Original Article

The effect of age on lens parameters and axial length among wide age range of Saudis: A prospective, cross-sectional study

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Abstract:

PURPOSE: The purpose of the study is to establish normative values of eye parameters such as lens thickness (LT), lens diameter (LD), and axial length (AXL) among wide age range of Saudis using Pentacam AXL and compare these values between gender, in addition to that, to find the correlation between the age and those parameters.

METHODS: In this prospective cross-sectional study, we measured LT, LD, and AXL in 125 healthy Saudi controls aged between 8 and 60 years using OCULUS Pentacam AXL. The screening tests were performed for each subject to exclude any ocular abnormalities using slit lamp (Haag-Streit BQ 900), refractive error measured using auto refractometer (Topcon KR-1 Autorefractor/Keratometer), and subject who has spherical equivalent more than ± 4.00D and astigmatism more than 1.00DC was excluded from the study. The mean of three readings of LT, LD, and AXL was taken. All examination was applied on one eye (right eye).

RESULTS: The overall mean and standard deviation of LT, LD, and AXL was 2.2 mm ± 0.5, 2.7 mm ± 0.6, and 23.8 mm ± 1.0, respectively. There was no statistically significant difference between males and females in these parameters in all age groups, except in Group 2 (age: 19–30 years), there was a statistically significant difference between males and females in AXL, mean difference ($M = 0.48$), and $P = 0.015$. The mean of LT and LD was negatively associated with age. However, there was no significant correlation between AXL and age.

CONCLUSION: Normative values of LT, LD, and AXL have been established in wide age group of healthy Saudis; the findings of the present study can highlight not only the normal range of the different ocular parameters, namely LT, LD, and AXL, but also their variation with age and gender.

Keywords:

Age, axial length, cataract, healthy Saudi controls, lens diameter, lens parameters, lens thickness, Pentacam axial length

Introduction

The structures of the lens of a human eye change with age. The fact that the incidence of cataract rises with age after 50 years,[1] leads to much of the effort for fundamental studies of tissue growth and development. The human lens ages lead to dysfunctional lens syndrome (DLS), including structural, optical, and functional changes. The structure of the aging lens is altered by the deposition of new lens proteins resulting in increases in the thickness, diameter, volume, and density of the lens.[2]

Measuring the lens parameters such as lens thickness (LT), lens diameter (LD), and axial length (AXL) are important in understanding the lens development and vital in clinical implications, such as cataract surgery and intraocular lens (IOL) implantation.

Ultrasound, optical coherence tomography (OCT), and OCULUS Pentacam are devices used for the assessment of LT, LD, and AXL. The Pentacam is a digital imaging system, i.e., highly accurate for evaluating the anterior segment, with a sensitivity of more than 50% and a specificity of 100%.[3] It has a high level of repeatability and reproducibility while measuring anterior segment parameters.[4] It is commonly used in screening tests because

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it allows for quick noncontact assessment of the anterior segment.[3]

Several studies have been published to evaluate the changes in crystallin lens parameters such as LT, LD, and AXL with aging using ultrasound and OCT.[5-8] However, from literature review, we were unable to retrieve similar information among Saudi population using the device OCULUS Pentacam AXL. Therefore, the aim of our study is to investigate the effect of the age on LT, LD, and AXL among wide age range of healthy Saudi controls using OCULUS Pentacam AXL.

The result of this study may help to understand the normative values of ocular lens biometrics among wide age range of Saudis and in understanding the lens development. Moreover, it could be helpful in clinical implications such as cataract surgery and IOL implantation.

Methods

In this prospective cross-sectional study, healthy Saudi individuals aged between 8 and 60 years old were included in this study. The subjects were divided into five age groups, Group 1 – (age 8–18 years), Group 2 – (age 19–30 years), Group 3 – (age 31–39 years), Group 4 – (age 40–50 years), and Group 5 – (age 51–60 years).[9]

This study was performed in optometry clinics at King Saud University, Riyadh, Saudi Arabia, from January 2022 to April 2022. It was conducted in accordance with the tenets of the Declaration of Helsinki,[10] regarding research involving human subjects. The study was approved by the ethical committee at King Saud University Medical City (ethics number E-21-6417). Each subject signed an informed consent form to participate in the study after receiving information on the objectives of the research.

