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Original Article

Anatomy Section

Variation of Axial Ocular Dimensions with Age, Sex, Height, BMI-and Their Relation to Refractive Status

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ABSTRACT

Background: Myopia is one of the most common causes of visual impairment worldwide.It is proved in earlier studies that the eye shape is different in myopic and nonmyopic children even at a very young age, with the former manifesting asymmetric axial globe elongation and the latter global expansion but limited information is available regarding hypermetropia.

Aim: To find out the variations of axial ocular dimensions in relation to age, sex, height and to demonstrate any possible correlation of body mass index (BMI) in myopic hypermetropic and emmetropic patients.

Settings: It is a cross-sectional observational study.

Materials and Methods: All the patients attending eye OPD in the Regional Institute of Ophthalmology (R.I.O.), Medical College, Kolkata, West Bengal, India from June2010 to May 2011.Axial dimensions were measured by B-mode USG. Refractive status was measured.Age, gender, height and BMI were also observed. After collecting all the data,all the variables were summarised by descriptive statistics followed by correlation testing by Pearson's Correlation Coefficient r.

Results: Height was positively correlated with axial length, anterior chamber depth, vitreous chamber depth ;age was positively correlated with axial length, vitreous chamber depth and negatively correlated with anterior chamber depth. Subjects with higher BMI tended to had refractions that were more hypermetropic.

Conclusion: The findings of the present study can highlight not only the normal range of the different ocular parameters namely axial length, anterior chamber depth, vitreous chamber depth and lens thickness but their variation with age, gender, height and weight.

Keywords: Axial length, Anterior chamber depth, Lens thickness, Vitreous chamber depth

INTRODUCTION

Uncorrected refractive errors (Ametropia) are responsible for 19.7% of blindness in India [1]. Axial ametropia (hypermetropia and myopia) is by far the most common and most important [2].

Axial ocular dimensions are important indicators of myopia & hypermetropia. Axial ocular dimensions include axial ocular length, anterior chamber depth, lens thickness, and vitreous chamber depth. These dimensions can be measured by using ultrasonic device. The axial ocular dimensions also vary with age, gender, height. Our study is on axial ocular dimensions and their relationship to age, sex, and anthropometric parameters and refractive status.

The standard value of the axial length of the eyeball is taken to be 24mm internationally, in an adult, irrespective of the sex, race and other body measurements [3]. Mean anterior chamber depth is considered to be 3.11mm [4].The vitreous chamber depth varies from 14.42mm to 16mm [5]. The study was intended to find out the variations of axial ocular dimensions in relation to age, sex, height and to demonstrate any possible correlation of body mass index (BMI) in myopic, hypermetropic and emmetropic subjects.

MATERIALS AND METHODS

It was a cross-sectional observational study. One hundred fifty two patients attending eye OPD during one year study period (June 2010-May 2011), in the Regional Institute of Ophthalmology (R.I.O.), Medical College, Kolkata, West Bengal, India were included in this study. Permission from Institutional Ethical Committee was taken. Children less than eight years, and persons more than 70 y, persons with ocular disease affecting ocular dimensions and with any obvious physical deformities were excluded from the study. Data on age was collected through interview or when proof was available. Subjects were assessed clinically. Weight was measured by weight beam scale. Height was also measured by standard method. Then BMI was calculated (as BMI=Weight in Kg/Height in metre^2).

Refractive status was also assessed according to standard method. Axial length, anterior chamber depth, lens thickness and vitreous chamber depth were measured by B-mode USG prior to administration of cycloplegic medicine. All the metric data were observed by the same individual to avoid observer's bias.After collecting all the data, the variables were summarized by descriptive statistics followed by correlation testing by Pearsons's Correlation Coefficient r. Result was tabulated and statistically correlated. Chi square test or Fisher's exact test were employed to test for significant difference in categorical variable between subgroups. The independent sample t-test or Mann-Whitney U-test were employed for inter group comparison of numerical variable as appropriate. All changes were two tailed and p-less than 0.05 were considered as statistically significant.

