RESEARCH ARTICLE

Axial length, anterior chamber parameters, and white-to-white corneal diameter: Their inter-correlations with intraocular pressure among young Saudis

Wafa Alotaibi[1], Saif Alrasheed[2]

Abstract

Objective: To evaluate axial length, anterior chamber angle, anterior chamber depth, refractive errors and white-to-white corneal diameter, and to assess their inter-correlations with intraocular pressure among young individuals.

Method: The prospective, cross-sectional study was conducted at the optometry clinics of King Saud University, Riyadh, Saudi Arabia, between January and April 2022, and comprised healthy subjects of either gender aged 8-37 years. Ocular parameters were noted, and the subjects were screened for ocular disorders with a slit lamp. The refractive error was assessed using an auto-refractometer. Data was analysed using SPSS 25.

Results: Of the 108 subjects, 61(56.5%) were females and 47(43.5%) were males. The overall mean age was 20.87±6.23 years. The mean anterior chamber angle was 39.26±5.04 degrees, mean anterior chamber depth was 3.06±0.30mm, mean white-to-white corneal diameter was 11.97±0.40mm, and mean intraocular pressure was 18.75±1.68mmHg. Intraocular pressure had a positive but non-significant correlation with myopia, anterior chamber angle, anterior chamber depth and axial length ($p>0.05$). Conversely, intraocular pressure had inverse but non-significant correlation with age, hyperopia and white-to-white corneal diameter ($p>0.05$).

Conclusion: Ocular biometric dimensions could be considered while assessing the risk factors for ocular hypertension.

Keywords: Young adult, Clinical practice, Retina, Risk factors, Intraocular pressure. (JPMA 76: 8; 2026)

DOI: https://doi.org/10.47391/JPMA.20964

Introduction

Biometric eye measurements are essential in clinical settings as they significantly influence the calculation of intraocular lens implants (IOLs), assessment of refractive error (RE), and measurement of intraocular pressure (IOP), particularly in glaucoma patients.[1-3] Common eye disorders can be better understood by considering certain parameters, such as the anterior chamber angle (ACA), anterior chamber depth (ACD), axial length (AXL), and white-to-white (WTW) corneal diameter. The AXL measures the distance between the anterior and posterior poles of the eye. In adults, this distance typically ranges 23-25mm, with a mean value of 23.30mm.[3,4] The WTW corneal diameter refers to the horizontal distance between the edges of the corneal limbus. This measurement is valuable in diagnosing and managing various eye conditions, including congenital glaucoma, microcornea and megalocornea.[2,5]

Ocular biometric parameters play a crucial role in explaining the underlying pathophysiological processes involved in many eye abnormalities.[6-8] Understanding the normal variations in ocular biometric dimensions among different races and ethnicities as well as being aware of their typical differences are essential for the accurate diagnosis and effective treatment of ocular diseases. Previous studies[9,10] have shown that individuals of Alaskan Eskimo descent have a shallower ACD compared to individuals of Chinese, black and white ethnic backgrounds. As a result, Eskimos may have an increased susceptibility to angle-closure glaucoma.

Additionally, research on the growth of ocular components and their impact on RE development suggests that myopia is primarily caused by alterations in growth patterns. In contrast, emmetropia and hyperopia result from variations in the initial size of the eye.[11,12]

IOP is a significant factor in the development of glaucoma, and is also thought to contribute to the progression of myopia and age-related macular degeneration. It has been hypothesised that an increase in IOP may exert stress on the sclera, leading to changes in ocular biometric dimensions.[13]

Most data used for the development of eye care services is derived from the developed world, which is not generalizable to ethnically, culturally and geographically more diverse populations. The current study was planned to focus on Saudi population by evaluating AXL, ACA, ACD, RE and WTW corneal diameter, and their inter-correlations with IOP.

[1]Department of Optometry, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia; [2]Department of Optometry, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia.