Patients with a history of any systemic disease such as diabetic or hypertension, previous ocular surgery or any ocular disease such as diabetic retinopathy, corneal opacity, cataract, nystagmus, or glaucoma, high refractive error, or spherical equivalent (S.E) > ±4.00D with astigmatism more than 1.00DC were excluded from the study. Pregnant women and smokers were excluded as well.

All individuals underwent ocular examinations to exclude any ocular abnormalities by slit lamp (Haag-Streit BQ 900) and refractive error measurements using autorefractometer (Topcon KR-1 Autorefractor/Keratometer).

After screening examination, the eligible subjects underwent LT, LD, and AXL measurements by OCULUS Pentacam AXL [Figure 1]. The mean of three readings of these parameters was taken. The Scheimpflug images can obtain information on the dimensions of the crystalline lens based on the anterior corneal apex. Hence, this value is displayed only if the pupil was dilated wide enough to detect the posterior crystalline lens surface.[3] The AXL is measured from the anterior surface of the cornea to the retina. All examination was performed for the right eye.

Data were analyzed using Statistical Package for Social Sciences (SPSS) software (version 21; SPSS, Inc, Chicago, IL, USA), and it presented as mean ± standard deviation (SD). As the data were normally distributed, the Pearson's correlation coefficient was applied to evaluate the correlation between age

Figure 1: OCULUS Pentacam® AXL.[3] AXL: Axial length

Table 1: Demographic data and normative values of lens thickness, lens diameter, and axial length among different age groups

Variable	Group 1 (age 8–18) years	Group 2 (age 19–30) years	Group 3 (age 31–39) years	Group 4 age 40–50) years	Group 5 (age 51–60) years
Age (years)					
Minimum–maximum	8–18	19–30	31–37	43–50	51–60
Mean±SD	12.9±3.6	22.0±2.6	33.2±2.3	47.6±2.6	55.7±3.7
Male (*n*)	13	33	2	2	2
Female (*n*)	8	48	7	6	4
Total (*n*)	21	81	9	8	6
SE of RE (D)*, mean±SD	1.5±1.2	1.3±1.2	0.7±0.5	1.3±1.4	1.3±0.7
Average LT of 3 readings (μm), mean±SD	3.0±0.7	2.6±0.6	2.4±0.5	2.4±0.7	2.2±0.6
Average LD of 3 readings (mm), mean±SD	2.5±0.6	2.2±0.5	2.2±0.4	2.1±0.6	2.0±0.5
Average AXL of 3 readings (mm), mean±SD	23.4±1.0	24.0±0.9	22.9±1.1	23.6±1.3	24.1±0.5

*Absolute values, regardless sign (+ or −). SD: Standard deviation, SE: Spherical equivalent, LT: Lens thickness, LD: Lens diameter, AXL: Axial length, RE: Refractive error

and LT, age and LD, age, and AXL. Unpaired *t*-test was applied to assess the difference between genders in these parameters. $P < 0.05$ is considered a significant value.

Results

Demographic data and normative values of lens thickness, lens diameter, and axial length among different age groups

Data were collected from (n = 125) individuals; 41.6% of them were males and 58.4% were females. The overall age (mean ± SD) for all participants was 24.4 ± 11.1 years. In addition, the overall absolute (mean ± SD) of S.E. value was 1.3 ± 1.1 D. Furthermore, the normative values of the LT, LD, and AXL parameters presented as mean ± SD are shown in Table 1.

Comparison between genders in lens thickness, lens diameter, and axial length measurements

There was no statistically significant difference found between males and females in the mean scores of LT,

Table 2: Difference between genders in lens thickness, lens diameter, and axial length measurements

