RJ. Association between stature, ocular biometry and refraction in an adult population in rural Myanmar: The Meiktila eye study. Clin Exp Ophthalmol 2007;35:834-9.
19. Song HT, Kim YJ, Lee SJ, Moon YS. Relations between age, weight, refractive error and eye shape by computerized tomography in children. Korean J Ophthalmol 2007;21:163-8.
20. He X, Zou H, Lu L, Zhao R, Zhao H, Li Q, *et al.* Axial length/corneal radius ratio: Association with refractive state and role on myopia detection combined with visual acuity in Chinese schoolchildren. PLoS One 2015;10:e0111766.