Original Article

Sonographic evaluation of the optic nerve sheath diameter and anterior chamber depth of the eye among apparently healthy adults in Kano, Nigeria

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Abstract

Background: Measurement of optic nerve sheath diameter (ONSD) and anterior chamber depth (ACD) by ultrasound is increasingly used as a marker to detect raised intracranial pressure and other eye pathologies. Knowledge of normal ONSD and ACD in a healthy population is essential in the interpretation of pathological conditions.

Aim: The study aimed at evaluating the ONSD and ACD of the eye in apparently healthy adults in Kano State.

Materials and Methods: This was a prospective and cross-sectional study conducted among apparently healthy adults in Kano State from April 2019 to October 2019. Using convenience sampling method, 384 adults participated in the study. An ethical approval was obtained from the Human Research and Ethics Committee of the Kano State Ministry of Health, and informed consent was obtained from all the selected participants. A portable digital ultrasound machine, Nortek CS 3 with a 7.5 MHz linear transducer, was used to obtain ACD and ONSD at 3 mm behind the globe, and the values were recorded in data capture sheet. The obtained data were analyzed using SPSS version 23.0.

Results: The mean and standard deviation of the right and left ONSDs for males was 4.42 ± 1.38 mm and 4.44 ± 1.41 mm and for the females was 4.39 ± 1.31 mm and 4.41 ± 1.31, respectively. The mean and standard deviation of the right and left ACDs for males was 3.16 ± 0.37 mm and 3.14 ± 0.35 mm and for females was 3.12 ± 0.40 mm and 3.11 ± 1.39 mm, respectively.

Conclusion: The study has established normative values for the ONSD and ACD of the eye in Kano State, Nigeria.

Keywords: Anterior chamber diameter, optic nerve sheath diameter, ultrasound

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INTRODUCTION

The optic nerve is a paired nerve that carries visual information from the retina to the brain, and it is the second of 12 paired cranial nerves. It is embryologically derived from optic stalks through the 7th week of embryological development and consisted of retinal ganglion cell axons and glial cells. It is an extension of the white matter of the brain covered by the meninges; therefore, it is considered a part of the central nervous system.[1] The optic nerve "arrives at the back of the eye, enclosed in a strong sheath,

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continued from the dura mater." Optic nerve is a part of the central nervous system is therefore surrounded by a subarachnoid space and experiences the same pressure change as the intracranial compartment.[2] Like other components of the central nervous system (CNS), it cannot regenerate if damaged by a myriad of processes, including traumatic, ischemic, or neurodegenerative diseases including hereditary optic neuropathy or glaucoma.[3] Optic nerve degeneration can result from various causes, including increased intraocular pressure, compromised vascular supply, and physical trauma. The anterior chamber is a fluid-filled space in the anterior compartment of the eye; it is bounded anteriorly by the cornea and posteriorly by the iris. It is filled with aqueous humor, which is clear and colorless and has a watery consistency (99% water), produced by the ciliary processes at a rate of 2 μl/min.[4] The aqueous humor travels from the posterior chamber from behind the iris, through the pupil into the anterior chamber, bathing the cornea and anterior segment. The aqueous humor is constantly replenished, as it flows through the pupil and fills the anterior chamber. Ultrasound measurement of the anterior chamber depth (ACD) could be used to assess elevated intraocular pressure. This is essential, as it necessitates instantaneous medical attention to lessen pain and avoid temporary or permanent damage to intraocular structures.[5]

Transorbital sonography is a noninvasive, safe, and easy method to access the retrobulbar aspect of the optic sheath (3 mm posterior to the globe) and can detect changes in the optic nerve diameter before papilledema sets in patients with raised intracranial pressure (ICP).[1] Ocular ultrasound is a relatively new application for both emergency and intensive care units, the simple procedure not only useful for diagnosing ocular trauma but also as a window to intracranial pathology. Although other imaging modalities have been used in the assessment of ONSD, ultrasound assessment of optic nerve sheath diameter (ONSD) could be a better option because of its nonionizing property, low cost, and rapid bedside operation, especially for cases that are not suitable for the intensive care unit and yet require real-time monitoring of ICP. Ultrasonic measurements of the ONSD have established different normal values for humans and determined the ONSD cutoff point for evaluating high ICP.[6] Eye sonography detection of an increased ONSD has been considered a reliable noninvasive indicator of intracranial hypertension.[7] It has been proposed as a useful screening tool for elevated ICP.[8] Kano State has an estimated population of 20 million; however, there is no comprehensive, documented study on normal ONSD and ACD of the eye by ultrasonography. There are some published articles on the ONSD and ACD of the eye in Africa. However, ethnicities and variations of the anthropometric parameters between individuals from different geographical regions can affect normative values,[9] hence the need to establish normative values in Kano State. The finding of the study will serve as a guide for sonographers, sonologists, and ophthalmologists in the diagnosis and management of patients with ophthalmic and intracranial hypertension. The study aims at evaluating the ONSD and ACD of the eye in apparently healthy adults in Kano State.