Correspondence: Wafa Alotaibi. e-mail: walotaibi@ksu.edu.sa

ORCID ID: 0000-0002-2940-5613

Submission complete: 05-09-2024 **1st Revision received:** 03-12-2024

Acceptance: 24-09-2025 **Last Revision received:** 23-09-2025

Subjects and Methods

The prospective, cross-sectional study was conducted at the optometry clinics of King Saud University, Riyadh, Saudi Arabia, between January and April 2022, and comprised healthy subjects of either gender aged 8-37 years who were enrolled using convenience sampling technique.[14] A non-probability sampling technique was employed in present study to select 108 young Saudis, comprising 61 females and 47 males.

Individuals with a history of ocular surgery or conditions such as diabetic retinopathy, corneal opacity, cataract or nystagmus, were excluded, and so were pregnant women and smokers.

After approval from the institutional ethics review committee, and informed consent from the participants, demographic data was collected, including age, gender, medical history of REs, and reported symptoms. Following this, all the participants underwent thorough ocular examinations to exclude any abnormalities. Ocular examinations included slit lamp evaluation (Haag-Streit BQ 900, Mason, Ohio, USA), RE assessment using an autorefractometer (Topcon KR-1 Autorefractor/ Keratometer, Tokyo, Japan) and IOP measurement with the (Nidek Tonoref II, Tokyo, Japan). After the screening process, the eligible participants underwent measurements of ACA, ACD, AXL and WTW using the (Oculus Pentacam AXL, Oculus, Wetzlar, Germany) (Figure 1).

Figure-1: Oculus Pentacam AXL.[15].
AXL: Axial length.

The Pentacam AXL is a modern device for measuring and analysing the anterior segment of the eye. In addition to anterior segment tomography, it includes integrated AXL measurement.[15]

One notable feature of the Pentacam is its ability to assess the quality of the scan through a quality specification (QS) indicator. An acceptable image is marked as 'OK' in the report. All images were

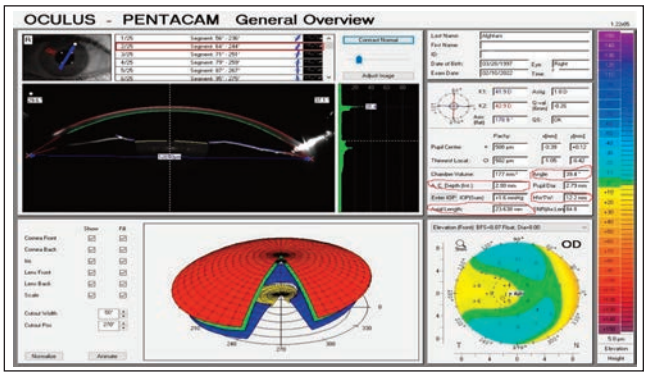

Figure-2: Oculus Pentacam overview map.

captured in a dark room. The participants were positioned in front of the Pentacam camera, with their chin and forehead resting securely on the frame. The image was focused using the joystick adjustment until the corneal surface was clearly visible on the monitor. The pupil and corneal apex were centred with the alignment marker before capturing the image.

The participants were instructed to blink to maximise tear distribution, and then, with their eyes open, to look directly at the fixation target centred in the scanning-slit light scan for two seconds. All measurements were taken automatically (Figure 2). The mean of three readings for ACA, ACD, AXL and WTW was recorded for each participant. The examination was conducted on the right eye. To minimise the effects of diurnal variations, all measurements were taken between 8am and 11am.

Data was analysed using SPSS 25. Shapiro-Wilk test was applied to assess data normality. As the data was normally distributed, descriptive statistics were used to summarise all the collected measurements. Additionally, bivariate correlation and Pearson's correlation coefficient were employed to evaluate the relationship of IOP with age, RE, ACD, ACA and WTW. $P<0.05$ was considered statistically significant.

Results

Of the 108 subjects, 61(56.5%) were females and 47(43.5%) were males. The overall mean age was 20.87±6.23 years (p=0.272). The mean ACA was 39.26±5.04 degrees, mean

Table-1: Descriptive measurements of ocular biometrics, refractive error (RE) and intraocular pressure (IOP).