Age groups	Measurements	Mean±SD	Mean difference	*P*
Group 1 (age 8–18) years (*n*=21)	LT			
	Males (*n*=13)	2.5±0.6	−0.04	0.897
	Females (*n*=8)	2.5±0.8		
	LD			
	Males (*n*=13)	2.9±0.5	−0.27	0.448
	Females (*n*=8)	3.2±1.1		
	AXL			
	Males (*n*=13)	23.4±1.0	0.13	0.778
	Females (*n*=8)	23.3±1.1		
Group 2 (age 19–30) years (*n*=81)	LT			
	Males (*n*=33)	2.2±0.5	−0.05	0.664
	Females (*n*=48)	2.2±0.5		
	LD			
	Males (*n*=33)	2.5±0.5	−0.24	0.069
	Females (*n*=48)	2.7±0.6		
	AXL			
	Males (*n*=33)	24.3±0.8	0.48	0.015
	Females (*n*=48)	23.8±0.9		
Group 3 (age 31–39) years (*n*=9)	LT			
	Males (*n*=2)	2.1±0.3	−0.13	0.732
	Females (*n*=7)	2.2±0.5		
	LD			
	Males (*n*=2)	2.5±0.4	0.15	0.715
	Females (*n*=7)	2.4±0.5		
	AXL			
	Males (*n*=2)	22.8±2.1	−0.08	0.935
	Females (*n*=7)	22.9±0.9		
Group 4 (age 40–50) years (*n*=8)	LT			
	Males (*n*=2)	2.2±0.4	0.10	0.852
	Females (*n*=6)	2.1±0.6		
	LD			
	Males (*n*=2)	2.2±0.3	−0.19	0.755
	Females (*n*=6)	2.4±0.8		
	AXL			
	Males (*n*=2)	24.3±0.6	0.92	0.413
	Females (*n*=6)	23.4±1.4		
Group 5 (age 51–60) years (*n*=6)	LT			
	Males (*n*=2)	2.0±0.4	0.07	0.886
	Females (*n*=4)	1.9±0.5		
	LD			
	Males (*n*=2)	2.3±0.4	0.07	0.911
	Females (*n*=4)	2.2±0.7		
	AXL			
	Males (*n*=2)	24.4±0.4	0.46	0.326
	Females (*n*=4)	23.9±0.5		

LT: Lens thickness, LD: Lens diameter, AXL: Axial length, SD: Standard deviation

LD, and AXL parameters in all age groups except in Group 2 – (age 19–30) years; there was statistically significant difference between males and females in AXL mean difference ($M = 0.48$ mm) and $P = 0.015$, $P < 0.05$ as shown in Table 2.

Correlation between age and lens thickness, age and lens diameter, age, and axial length

There was statistically significant negative correlation between age from 8 to 60 years and LT average measurement variables with $P < 0.05$. The correlation coefficient of $r = -0.216$ indicates a weak negative of association [Table 3]. In other words, as age increases by 1 year, the average LT measurement decreases by 0.216 mm.

In addition, the results showed that the average measurement variables of LD had statistically significant negative correlation with age from 8 to 60 years with $P < 0.001$. The correlation coefficient of $r = -0.291$ indicates a moderate negative of association [Table 3]. In other words, as age increases by 1 year, the average LD measurement decreases by 0.291 mm.

Table 3: Pearson's correlation coefficients results for lens thickness, lens diameter, and axial length measurements and age (8–60 years) variable (n=125)

Variable	Statistic	LT average	LD average	AXL average
Patient's age	Pearson correlation	−0.216	−0.291	0.055
	P	0.015	0.001	0.545
	n	125	125	125

LT: Lens thickness, LD: Lens diameter, AXL: Axial length

Moreover, results in Table 3 showed that there was no statistically significant positive correlation between age and AXL average measurement variables with $P = 0.545 > 0.05$. The correlation coefficient of $r = 0.055$ indicates very weak positive association.

Discussion

In this study, Pentacam AXL was used to investigate the eye parameters such as LT, LD, and AXL among Saudi population as they got older. These parameters play an important role in diagnosis and treatment of cataract due to those changes that could be happening through aging process. Cataract and age are just one of the factors that affect the lens,[2] which lead to DLS, including structural, optical, and functional changes.[2]

As presented in this study, the normative values of LT, LD, and AXL among Saudi population were LT = 2.2 ± 0.5 μm, LD = 2.7 ± 0.6 mm, and AXL = 23.8 ± 1.0 mm. However, in other studies, these values were different. The difference between the results of this study and prior studies[5-8] maybe related to deferent in the ethnicity, age range, genetics, environmental factors, devices, study design, and sample size. Table 4 shows LT, LD, and AXL among different populations.

