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ORIGINAL RESEARCH

Normative Values for Anterior Segment Parameters Associated with Glaucoma in "At-Risk" Ghanaian Clinical Population

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Purpose: To provide normative data on anterior segment parameters associated with glaucoma in a Ghanaian population and examine their associations with demographic and anthropometric variables.

Patients and Methods: A total of 338 eyes from 116 males and 222 females (mean age: 61.86 ± 9.54 years, range: 45–89 years) were included in this cross-sectional observational study. Ocular examinations included visual acuity using Snellen chart at 6 m, auto-refraction using Retinomax K+ Screen Hand-Held Autorefractor, Goldmann applanation tonometry, slit-lamp biomicroscopy, fundus examination using 90D Volks lens and Pentacam tests using Oculus Pentacam®. Body height was measured using a measuring tape, and body weight was measured with a weighing scale.

Results: Mean values for corneal parameter measurements were: central corneal thickness (CCT) = 513.42 ± 34.63 µm, corneal diameter (CD) = 11.33 ± 0.44 mm, corneal volume (CV) = 58.14 ± 4.13 mm^3. Mean values for anterior chamber measurements were: anterior chamber angle (ACA) width = 39.39 ± 11.68°, anterior chamber depth (ACD) = 3.43 ± 0.68mm, anterior chamber volume (ACV) = 137.82 ± 37.23 mm^3. Males had significantly larger corneas and ACV ($p = 0.00$) than females. Age demonstrated a significant negative correlation with CCT ($r = −0.691$, $p = 0.001$) and CD ($r = −0.007$, $p = 0.003$), while a positive correlation was observed between age and ACA width ($r = +0.147$, $p = 0.036$). Regarding anthropometric variables, height correlated positively with CD ($r = +0.162$, $p = 0.001$) and ACV ($r = +55.536$, $p = 0.041$). Weight correlated positively with CCT ($r = +0.360$, $p = 0.01$) and CV ($r = +0.034$, $p = 0.04$).

Conclusion: Thinner CCT and marginally lower CV in Ghanaians may be associated with glaucoma risk. Larger ACA, ACV and deep ACD may contribute to the relatively lower prevalence of angle-closure glaucoma reported in Ghanaians.

Keywords: anterior segment, ocular parameters, glaucoma, normative database, Ghana

Introduction

Glaucoma is a blinding, degenerative ocular disease characterized by progressive optic nerve damage and a characteristic pattern of visual field loss.[1] It is a major global public health problem and a leading cause of irreversible blindness worldwide, with substantial disease burden reported across Africa, Asia, Europe, and the Americas.[2] Although the prevalence and dominant glaucoma subtypes vary by region and ethnicity, population-based studies consistently demonstrate that glaucoma represents a significant cause of visual impairment globally.[2] The disease encompasses a heterogeneous group of optic neuropathies, commonly classified as primary open-angle or angle-closure glaucoma, which differ in their underlying mechanisms and anterior segment anatomy.[1] The primary open-angle glaucoma (POAG) subtype predominantly affects individuals of African descent, whereas primary angle-closure glaucoma (PACG) is most common among Asians.[2] Persons of African ancestry are reported to have a younger age of onset, higher prevalence, and more severe disease course compared with other ethnicities.[3] Consistent with this, Ghana has a high glaucoma prevalence of approximately 8.5% among persons 40 years and older, along with an elevated risk of glaucoma-related blindness.[3,4]

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Given the asymptomatic and chronic nature of POAG, early diagnosis and management are critical.[5] Clinically, glaucoma assessment involves careful examination and quantification of the anatomical ocular structures implicated in the disease process. Since anterior segment ocular parameters associated with glaucoma vary across ethnicities,[6] establishing population-specific normative data is essential for early diagnosis and effective management.

Corneal parameters, including central corneal thickness (CCT), corneal volume (CV), and corneal diameter (CD), have all been associated with glaucoma.[7,8] CCT influences intraocular pressure (IOP) measurements, where thinner corneas may lead to IOP underestimation and delayed diagnosis.[9] Moreover, CCT is recognized as an independent risk factor for glaucoma development and progression, and it varies among ethnic groups.[10,11] In Ghana, Kyei et al[12] reported a mean CCT of 506.7 µm in 162 participants, whereas Ntim-Amponsah et al[13] found a higher mean of 533.3 µm in 169 participants. Kyei et al[12] attributed the discrepancy to differences in participant age distribution; however, small sample sizes limited both studies.[12,13] Hence, larger studies are needed to validate these findings.