Variable	n	Minimum	Maximum	Mean±SD	Skewness	Kurtosis
Average Hyperopia of 3 readings	29	+0.25	+2.50	0.66±0.65	1.96	3.03
Average Myopia of 3 readings	79	-0.25	-4.00	1.59±1.10	0.70	-0.56
Average ACA of 3 readings	108	28.87	52.53	39.26±5.04	0.27	-.24
Average ACD of 3 readings	108	2.23	3.75	3.06±0.30	-.23	-.25
Average AXL of 3 readings	108	21.55	26.73	23.85±1.02	.12	.15
Average WTW of 3 readings	108	11.03	12.93	11.97±0.40	-.02	-.28
Average IOP of 3 readings	108	14	21	18.75±1.68	-.50	-.43

AXL: Axial length, ACA: Anterior chamber angle, ACD: Anterior chamber depth, WTW: White-to-white corneal diameter.

ACD was 3.06±0.30mm, mean WTW corneal diameter was 11.97±0.40mm, and mean IOP was 18.75±1.68mmHg. Based on objective refraction, the mean spherical equivalent was -1.59±1.10 dioptres (D) for myopic eyes, and 0.66±0.65D for hyperopic eyes (Table 1).

There was a weak inverse relationship between age and IOP, which was not significant (p=0.272). Similarly, there was a weak inverse correlation between hyperopia and IOP, which was not significant (p=0.259). There was a positive but non-significant relationship between myopia and IOP (p=0.475) (Table 2).

ACA, ACD, AXL and WTW corneal diameter had no significant association with IOP (Table 3, Figures 3-4).

Table-2: Correlation coefficients among age, refractive error and IOP.

Variable	Mean±SD	95% CI	Correlation	*p*-value
Age (years)	20.87±6.24	19.68-22.06	-0.107	0.272
Average Hyperopia of 3 readings	0.66±0.65	0.38-0.94	-0.245	0.259
Average Myopia of 3 readings	1.59±1.10	1.34-1.83	0.081	0.475

IOP: Intraocular pressure, SD: Standard deviation, CI: Confidence interval.

Table-3: Correlation coefficients between ocular biometric dimensions and IOP.

Variable	Mean ± SD	95% CI	Correlation	*p*-value
Average ACA of 3 readings	39.26±5.04	38.30-40.22	0.038	0.695
Average ACD of 3 readings	3.06±0.30	3.00-3.12	0.070	0.469
Average AXL of 3 readings	23.85±1.02	23.66-24.05	0.112	0.249
Average WTW of 3 readings	11.97±0.40	11.89-12.04	-0.108	0.266

IOP: Intraocular pressure, AXL: Axial length, ACA: Anterior chamber angle, ACD: Anterior chamber depth, WTW: White-to-white corneal diameter, SD: Standard deviation, CI: Confidence interval.

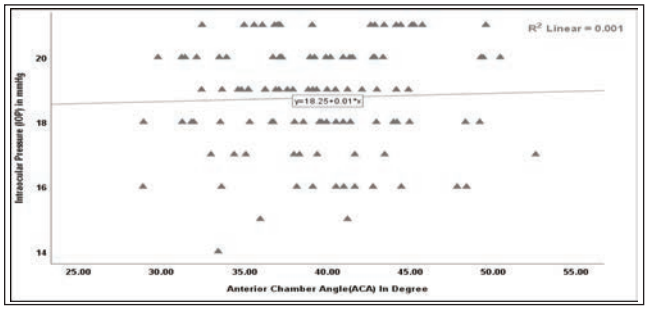

Figure-3: Scatter plot showing IOP (mmHg) and association with ACA (degree). The regression calculation was expressed as follows:
IOP (mmHg) =18.25+0.01 (ACA). Pearson correlation coefficient between IOP and ACA was $r2$=0.001 (p=0.695).
IOP: Intraocular pressure, ACA: Anterior chamber angle.

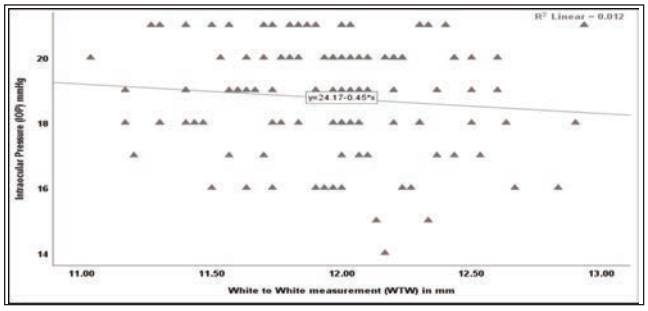

Figure-4: Scatter plot showing IOP (mmHg) and its relationship with WTW corneal diameter. The calculation for regression was expressed as follows: IOP (mmHg) = 24.17 - 0.45 (WTW). Pearson correlation coefficient between IOP and WTW was r2=0.012 (p=0.266).
IOP: Intraocular pressure, WTW: White-to-white.