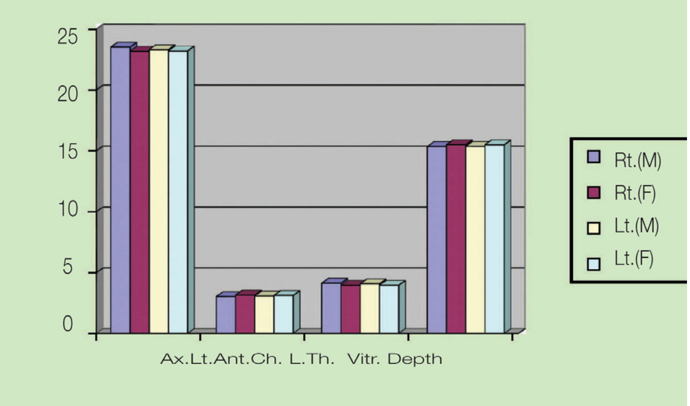
RESULTS

Among the 152 subjects 40 were emmetropic, 57 were myopic and 55 were hypermetropic. Among emmetropic subjects number of males and females were 20 each, respectively. Among myopic subjects 33 were male and 24 were female. Among hypermetropic subjects 28 were male and 27 were female. The observed axial ocular dimensions and their gender comparison in emmetropic, myopic and hymermetropic subjects has been depicted in [Table/Fig-1-4].

In emmetropic eyes good positive correlation were found between axial length {Pearson's Correlation Coefficient 'r' = 0.56 (rt), 0.58 (lt)}, and vitreous chamber depth {'r' = 0.54 (rt), 0.60 (lt)} and height. Good positive correlation was also found between axial length {Pearson's Correlation Coefficient 'r' = 0.62 (rt), 0.58 (lt)}, and vitreous chamber depth {'r' = 0.67 (rt), 0.64 (lt)} and age [Table/Fig-5,6]. Negative correlation was found between anterior chamber depth {'r' = - 0.22 (rt),- 0.26 (lt)} and age [Table/Fig-5].

	Parameters	Mean		Median		Std.Dev.		Std.Error	
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
Emm-etropia	Axial Length	23.35	23.26	23.08	23.10	0.87	0.64	0.13	0.10
	Ant. Chamber	3.08	3.10	3.0	3.05	0.56	0.55	0.09	0.09
	Lens Thickness	4.04	4.01	3.99	3.99	0.24	0.17	0.04	0.03
	Vitreous Depth	15.42	15.43	15.51	15.50	0.36	0.36	0.06	0.06
Myopia	Axial Length	25.23	25.31	24.82	24.92	1.10	1.12	0.15	0.15
	Ant. Chamber	3.28	3.29	3.10	3.15	0.43	0.42	0.06	0.06
	Lens Thickness	3.86	3.88	3.94	3.98	0.23	0.23	0.03	0.03
	Vitreous Depth	16.16	16.20	16.0	16.02	0.60	0.59	0.08	0.08
Hyperm-etropia	AxialLength	22.50	22.48	23.32	22.72	1.38	1.44	0.19	0.20
	Ant. Chamber	3.08	3.07	3.00	3.00	0.38	0.37	0.05	0.05
	Lens Thickness	3.88	3.86	3.93	3.91	0.19	0.24	0,03	0.03
	Vitreous Depth	14.20	14.19	14.64	14.62	1.38	1.38	0.19	0.19

[Table/Fig-1]: Axial Ocular Dimensions (in mm) in emmetropic and ametropic subjects



[Table/Fig-2]: Comparison of Axial Ocular Dimensions between males and females in emmetropic eyes
Ax.Lt.-axialocular dimension.Ant.Ch.-anterior chamber.L.Th.-lensthickness.Vitr.Depth-vitreouschamber depth

In myopic eyes good positive correlation was found between axial length {Pearson's Correlation Coefficient 'r' = 0.68 (rt), 0.66 (lt)}, and vitreous chamber depth {'r' = 0.61 (rt), 0.61 (lt)} and height [Table/Fig-5].