Corneal volume also plays a role in glaucoma pathogenesis due to its association with corneal hysteresis, an established biomechanical biomarker for glaucoma.[7,14] Lower CV and corneal hysteresis values may predispose the lamina cribrosa and optic nerve head to glaucomatous damage.[7,14] However, there is a paucity of literature on reference values for CV,[15] and no published studies have reported normative CV data in Ghanaian populations.

Corneal diameter has been linked to congenital glaucoma and POAG.[16,17] A genetic study in a Chinese family identified a gene (GJA1) associated with both microcornea and POAG, supporting a genetic link between the two conditions.[17] Reported horizontal visible iris diameter (HVID) ranges vary among populations from 10.7 mm to 13.16 mm in Caucasians, 10.7 mm to 14.59 mm in Iranians, 10.5 mm to 12.4 mm in Chinese, and 9 mm to 12.5 mm in Africans (notably Nigerians).[6] Baseline CD data for Ghanaians, however, remain unavailable.

Anterior chamber parameters, including anterior chamber depth (ACD), anterior chamber volume (ACV), and anterior chamber angle (ACA), are important biomarkers for glaucoma development and progression.[18,19] Shallow ACDs are strongly associated with PACG; eyes with ACD less than 2.80 mm are at greater risk of angle closure than those with ACD ≥ 3 mm.[20] In Ghana, Kyei et al[12] reported an average ACD of 3.5 mm in a small sample. Both ACV and ACA are key determinants of PACG susceptibility.[19]

Although Ghana bears a disproportionately high glaucoma burden, only a few studies have established normative data for corneal and anterior chamber parameters among Ghanaians, a population at particularly high risk. This study, therefore, aims to provide normative data on anterior segment parameters associated with glaucoma in a clinical population of Ghanaians aged 45–89 years, and to examine their associations with key demographic and anthropometric variables, thereby offering additional insight into factors that may influence ocular structure in individuals of Ghanaian descent. Given that older age is a major risk factor for glaucoma, such data will help clinicians identify at-risk individuals and support early detection and tailored management of glaucoma and other anterior segment disorders.

Materials and Methods

Study Participants

This study forms a subset of the *Genetics in Glaucoma Patients of African Descent (GIGA)* study. GIGA is a multicenter cross-sectional case–control study involving individuals diagnosed with POAG and non-glaucomatous controls recruited from Ghana, South Africa, and Tanzania.[21] A few studies have reported findings from the Ghanaian cohort of the GIGA Study.[22–27] However, the present study provides normative values for anterior segment parameters associated with glaucoma, many of which have not been previously documented despite the high prevalence of glaucoma in this population. Furthermore, this study examines the associations between anterior segment parameters and key demographic and anthropometric variables, providing additional insights into factors that may influence ocular structure in Ghanaians. The Ghanaian arm of the GIGA Study was conducted between May 2018 and August 2024, with data collection carried out from May 2018 to August 2022. The participants for the present study were recruited consecutively from the Eye Clinic of the Komfo Anokye Teaching Hospital (KATH), the second-largest hospital in Ghana, which serves approximately 13 of the country's 16 regions. Eligibility was determined by an ophthalmologist affiliated with KATH. A total of 480 individuals of Ghanaian descent aged 45 years and older were initially assessed for eligibility. Of these, 142 were excluded due to corneal abnormalities, ocular infections, or poor-quality scans, resulting in 338 participants included in the final analysis. Participants had no history of corneal abnormalities (including corneal scars, severe dry eye with corneal or conjunctival fluorescein staining, ectasia, or dystrophies), ocular infection, pterygium involving the cornea, ocular hypertension, ocular trauma, glaucoma, or the use of anti-glaucoma medications.

Ocular and Non-Ocular Assessments

All study participants underwent comprehensive ophthalmic examinations, including visual acuity (VA) assessment using a Snellen or Tumbling E chart at 6 m, auto-refraction, and intraocular pressure (IOP) measurement with Goldmann applanation tonometry. Slit-lamp biomicroscopy and fundus examination using a 90D Volk lens were performed, and anterior segment imaging was obtained with the Oculus Pentacam®. Pentacam scans were considered reliable if they displayed an "OK" quality indicator.

Anterior segment parameters recorded included central corneal thickness (µm), corneal diameter (mm), corneal volume (mm^3), anterior chamber depth (mm), anterior chamber angle width (degrees), and anterior chamber volume (mm^3). Participants' height was measured with a measuring tape while barefoot and recorded in meters, and weight was measured using a weighing scale and recorded in kilograms.

Ethical Considerations

Approval for this study was obtained from the Committee for Human Research Publication and Ethics of the School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (Reference: CHRPE/AP/540/17), and the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (Reference: BREC/00005722/2023). Written informed consent was obtained from all participants. To ensure confidentiality and anonymity, each participant was assigned a unique identification number. The study adhered to the principles of the Declaration of Helsinki.