Discussion

The current study examined the inter-correlations between IOP and ocular biometric dimensions, including ACA, ACD, AXL, REs and WTW corneal diameter, among young Saudis. The findings showed that IOP was positively correlated with myopia, ACA, ACD and AXL, though these correlations were not significant (p>0.05). Conversely, IOP was inversely correlated with participants' age, hyperopia and WTW corneal diameter, none of which were significant (p>0.05).

Previous studies[16,17] reported that glaucoma commonly affects individuals with myopia and is strongly associated with elevated IOP. Shen et al.[18] highlighted the risks linked to various types of glaucoma across all degrees of low and high myopia. These findings align with the current study. However, this correlation was not statistically significant (p=0.475), likely due to the sample comprising young participants with low myopia. Further studies involving individuals with moderate and high myopia are needed. Additionally, the findings supported a positive correlation between AXL and IOP. Leydolt et al.[19] investigated changes in ocular biometrics in response to variations in IOP in human eyes, and found that an increase in IOP, due to mechanical pressure, led to an increase in AXL. Interestingly, when IOP levels returned to the normal after rest, a corresponding decrease in AXL was observed. This underscores the importance of assessing ocular rigidity when evaluating IOP in human eyes. Similarly, a previous study[20] demonstrated that increased IOP leads to choroidal thinning and elongation of AXL. Several authors[21-24] have suggested that changes in IOP significantly impact ocular biometric dimensions. Furthermore, Foster et al.[25] reported a significant positive correlation between IOP and AXL. The Gutenberg Health Study[26] also found that a narrower ACA was significantly associated with higher IOP. In contrast, the current findings showed no significant correlation between IOP and ACA among young Saudi adults. These differences may stem from variations in study populations. The German study was population-based and included participants with a mean age of 57.3±10.2 years, while the current study involved a smaller sample of younger participants with a mean age of 20.87±6.24 years. Additionally, the current study measured IOP at a single time point, which did not account for individual variations throughout the day. The current study used Nidek Tonoref II non-contact tonometry to measure IOP, which, while

convenient, does not align with the gold-standard Goldmann applanation tonometry, potentially introducing bias. Moreover, the ACA was assessed using Scheimpflug imaging rather than gonioscopy, which is considered the gold standard for angle evaluation. These methodological differences may have introduced measurement biases, and affected the accuracy of the findings.

A study[27] investigated the correlation between IOP and ACD in patients with primary open-angle glaucoma, finding no significant association. Similarly, the present study found a weak positive association between IOP and ACD, which was not significant (p=0.469). The findings align with the Gutenberg Health Study,[26] which also reported no significant association between ACD and higher IOP. Various factors can influence the relationship between IOP and ocular biometric parameters. Measurement variability due to different examination techniques or instruments used for assessing ocular biometrics and IOP may contribute to these inconsistencies. It is well-established that non-contact tonometry tends to yield higher IOP readings compared to the Goldmann applanation tonometry. This overestimation is partly due to the shorter duration of corneal deformation during the measurement process.

The current study showed that the mean horizontal WTW corneal diameter in young Saudi adults was 11.97±0.40 mm, which is comparable to the mean reported in an Iranian population[2] (11.65±0.36 mm). The WTW corneal diameter is commonly used for monitoring and diagnosing congenital glaucoma, microcornea and megalocornea. Understanding its normal values and correlations with other ocular parameters is essential for eye-care professionals in diagnosing and managing various ocular conditions. The current study found an inverse association between IOP and WTW corneal diameter, which was not significant (p=0.266). To the best of our knowledge, the current study is the first to assess the association between IOP and WTW corneal diameter in young adults.