According to this study, there was no statistically difference found between males and females in LT, LD, and AXL parameters in all age groups except in Group 2; there was a statistically significant difference between males and females in AXL, the mean difference M = 0.48 mm and $P = 0.015$, the

Table 4: Lens parameters and axial length among different populations

Author	Types of RE	*n*	Population	Age range (years)	Instrument	LT (μm)	LD (mm)	AXL (mm)
Current study, 2023	Emmetropia Low myopia Low hyperopia	125	Saudis	8–60 (24.4±11.1)	Pentacam AXL	2.2±0.5	2.7±0.6	23.8±1.0
Meng *et al*., 2021[5]	Cataract patients	24,013	Chinese	30–80 (62.5±13.6)	IOL master 700			24.71±2.81
Waring *et al*., 2021[7]	Normal Myopic Hyperopic	293	South Carolina	60–80 (68.2±8.5)	Vivo SD-OCT	4.7±0.4	10.7±0.5	

LT: Lens thickness, LD: Lens diameter, AXL: Axial length, IOL: Intraocular lens, OCT: Optical coherence tomography, RE: Refractive error, SD: Standard deviation

Table 5: Comparison between genders for current study and previous studies

Author	*n*	Population	Age (years) range, mean±SD	Instrument	Result
Current study, 2023	125 Male 52 Female 73	Saudis	8–60 (24.4±11.1)	Pentacam AXL	We found no significant different between males and females in LT, LD, and AXL in all age groups, except in Group 2, the AXL was longer in males this may be due to different in RE between gender in this group
Meng *et al*., 2021[5]	24,013 Male 10,563 Female 13,450	Chinese	13–60 (62.5±13.6)	IOL Master 700	There was no significant between genders in LT male (4.52±0.47) female (4.50±0.46) However, males have slightly thicker LT than females
Mashige KP, Oduntan OA, 2017[8]	600 Male 305 Female 295	Black South Africans	10–66 (28.15±13.1)	Nidek US-500 A-scan ultrasound	Males had a significantly greater LT and longer AXL than females

LT: Lens thickness, LD: Lens diameter, AXL: Axial length, IOL: Intraocular lens, SD: Standard deviation, RE: Refractive error

AXL was longer in males. Similarly, Mashige and Oduntan[8] showed a significant difference between genders in AXL; the AXL was longer in males compared to females. However, Mashige and Oduntan[8] found a significant difference between males and females in LT, males had significantly greater LT, which does not agree with our results, the explanation of this difference may be due to the difference in sample size, population, methodology of study, and the devices [Table 5].

Regarding the correlation between the geometric parameters and age, the results of this study showed a significant negative correlation between LT and age, LD, and age. Our findings were not comparable with Waring *et al*.[7] and they found a significant positive correlation of LT and LD with age $r = 0.526$ and $r = 0.326$, respectively ($P < 0.001$). Moreover, our finding not corresponded to Martinez-Enriquez *et al*.,[6] they found that LT and LD showed a biphasic behavior, LT and LD decreased fast before age 20 years and remained almost constant thereafter. Similarly, Wang *et al*.[11] found that both LT and density are significantly associated with age, whereas they do not change linearly with age, which confirms that LT and density did not show a simple linear relationship with age; the explanation of the difference between our results and previous studies may be due to that the sample size of subjects after 30 years old was too small to explore the true association and also may be due to the deferent in race, study design, and instruments.

According to AXL measurements, we found that there was no statistically significant positive correlation between age and AXL, $r = 0.055$. Our finding is comparable with Roy,[12] they reported that the AXL is positively correlated with age, $r = 0.62$, in emmetropic right eyes, however, the correlation was statistically significant. Some of these findings appeared to contradict our findings, this could be because the type of refractive error was different between studies; the populations were different as well the sample size.

This study is limited by some conditions mainly due to a small sample size, especially in the older age group. However, this study could represent the population in age range from 8 to 30 years old because the majority of participants was at this age range. Moreover, young people represent the largest segment of Saudi society and age of 35 represent 67% of the entire population. Therefore, the results of this study are reasonably representative of Saudi population. On the other hand, it is the first study for LT, LD, and AXL that have been done in Saudi Arabia and it is beneficial since the LT, LD, and AXL differ among ethnicities.

Conclusion

Normative values of LT, LD, and AXL have been established in wide age group of healthy Saudis; the findings of the present study can highlight not only the normal range of the different ocular parameters, namely LT, LD, and AXL, but also their variation with age and gender. The findings of this study may be helpful in clinical implication, especially in cataract surgeries and IOL implantation. Further research with a larger sample size in the older age group is recommended.

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Conflicts of interest

There are no conflicts of interest.

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