Statistical Analysis

Data were analyzed using the Statistical Software for Data Science (STATA) version 17, after being entered into a digitized online database (Castor EDC). A multivariate regression model was used to assess differences in mean ocular parameter measurements between the right and left eyes. Descriptive statistics, including means, standard deviations, and ranges, were generated in STATA. Associations between anterior segment parameters and demographic or other non-ocular factors were examined using multivariate regression analyses. Pearson correlation coefficients (r) were used to quantify the strength and direction of bivariate associations, while simple linear regression models were fitted to estimate the corresponding regression equations for visualization and interpretation. Scatter plots were created to visually represent significant correlations. Statistical significance was defined as $p < 0.05$.

Results

A total of 338 participants with a mean age of 61.86 ± 9.54 years (range: 45–89 years) satisfied the inclusion criteria of the study; of which 116 (34.3%) were males, and 222 (65.7%) were females. Multivariate regression revealed no significant difference between right and left eye measurements for all measured ocular parameters ($p>0.05$). Therefore, all analyses were conducted on the right eyes only. The mean values for the anterior segment parameters measured in this Ghanaian population were: CCT = 513.42 ± 34.63 µm, CD = 11.33 ± 0.44 mm, CV = 58.14 ± 4.13 mm^3, ACA width = 39.39 ± 11.68°, ACD = 3.43 ± 0.68 mm and ACV = 137.82 ± 37.23 mm^3. The correlations between all measured anterior segment parameters and demographic and anthropometric measurements are described below.

Sex and Anterior Segment Parameters

As shown in Table 1, there were significant differences in corneal diameter and anterior chamber volume by sex. Ghanaian males had significantly larger mean corneal diameter (11.50 mm ± 0.44) than females (11.25 mm ± 0.41). Ghanaian males also had larger anterior chamber volume measurements (150.59 mm^3 ± 40.40) compared to females

Table 1 Anterior Segment Parameters of Ghanaians (≥45 Years) by Sex

Anterior Segment Parameter		Right Eye (OD)			
		N=338	Males n=116	Females n=222	P-value (Sex)
Central Corneal Thickness (μm)	**Mean ± SD**	513.42 ± 34.63	515.72 ± 33.37	512.21 ± 35.28	0.840
	Range	386.00–630.00	402.00–615.00	386 – 630	
	95% CI	509.71–517.12	509.59–521.86	507.55–516.88	
Corneal Diameter (mm)	**Mean ± SD**	11.33 ± 0.44	11.50 ± 0.44	11.25 ± 0.41	**0.000**
	Range	9.80–12.50	10.50–12.50	9.80–12.50	
	95% CI	11.29–11.38	11.42–11.58	11.19–11.30	
Corneal Volume (mm^3)	**Mean ± SD**	58.14 ± 4.13	58.15 ± 3.80	58.14 ± 4.30	0.752
	Range	49.00–79.90	50.00–70.80	49.00–79.90	
	95% CI	57.70–58.58	57.45–58.85	57.57–58.71	
Anterior Chamber Angle Width (°)	**Mean ± SD**	39.39 ± 11.68	40.23 ± 11.59	38.96 ± 11.73	0.901
	Range	13.00–89.50	13.00–80.10	15.2–89.50	
	95% CI	38.15–40.64	38.10–42.36	37.41–40.51	
Anterior Chamber Depth (mm)	**Mean ± SD**	3.43 ± 0.68	3.45 ± 0.66	3.43 ± 0.69	0.920
	Range	1.95–5.95	1.95–5.66	2.27–5.95	
	95% CI	3.36–3.51	3.33–3.57	3.33–3.52	
Anterior Chamber Volume (mm^3)	**Mean ± SD**	137.82 ± 37.23	150.59 ± 40.40	131.15 ± 33.69	**0.000**
	Range	33.00–266.00	41.00–263.00	33.00–266.00	
	95% CI	133.84–141.81	143.17–158.02	126.69–135.60	

Note: Bold p-values indicate statistical significance derived from multivariate regression.

(131.15 mm^3 ± 33.69). No sex-related differences were observed in ACA width (p = 0.901), ACD (p = 0.920), CCT (p = 0.840), or CV (p = 0.752).

Age and Anterior Segment Parameters

Multivariate regression showed negative correlations between age and CCT (r = −0.691, 95% CI [−1.089, −0.294], p = 0.001) and CD (r = −0.007, 95% CI [−0.012, −0.003], p = 0.003), as depicted in Figure 1. The regression equations were: CCT = 559–0.735 × AGE and CD = 11.8–0.00815 × AGE.