However, the current study has limitations because of its focus on age, REs, and the exclusion of glaucoma patients, which likely influenced the outcomes. Future research should include older age groups (over 70 years), a wider range of REs, including low, moderate and high myopes and hyperopes, and participants with risk factors for developing ocular hypertension.

Conclusion

Among young Saudi adults, IOP showed a positive correlation with myopia, ACA, ACD and AXL, but these correlations were not significant. Conversely, IOP was inversely correlated with age, hyperopia and WTW corneal diameter though these associations were also not significant.

Limitation: The sample size, for this study was not calculated which can influence the generalisability of the research.

Acknowledgment and Funding: We are grateful to the Deanship of Scientific Research and College of Applied Medical Sciences Research Centre at King Saud University for facilitating the study.

Disclaimer: None.

Conflicts of Interest: None.

Source of Funding: The Deanship of Scientific Research and College of Applied Medical Sciences Research Centre, King Saud University, Saudi Arabia.

1. Hashemi H, Bouyeh A, Khabazkhoob M. Association between Refractive Errors and Ocular Biometry in an Elderly Population. Optom Vis Sci 2023;100:74-81. doi: 10.1097/OPX.0000000000001966.
2. Hashemi H, Khabazkhoob M, Emamian MH, Shariati M, Yekta A, Fotouhi A. White-to-white corneal diameter distribution in an adult population. J Curr Ophthalmol 2015;27:21-4. doi: 10.1016/j.joco. 2015.09.001.
3. Alrasheed SH, Aldakhil S. Corneal curvature, anterior chamber depth, lens thickness, and vitreous chamber depth: their intercorrelations with refractive error in Saudi adults. Open Ophthalmol J 2022;16:1-8. DOI: 10.2174/18743641-v16-e2209300.
4. Sardari S, Khabazkhoob M, Jafarzadehpur E, Fotouhi A. The Repeatability of Axial Length Measurements Using a Scheimpflug-based System. J Ophthalmic Vis Res 2023;18:396-404. doi: 10.18502/ jovr.v18i4.14551.
5. AlObaisi S, Alnasser BN, Almuhawas HA, Alhoshan SA, Aldebasi MH, Alshaye R, et al. Understanding post-operative refractive outcome in pediatrics after IOL implementation: factors and predictors. Int Ophthalmol 2024;44:364. doi: 10.1007/s10792-024-03280-w.
6. Cox RA, Read SA, Hopkins S, Wood JM. Ocular biometry measures and their correlation with refractive error in Aboriginal and Torres Strait Islander children. Clin Exp Optom 2023;106:187-94. doi: 10.1080/08164622.2022.2152652.
7. Rozema JJ. Refractive development I: Biometric changes during emmetropisation. Ophthalmic Physiol Opt 2023;43:347-67. doi: 10.1111/opo.13094.
8. Oduntan OA, Mashige KP. Axial length, anterior chamber depth and lens thickness: Their intercorrelations in black South Africans. Afr Vision Eye Health 2017;76:2-7.doi.org/10.4102/ aveh.v76i1.362.
9. Chen X, Huang Y, Chen H, Liu L. Distribution and Characteristics of Ocular Biometric Parameters among a Chinese Population: A Hospital-Based Study. Ophthalmol Ther 2023;12:2117-31. doi: 10.1007/s40123-023-00716-x.
10. Wojciechowski R, Congdon N, Anninger W, Teo Broman A. Age, gender, biometry, refractive error, and the anterior chamber angle among Alaskan Eskimos. Ophthalmology 2003;110:365-75. doi: 10.1016/S0161-6420(02)01748-7.
11. Rozema J, Dankert S, Iribarren R. Emmetropization and nonmyopic eye growth. Surv Ophthalmol 2023;68:759-83. doi: 10.1016/ j.survophthal.2023.02.002.
12. Alrasheed SH, Alghamdi W. Systematic review and meta-analysis of the prevalence of myopia among school-age children in the Eastern