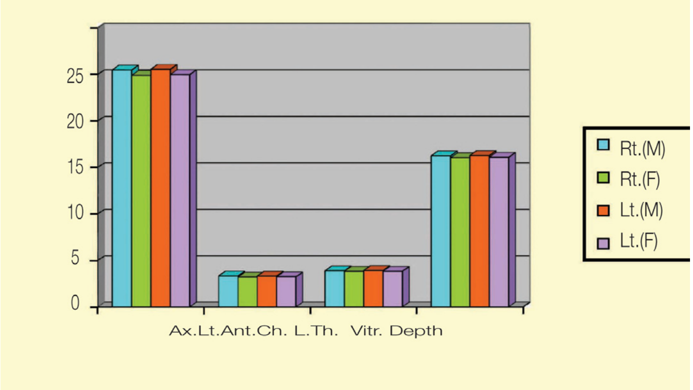
In hypermetropic eyes negative correlation was found between axial length {Pearson's Correlation Coefficient 'r' = - 0.33 (rt), - 0.36 (lt)}, and vitreous chamber depth {'r' = - 0.38 (rt), - 0.38 (lt)} and height [Table/Fig-5].

Negative correlation was also found between BMI and axial length {Pearson's Correlation Coefficient 'r' = 0.61 (rt), - 0.57 (lt)} and vitreous chamber depth {Pearson's Correlation Coefficient 'r' = 0.58 (rt), - 0.57 (lt)} [Table/Fig-5].

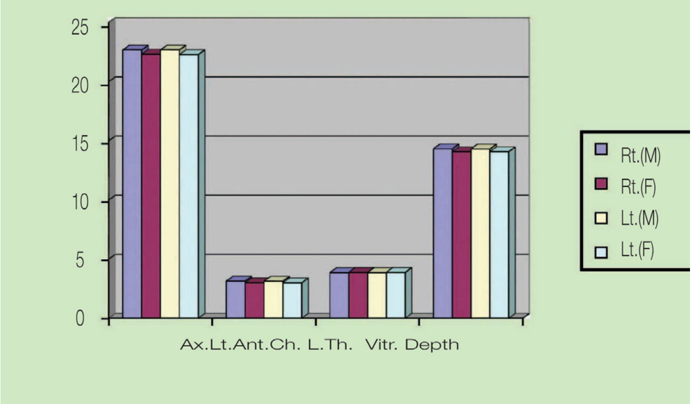
It was found that mean BMI was more in hypermetropic than myopic and more in high hypermetropic (26.54) than mild to moderate hypermetropic (21.93), The variations were statistically significant (p-value=0.01) [Table/Fig-7,8].

DISCUSSION

The present work focuses on the axial length of the eyeball. As the central part of the retina provides the greatest acuity of vision, the antero-posterior axial length of the eyeball is of greatest importance in refraction. In fact the multiple regression models revealed that



[Table/Fig-3]: Comparison of Axial Ocular Dimensions (in mm) between males and females in myopic eyes
Ax.Lt.-axialocular dimension.Ant.Ch.-anterior chamber.L.Th.-lensthickness.Vitr.Depth-vitreouschamber depth



[Table/Fig-4]: Comparison of Axial Ocular Dimensions (in mm) between males and females in hypermetropic eyes
Ax.Lt.-axialocular dimension.Ant.Ch.-anterior chamber.L.Th.-lensthickness.Vitr.Depth-vitreouschamber depth

axial length and vitreous chamber depth were the strongest determinants of refractive status [6]. Another study also revealed that children with myopia have longer axial length and vitreous chamber depth compared to those who are emmetropic [7]. It was observed in one study that myopes tend to have longer axial length and hypermetropes tend to have a shorter axial length comparing to that with emmetropes [8].

The mean axial length of the emmetropic eye have been found as 22.8 mm for boys and 22.5 mm for girls at the age of seven years to 23.27 mm and 22.94 mm, respectively, at the age of 15 y. After puberty the mean axial length in male and female have been found as 23.3mm and 22.9 mm respectively [9]. Mean axial length was 22.61±0.02mm among Australian school students with mean age of 6.7y [10]. In the present study, the axial length, anterior chamber depth, lens thickness, vitreous depth was 23.35, 3.08, 4.04, 15.42mm.respectively.

In one previous study it was revealed that mean anterior chamber depth was 3.11mm [4]. Regarding length of vitreous its value was15.55mm at the age of 12 [10] and in adult the value ranged from 14.42 to 16mm [5].

The influence of sex over refractive errors and its relation with the axial length of the eyeball have been extensively studied in the present work. Gender differences are not significant in emmetropic subjects which is statistically insignificant (p-value = 0.26).