However, a positive correlation was observed between age and ACA width (r = +0.147, 95% CI [0.009, 0.284], p = 0.036) represented by the regression equation: ACA width = 29.6 + 0.158 × AGE. There were no significant correlations between age and CV (p = 0.428), ACV (p = 0.814), or ACD (p = 0.144).

Anterior Segment Parameters and Their Correlations with Anthropometric Measurements

Height

The mean height of the study participants was 1.61 ± 0.83 m (range: 1.38–1.85 m). A positive correlation was observed between height and CD (r = +0.1622, 95% CI [1.007, 2.217], p = 0.001) and ACV (r = +55.536, 95% CI [2.352, 108.720], p = 0.041), as depicted in Figure 2. The regression equations were: CD = 8.6 + 1.7 × Height and ACV = 58.2 +

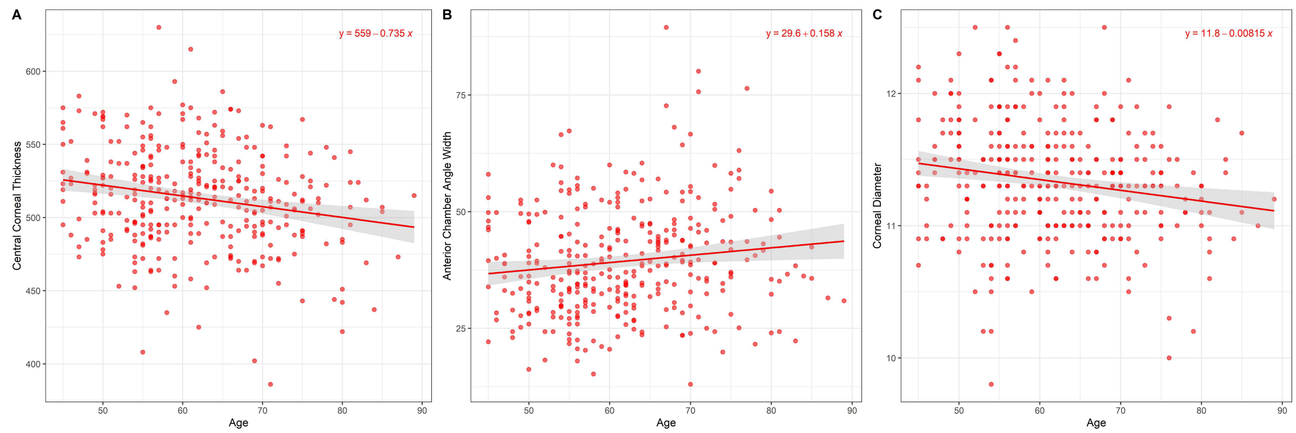

Figure 1 Scatter plots illustrating the association between age and selected anterior segment parameters in the study population. (**A**) Central corneal thickness (CCT) shows a negative linear association with age (y = 559 − 0.735x), indicating a progressive reduction in CCT with increasing age. (**B**) Anterior chamber angle (ACA) demonstrates a positive linear association with age (y = 29.6 + 0.158x), suggesting a gradual widening of the angle across the age spectrum. (**C**) Corneal diameter (CD) shows a modest negative association with age (y = 11.8 − 0.00815x), suggesting a slight decrease in CD with increasing age. Solid lines represent fitted linear regression models, with shaded areas indicating 95% confidence intervals.