Mediterranean Region. East Mediterr Health J 2024;30:312-22. doi: 10.26719/2024.30.4.312.
13. Farag CS, Gouda J, Maher S, El-Fayoumi D, Elhilali H. Incidence and predisposing factors of intraocular Lens tilt following secondary ciliary sulcus implantation in children: An ultrasound biomicroscopic study. Eur J Ophthalmol 2024;34:1400-7. doi: 10.1177/11206721241229468.
14. Stratton SJ. Population Sampling: Probability and Non-Probability Techniques. Prehosp Disaster Med 2023;38:147-8. doi: 10.1017/S1049023X23000304.
15. OCULUS. Pentacam® AXL Wave. [Online] 2024 [Cited 2024 November 21]. Available from URL: https://www.pentacam.com/axl-wave/us/public/.
16. Sun MT, Tran M, Singh K, Chang R, Wang H, Sun Y. Glaucoma and Myopia: Diagnostic Challenges. Biomolecules 2023;13:562. doi: 10.3390/biom13030562.
17. Lee J, Ahn EJ, Kim YW, Ha A, Kim YK, Jeoung JW, et al. Impact of myopia on the association of long-term intraocular pressure fluctuation with the rate of progression in normal-tension glaucoma. Br J Ophthalmol 2021;105:653-60. doi: 10.1136/bjophthalmol-2019-315441.
18. Shen L, Melles RB, Metlapally R, Barcellos L, Schaefer C, Risch N, et al. The Association of Refractive Error with Glaucoma in a Multiethnic Population. Ophthalmology 2016;123:92-101. doi: 10.1016/j.ophtha.2015.07.002.
19. Leydolt C, Findl O, Drexler W. Effects of change in intraocular pressure on axial eye length and lens position. Eye (Lond) 2008;22:657-61. doi: 10.1038/sj.eye.6702709.
20. Lu HC, Chen HY, Huang CJ, Chu PH, Wu LS, Tsai CY. Predicting Axial Length From Choroidal Thickness on Optical Coherence Tomography Images With Machine Learning Based Algorithms. Front Med (Lausanne) 2022;9:e850284. doi: 10.3389/fmed.2022.850284.
21. Chen YY, Wang TH, Huang JY, Su CC. Relationship of axial length and corneal biomechanical properties with susceptibility to unilateral normal-tension glaucoma. Graefes Arch Clin Exp Ophthalmol 2022;260:255-64. doi: 10.1007/s00417-021-05346-2.
22. Sorokin EL, Marchenko AN, Pashentsev YE. Phacoemulsification in prevention of acute angle-closure glaucoma attack. Vestn Oftalmol 2022;138:37-46. doi: 10.17116/oftalma202213802137.
23. Lin J, Vasudevan B, Gao TY, Zhou HJ, Ciuffreda KJ, Liang YB, et al. Intraocular Pressure and Myopia Progression, Axial Length Elongation in Rural Chinese Children. Optom Vis Sci 2023;100:708-14. doi: 10.1097/OPX.0000000000002065.
24. Mutwaly RF, Alrasheed SH, Elmadina AEM, Aldakhil S. Morphology and thickness of corneal endothelial cells in young Sudanese individuals with myopia. J Med Life 2023;16:1808-12. doi: 10.25122/jml-2023-0251.
25. Foster PJ, Broadway DC, Garway-Heath DF, Yip JL, Luben R, Hayat S, et al. Intraocular pressure and corneal biomechanics in an adult British population: the EPIC-Norfolk eye study. Invest Ophthalmol Vis Sci 2011;52:8179-85. doi: 10.1167/iovs.11-7853.
26. Hoffmann EM, Aghayeva F, Wagner FM, Fiess A, Nagler M, Münzel T, et al. Intraocular Pressure and Its Relation to Ocular Geometry: Results From the Gutenberg Health Study. Invest Ophthalmol Vis Sci 2022;63:40. doi: 10.1167/iovs.63.1.40.
27. Adewara BA, Adegbehingbe BO, Onakpoya OH, Ihemedu CG. Relationship between intraocular pressure, anterior chamber depth and lens thickness in primary open-angle glaucoma patients. Int Ophthalmol 2018;38:541-7. doi: 10.1007/s10792-017-0488-4.

Author Contribution:
WA: Concept, design, data acquisition, drafting and critical revision.
SA: Concept, design, data analysis, interpretation, drafting and critical revision.