In one research work it was observed that among the myopic groups (p< 0.001) and among the hyperopic groups (p=0.025) male – female variation in mean ocular axial length were significant [11]. It was also found that women had an axial length, which was significantly less in the hyperopic groups. This was also supported by another study [12]. Larger eyes for men (vs women) were also the finding of another previous study [4]. Not only the axial length of

	Anthrop-ometric Measur-ements	Axial Length		Ant.Chamber		Lens-thickness		Vitreous Depth	
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
Emme-tropic	Height	0.56	0.58	0.32	0.36	0.35	0.26	0.54	0.60
	Weight	0.40	0.44	0.34	0.32	0.33	0.28	0.48	0.44
	BMI	0.42	0.47	0.43	0.46	0.21	0.20	0.26	0.26
Myopic	Height	0.68	0.66	0.49	0.43	0.12	0.14	0.61	0.61
	Weight	0.38	0.40	0.38	0.36	0.32	0.30	0.43	0.41
	BMI	0.26	0.24	0.23	0.21	0.33	0.31	0.17	0.12
Hyperm-etropic	Height	-0.33	-0.36	0.14	0.10	0.16	0.14	-0.38	-0.38
	Weight	0.24	0.22	0.12	0.10	0.16	0.14	0.22	0.28
	BMI	-0.61	-0.57	0.13	0.11	0.14	0.18	-0.58	-0.57

[Table/Fig-5]: Correlations of eye dimensions with anthropometric parameters in emmetropic, myopic and hypermetropic eyes
ValuesinthematrixabovearePearson'scorrelationcoefficientr.(Interpretation–r≥0.7impliesstrongcorrelation.r=0.5 to 0.7impliesgoodcorrelation,r=0.3to0.5impliesfaircorrelation&r=<0.3impliespoorcorrelation)

	Axial Length		Ant.Chamber		Lens-thickness		Vitreous Depth	
	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
Age	0.62	0.58	-0.22	-0.26	0.43	0.46	0.67	0.64

[Table/Fig-6]: Correlations of eye dimensions with age in emmetropic eyes
ValuesinthematrixabovearePearson'scorrelationcoefficientr.
(Interpretation–r≥0.7impliesstrongcorrelation.r=0.5to0.7impliesgoodcorrelation,r
=0.3to0.5impliesfaircorrelation&r=<0.3impliespoorcorrelation)

the eyeball but the vitreous chamber of the globe was found to be larger in male than female [10,12]. The studied biometrics (AL, ACD, VCD AND LT) were all higher in men compared to women in a study done in the population of Shahroud in the north of Iran [13].

In contrast to the findings of majority of studies one study revealed that male and female eyes of same age had same sized globe [14]. In the present study the vitreous chamber depth was significantly higher in male than in female only among myopic persons.

It was suggested height correlated positively with axial length ($p<0.01$, B = 0.20) and vitreous chamber depth ($p< 0.01$, B = 0.19) [15].

According to conclusion of one previous study also, larger eyes were found between taller and even adjustment for height can thus explain or attribute to the different findings between male and female [4]. Height and weight were significantly correlated with all ocular biometric parameters except lens thickness [16]. After adjustment for age and gender, taller and heavier persons had eyes with longer axial length, deeper anterior and vitreous chamber depth [15,16]. Height showed good correlation with axial length and vitreous chamber depth and fair correlation with anterior chamber depth in both emmetropic and myopic eyes in the present study.

Refractive Status	n	BMI Range	BMI Mean	BMI Media	BMI Std. De	BMI Std. Error
MM	38	16.63-27.08	20.59	20.00	2.99	0.48
HM	19	16.83-26.83	21.98	22.02	2.57	0.59
MH	37	17.93-26.01	21.93	21.93	1.95	0.32
HH	18	20.95-30.48	26.54	27.42	2.79	0.65
E	40	15.94-30.19	22.39	23.11	3.89	0.62

[Table/Fig-7]: Comparison of Body Mass Index between groups with different refractive error status
MM-mildtomoderatemyopia HM-highmyopia
MH-mildhypermetropiaHH-highhypermetropiaE-emmetropia

	SS Effect	df Effect	MS Effect	SS Error	dF Error	MS Error	F	p
BMI	440.49	4	110.12	1310.59	147	8.91	12.35	0.001

[Table/Fig-8]: One-way Analysis of Variance (ANOVA) for significant difference between groups with different refractive error status

Height was revealed to be the only anthropometric parameter which was strongly correlating with axial length in a study conducted among Sydney school students [17]. One study conducted among Singapore Chinese children revealed that taller children had eyes with longer axial length, deeper vitreous chamber [18]. According to another study, increase in weight was associated with deeper anterior chamber after adjustment of height [17]. But shorter vitreous chamber was found among heavier children [18]. But the present study failed to show any such correlation of weight with any ocular parameters studied.Differences between the present results and earlier similar studies has been depicted in [Table/Fig-9].