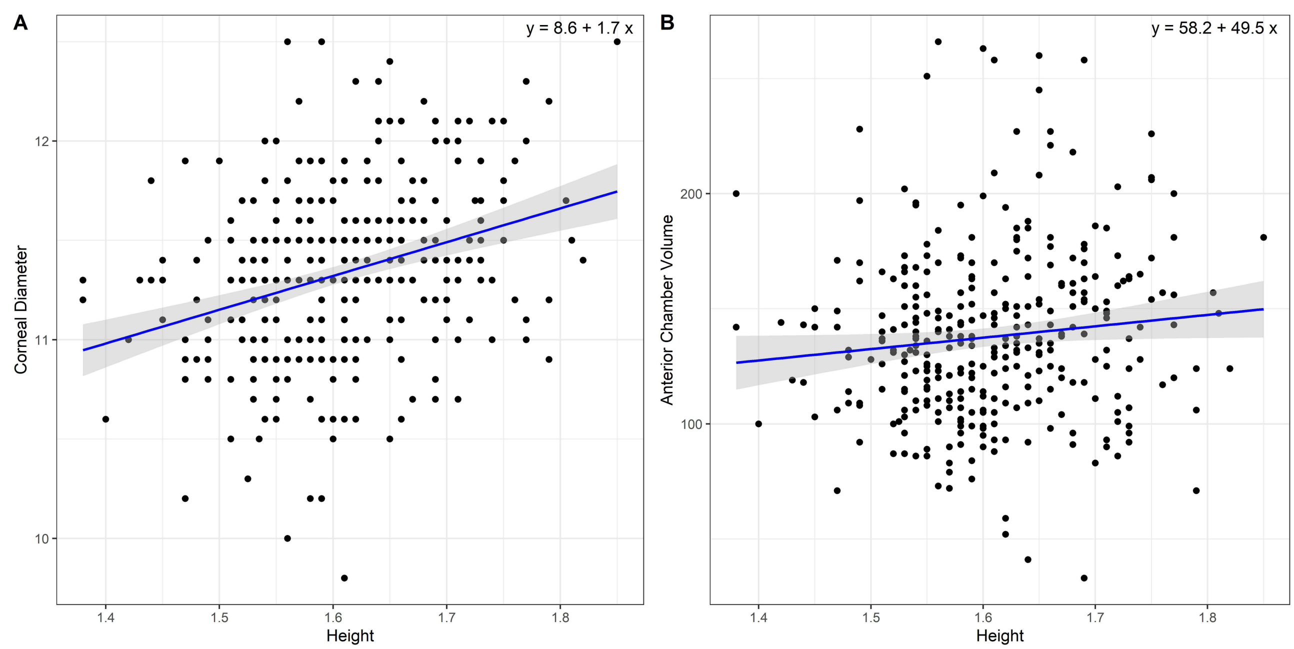

Figure 2 Scatter plots illustrating the association between height and anterior segment parameters. (**A**) Corneal diameter (CD) demonstrates a positive linear association with height (y = 8.6 + 1.7x), indicating a larger CD with increasing height. (**B**) Anterior chamber volume (ACV) also shows a positive linear association with height (y = 58.2 + 49.5x), suggesting greater ACV in taller individuals. Solid lines represent fitted linear regression models, with shaded areas indicating 95% confidence intervals.

49.5 × Height. There were no significant correlations between height and CCT (p = 0.248), CV (p = 0.393), ACA Width (p = 0.727) and ACD (p = 0.796).

Weight

The mean weight recorded in this study was 69.56 ± 14.64 Kg (range: 36.50–141.30 Kg). A positive correlation was observed between weight and CCT (r = +0.360, 95% CI [0.086, 0.634], p = 0.010), represented by the regression equation: CCT = 484 + 0.418 × WEIGHT. Again, a positive correlation was recorded between weight and CV (r = +0.034, 95% CI [0.001, 0.067], p = 0.044), represented by the regression equation: CV = 55 + 0.03898 × WEIGHT. The

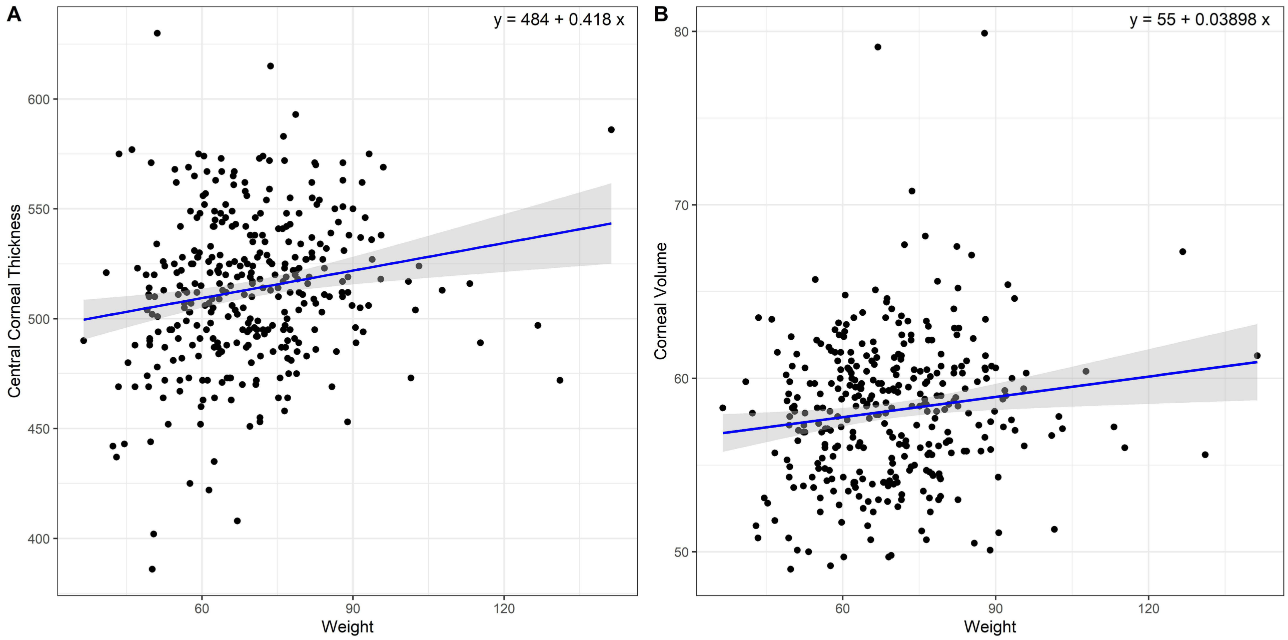

Figure 3 Scatter plots showing the association between body weight and corneal parameters. (**A**) Central corneal thickness (CCT) demonstrates a modest positive linear association with weight (y = 484 + 0.418x), indicating slightly thicker corneas with increasing body weight. (**B**) Corneal volume (CV) also shows a positive linear association with weight (y = 11 + 0.00447x). Solid lines represent fitted linear regression models, with shaded areas indicating 95% confidence intervals.

correlation graphs are depicted in Figure 3. Conversely, there were no significant correlations between weight and CD (p = 0.706), ACV (p = 0.506), ACA Width (p = 0.126) and ACD (p = 0.818).

Body Mass Index (BMI)

The mean BMI of the study participants was 26.89 ± 5.10 Kg/m^2 (range: 16.73–45.35 Kg/m^2). There were no significant correlations between BMI and all anterior segment ocular parameters measured in this study – CCT (p = 0.068), CD (p = 0.778), CV (p = 0.131), ACA width (p = 0.382), ACD (p = 0.826) and ACV (p = 0.651).

Discussion

Normative data of corneal and anterior chamber ocular parameters associated with glaucoma are important in identifying individuals at risk for the disease. This report on CCT, CD, CV, ACA width, ACD, and ACV values in a Ghanaian clinical population provides an opportunity to compare data with other races and ethnic groups from several countries. Table 2 provides an overview of corneal and anterior chamber data from selected studies in individuals of different ages, races, and ethnicities, compared with findings from our study.

In the current study, the mean CCT was 513.42 µm, which is similar to the mean CCT measurement of 515.7 µm reported by Ntim-Amponsah et al[13] in a Ghanaian population of adults aged 50 years and older. Kyei et al[12] also reported a mean CCT of 506.70 µm in a Ghanaian population with a mean age of 63.75 years (range, 21–91 years). The slight difference in these mean CCT values could be attributed to the fact that the study participants in the Kyei et al[12] study were older than those in the current study (mean age = 61.86 years). This assertion is supported by the fact that CCT decreases with increasing age.[28] However, studies among Nigerians[29,30] and Cameroonians[31] reported slightly higher values in a relatively similar age cohort, suggesting possible nationality/geographic differences among Africans in these parameters. This finding may partly explain the severe course of glaucoma among Ghanaians,[3] since existing literature indicates CCT as an independent risk factor for glaucoma, and individuals with thin CCT measurements are more prone to glaucoma.[32–34]

CCT decreased with increasing age due to a reduction in the density of keratocytes.[12] The equation represented this relationship: CCT = 559–0.735 × AGE, suggesting that a 10-year increase in age will result in a 7.35 µm reduction in CCT. Iyamu and Osuobeni[28] also predicted an approximate 7µm decrease in CCT with a 10-year increase in age among

Table 2 Comparison of the Measured Anterior Segment Parameters with Published Data