One previous study stated that children with higher BMI had refractions that were more hyperopic ($p=0.01$, $p = 0.08$) [18]. The conclusion of another research work supported the view that heavier persons tended to be less myopic i.e. slightly hyperopic [16]. This view is supported in the present study which also found that mean BMI was more in hypermetropic than myopic and more in high hypermetropic (26.54) than mild to moderate hypermetropic (21.93), (p-value=0.01). Therefore adult height is independently related to ocular dimensions but does not appear to influence the refraction. Conversely weight is independently related to refraction.

One study at State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center mentioned that axial length did not change with age but was consistently shorter in women [19]. No age related difference was found in axial length of eye in another study [20]. But the present study showed good positive correlation between axial length (Pearson's Correlation Coefficient 'r' = 0.62 (rt), 0.58 (lt)) and age. Lens thickness increased with age and tended to be greater in women and Europeans. Other studies also showed similar finding

	Axial length		Anterior Chamber Depth		Vitreous Chamber Depth		Lens thickness	
	Previous studies	Present study	Previous studies	Present study	Previous studies	Present study	Previous studies	Present study
Gender	♂ >♀ [4, 9, 10, 11,13] ♂> ♀in myopic [13]and hypermetropic [11,12]	♂>♀in myopic and hypermetropic, but insignificant among emmetropic	♂>♀ [13]		♂>♀ [10,12,13]	♂>♀ in myopic		
Age		Good correlation	Negative correlation[14,15 & 20].Positive correlation during school age [9]				Positive correlation[16] Negative correlation during school age [9]	Fair correlation
Height		Good correlation in myopic and hypermetropic	Positive correlation [16,17]	Fair correlation in myopic and emmetropic	Positive correlation [15, 16,18]	Good correlation in myopic and emmetropic		
Weight	Positive correlation [16]		Positive correlation [16]		Positive correlation [16] and negative correlation [18]			

[Table/Fig-9]: Comparison of the findings of the present study with previous one

[5,14].The present study also showed that the lens thickness is fairly correlated with age ('r' = 0.43 (rt), 0.46 (lt)).

Different studies suggested that anterior chamber depth decreases with increasing age [14,15,20]. In fact anterior chamber depth has been found to vary with both age and sex [21]. The present study also supports this finding. Negative correlations were found between anterior chamber depth ('r' = - 0.22 (rt), - 0.26 (lt)) and age. In this perspective of change of axial length, anterior chamber depth and lens thickness with age there is an interesting finding of one study which stated that during school age axial length and anterior chamber depth increased with severity of myopia in contrast the lens thickness decreased whereas after age of 20 anterior chamber depth decreased with aging and lens thickness increased with aging [9]. Among adult population of northern part of Iran it was found that except for LT which increased with age, all other parameters decrease with age [13].

Global advances in ophthalmology have created a greater need for ocular parameters in different clinical and diagnostic fields. One important ophthalmic parameter is the axial length (AL) which is commonly needed for intraocular lens power calculation before cataract and refractive surgery and helps ophthalmologists in the diagnosis of several eye conditions such as staphyloma, and risk of retinal detachment [12].

CONCLUSION

There were positive correlation between axial length, anterior chamber depth, vitreous chamber depth and height; axial length, vitreous chamber depth and age. Negative correlation was found between anterior chamber depth and age. Subjects with higher BMI tended to had refractions that were more hyperopic. Differences between the present results and references are reflections of environmental, systemic, endocrine or metabolic factors on refractive development.

The findings of the present study can highlight not only the normal range of the different ocular parameters namely axial length, anterior chamber depth, vitreous chamber depth and lens thickness but their variation with age, gender, height and weight. The overall idea about deviation of these parameters in myopic and hypermetropic eyes from emmetropic one can be drawn so that from the baseline measurement of these parameters timely interventions could be made at incipient stage.

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