Author/s	Ethnicity	Method	No. of Eyes	Age (Years)	CCT (µm)	CV (mm^3)	CD (mm)	ACA Width (°)	ACD (mm)	ACV (mm^3)
Current Study	Ghanaians	Rotating Sch eimpflug technology	338	61.86±9.54	513.42±34.63	58.14±4.13	11.33±0.44	39.39±11.68°	3.43±0.68	137.82±37.23
Ntim-Amponsah et al[13]	Ghanaians	Ultrasound pachymetry	NR	≥ 50	515.70	–	–	–	–	–
Kyei et al[12]	Ghanaians	Wavelight oculyzer II (CCT) Nidek US4000 EchoScan (ACD)	162	63.75±12.84	506.70±39.20	–	–	–	3.50±0.60	–
Mercieca et al[29]	Nigerians	Ultrasound pachymetry	70	63.10±11.20	535.00±38.00	–	–	–	–	–
Iyamu et al[30]	Nigerians	Ultrasound pachymetry	95	44.90±15.20	547.00±29.50	–	–	–	–	–
Eballe et al[31]	Cameroonians	Ultrasound pachymetry	970	31.40±15.50	528.74±35.89	–	–	–	–	–
Iyamu and Osuobeni[28]	Nigerians	Ultrasound pachymetry	130	47.80±16.80	–	–	11.39±0.69	–	–	–
Mashige and Oduntan[35]	South Africans	Oculus Keratograph 4 (CD) Nidek US-500 Echoscan (ACD)	600	28.15±13. 10	–	–	11. 77±0.32	–	3.21±0.40	–
Sedaghat et al[7]	Iranians	Rotating Scheimpflug technology	500	2930±6.90	–	60.10±3.50	–	–	–	–
Abib and Santos[15]	Brazilians	Rotating Scheimpflug technology	150	NR	–	60.13±3.56	–	–	–	–
Mannion et al[36]	Caucasians	Rotating Scheimpflug technology	21	30.90±8.40	–	61.90±4.12	–	–	–	–
Domínguez-Vicent et al[37]	Brazilians	Pentacam Scheimpflug	80	30.36±7.32	–	–	–	39.26±2.85	–	–
Schuster et al[38]	Caucasians	Pentacam Scheimpflug	3014	58.60±10.40	–	–	–	32.60±5.50	–	–
Hashemi et al[39]	Iranians	Pentacam Scheimpflug	2681	36.03±18.50	–	–	–	34.82	–	–
Sun et al[40]	Koreans	AS Optical Coherence Tomography	388	66.00±11.30	–	–	–	–	2.83±0.52	–
Wang et al[41]	Caucasians	AS Optical Coherence Tomography	121	59.80±11.70	–	–	–	–	2.91±0.40	–
Wang et al[42]	Caucasians	AS Optical Coherence Tomography	121	59.80±11.70	–	–	–	–	–	172.80±41.30
Orucoglu et al[43]	Turks	Rotating Scheimpflug imaging	666	39.3±19.70	–	–	–	–	–	185.51±47.80
Wang et al[42]	Southern Chinese	AS Optical Coherence Tomography	121	59.90±11.70	–	–	–	–	–	132.00±33.60
Anandan et al[44]	Sri Lankans	Pentacam Scheimpflug	119	42.58±13.15	–	–	–	–	–	131.29±34.26

Abbreviations: CCT, central corneal thickness; CV, corneal volume; CD, corneal diameter; ACA, anterior chamber angle; ACD, anterior chamber depth; ACV, anterior chamber volume; NR, not reported.

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Nigerians. Sex had no significant effect on CCT in this study. This finding aligns with a previous report.[13] Similarly, as reported by Rufer et al,[45] there was no correlation between height and CCT However, weight correlated positively with CCT, as indicated by the regression equation CCT = 484 + 0.418 × WEIGHT, suggesting that a 10 kg increase in weight yields an approximate 4.2 µm increase in CCT. This increase in CCT with increasing weight measurements may be because persons with higher weight measurements tend to have higher serum glucose concentrations[46] and high serum glucose concentrations tend to influence CCT measurements, potentially affecting IOP readings.[47] Although body weight is directly linked to BMI, there was no significant correlation between BMI and CCT (p = 0.07). This is consistent with the findings of Rüfer et al[45] and Teberik et al.[48]

The mean horizontal corneal diameter measured in this study was 11.33 ± 0.44 mm. This finding is consistent with those reported in Nigerians[28] and South Africans[35] (Table 2). Given this, it can be postulated that the normal range for horizontal corneal diameter measurements in Ghanaian adults is 9.80 mm to 12.60 mm. Therefore, Ghanaian adults with a corneal diameter (CD) of less than 9.80 mm may be classified as having microcorneas. In light of findings reported by Huang et al[17] this observation raises the hypothesis that reduced CD could be associated with open-angle glaucoma in Ghanaians. Further well-designed studies are required to explore this potential association before any clinical implications can be inferred. CD was inversely related to age and was represented by the equation: CD = 11.8–0.00815 × AGE (Figure 1), suggesting an approximate decrease of 0.08 mm per decade. Similar reports were made among Nigerians[28] and South Africans[35,] and attributed this to changes in the corneal architecture and other biomechanical properties.

Males had significantly larger corneal diameters than females, consistent with previous reports.[8,35,36] Iyamu and Osuobeni[28] attributed this finding to the fact that men are generally taller than women and have correspondingly larger eyes. In the current study, males were significantly taller than females (p<0.001). Therefore, this could account for the sex difference in mean CD values. Consequently, height correlated positively with CD, represented by the regression equation: CD = 8.6 + 1.7 × HEIGHT. Based on this regression equation, a 0.1m increase in height will result in an approximate 0.2 mm increase in CD, thereby confirming the fact that taller individuals have larger eyes. This finding aligns well with existing literature.[28,49.]

The mean CV measured at the 10mm zone was 58.14 ± 4.13 mm^3 (range = 49–79.9 mm^3), which is slightly lower than that of other ethnicities (Table 2). The marginally lower mean CV measurements observed in this study may be relevant to ocular characteristics reported in populations with a high glaucoma burden. A strong positive correlation between corneal hysteresis and CV has been demonstrated;[7] however, this relationship was not examined in the present study. Further research is therefore warranted to investigate the association between CV and corneal hysteresis in the Ghanaian population. Similar to the findings by Orucoglu et al.[43] CV did not correlate with age and sex in this study. Again, CV showed a positive association with body weight, as described by the regression equation CV = 55 + 0.03898 × WEIGHT, indicating that a 10-kg increase in body weight corresponds to an estimated increase of 0.3898 in CV, a magnitude that appears clinically insignificant. In contrast, Uzun et al reported no significant association between body weight and CV.[50]

The mean anterior chamber angle measured in this study was 39.39° ± 11.68°, which is similar to those reported among Brazilians[37] but higher than those among Caucasians[38] and Iranians[39] (Table 2). Although it is difficult to make direct comparisons due to the variations in age, methodology and instruments used, our results suggest that the high ACA may partly explain the low frequency of angle closure among Ghanaians. There was a weak but significant positive correlation between ACA and age in the present study, represented by the equation: ACA = 29.6 + 0.158 × AGE. This equation suggests an increase in ACA by 1.58° per decade, which may be clinically insignificant, as it appears most Ghanaians already have larger anterior chamber angles. Sex was not significantly associated with ACA, a result similar to that reported by Hashemi et al[39] However, Orucoglu et al[43] found males to have higher ACA values than females. The authors[43] attributed the sex difference in ACA measurements to differences in sex hormones.

The mean ACD of 3.43 ± 0.68 mm recorded in this study is similar to the 3.5 ± 0.6 mm reported by Kyei et al[12] in Ghanaians (Table 2). Results from other countries indicate lower ACD than that reported in the current study (Table 2), which may explain the relatively low prevalence of PACG among Ghanaians due to their deeper anterior chambers. Age had no significant effect on ACD in this study, which is contrary to previous reports.[31,39]

The mean ACV measured in this study was 137.82 ± 37.23 mm^3, which is lower than the 172.8 mm^3 reported among Caucasians[42] and 185.51 mm^3 found in Turks[43] (Table 2). However, it is slightly higher than the 132 mm^3

found in Southern Chinese[42] and 131.29 mm^3 found in Sri Lankans.[44] Since a small anterior chamber is associated with PACG, these differences may explain the high prevalence of PACG in Asians, followed by Africans, Europeans and North Americans.[51] Males had significantly larger ACV measurements than females, which is consistent with findings from previous studies.[39,43] This finding may be explained by the fact that men are generally taller than women and have larger eyes. To the same effect, there was a positive correlation between height and ACV, represented by the equation: ACV = 58.2 + 49.5 × HEIGHT. This equation suggests that a 0.1m increase in height will yield a 4.95 mm^3 increase in ACV.

Limitations and Recommendations

The current study included persons aged 45 years and older; therefore, the reference values presented may not apply to persons younger than 45 years. Future studies should include younger participants to provide comprehensive normative reference values for the Ghanaian population. Also, the normative measurements for some of the corneal parameters measured in this study suggested the probability of lower corneal hysteresis in Ghanaians. However, corneal hysteresis was not measured in this study. Future studies should measure corneal biomechanical properties, such as corneal hysteresis, in Ghanaians, as this may provide more insight into the high prevalence of glaucoma in Ghanaians. Although Ghana is a multiethnic country, this study was underpowered to detect potential ethnic differences in anterior segment parameters, as the sample was predominantly drawn from the Akan ethnic group. In addition, the cross-sectional design limited causal inferences. Again, a priori sample size estimation was not performed. The study sample was derived from the available participants in the parent GIGA Study, which may limit statistical power, particularly for detecting smaller associations. Finally, the hospital-based nature of the sample may restrict the generalizability of the findings to the broader Ghanaian population.

Conclusion

This study presents reference values for selected anterior segment parameters associated with glaucoma in a Ghanaian clinical population. Compared with other ethnicities, Ghanaians demonstrated relatively thinner CCT and marginally lower CV, features that may be relevant to the ocular characteristics observed in populations with a high glaucoma burden. Smaller CD measurements were also identified, raising the hypothesis that reduced CD may warrant further investigation in relation to glaucoma in this population. In addition, larger ACA and ACV, along with deeper ACD, were observed, which may contribute to understanding the comparatively lower prevalence of PACG reported among Ghanaians. Overall, these findings provide population-specific descriptive data that may inform future longitudinal and mechanistic studies.

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Disclosure

The authors report no conflicts of interest in this work.

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