MATERIALS AND METHODS

This was a prospective and cross-sectional study conducted in Kano State from April 2019 to November 2019. Ethical approval to conduct the study was obtained from the Human Research and Ethics Committee of the Kano State Ministry of Health, and informed consent was obtained from all the selected individuals. Using stratified sampling method, seven hospitals were selected from the three geopolitical regions of the state: two from the south, three from the central, and two from the north. Using convenience sampling method, 384 individuals were selected for the study. The inclusion criteria include apparently normal adults, inhabitants of Kano, and those aged 18–65 years. The exclusion criteria include patients with physical eye problem, those with a history of blurred vision, those with a history of severe or persistent headache, those aged <18 and >65 years, and the patients whose pathology was detected during scanning. A portable digital ultrasound machine, Nortek CS 3 with 7.5 MHz linear transducer, was used as an instrument for data collection. The patient was supine on the table with the eye closed. Ultrasound gel was applied on top of the closed upper eyelid, and 7.5 MHz ultrasound transducer was used for the scan, with a slow, continuous sweeping of the transducer; first, the optic nerve sheath was scanned and then the anterior chamber of the eye. The measurement of the ONSD was taken 3 mm behind the globe of the eye at the right angle to the retina, as shown in Figure [1a and b]. The measurement of the ACD was taken from the cornea to the anterior surface of the lens midway between the angles of the eye, as shown in Figure 2a and b. For each eye, two measurements were taken for the ONSD, and the average was recorded and the same method was applied to the measurement of the ACD. Descriptive analysis was used in determining the mean and standard deviations. The Student's *t*-test was used to determine the difference in the mean diameter of the optic nerve sheath and anterior chamber of the eye between males and females. Pearson correlation was used to determine the relationship between

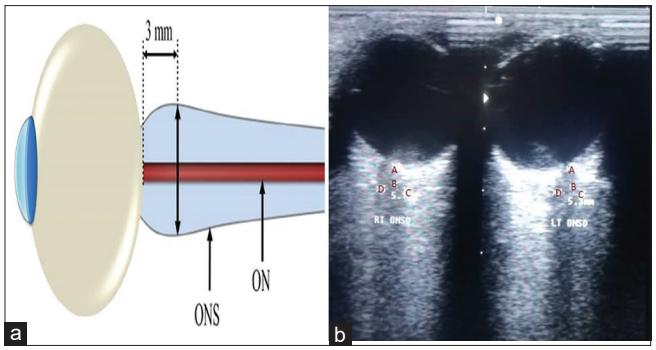

Figure 1: (a) Diagram showing the landmarks for the measurement of the optic nerve sheath diameter.[10] (b) An ocular sonogram of the right and left eyes of a 27-year-old participant showing how the measurement of the optic nerve sheath diameter was performed. AB is the distance (3 mm) from the globe of the eye to where the measurement was performed. CD is the optic nerve sheath diameter; 5.1 mm for the right and 5.3 mm for the left

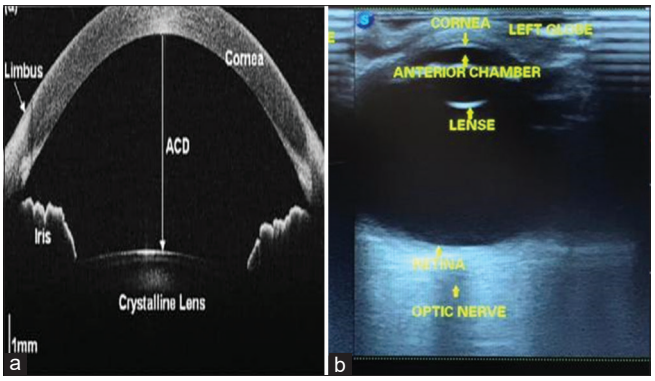

Figure 2: (a) Diagram showing the landmarks for the measurement of the anterior chamber depth.[11] (b) An ocular sonogram of the right and left eyes of a 28-year-old participant showing how the measurement of the anterior chamber depth was performed. The cornea and the lens of the left eye which are the landmarks for the measurement of the anterior chamber depth are demonstrated

optic nerve sheath and anterior chamber of the eye with the age, height, weight, body mass index (BMI), and body surface area (BSA). SPSS version 23 (IBM, Armonk, New York, America) was used for data analysis. The preset *P* value was 0.05.

RESULTS

The male-to-female ratio of the selected participants was 1:1; in males, the age ranged 18–65 years, while in females, it ranged 18–50 years. The mean and standard deviation of the age, height, weight, BMI, and BSA for the male selected participants was 34.74 ± 12.35 years, 166.07 ± 7.29 cm, 68.00 ± 12.84 kg, 24.63 ± 4.23 kg/m^2, and 1.76 ± 0.19 m^2, respectively. For the female selected participants, it was 26.46 ± 6.36 years, 160.08 ± 11.83 cm, 59.66 ± 13.073 kg, 23.15 ± 4.79 kg/m^2, and 1.74 ± 0.16 m^2, respectively.

The mean and standard deviation of the right and left ONSDs for the male selected participants was 4.42 ± 1.38 mm and 4.44 ± 1.41 mm, respectively, while for the female selected participants, it was 4.39 ± 1.31 mm and 4.41 ± 1.31, respectively. For males, the mean and standard deviation of the right and left ACDs was 3.16 ± 0.37 mm and 3.14 ± 0.35 mm, respectively, while for females, it was 3.12 ± 0.40 mm and 3.11 ± 1.39 mm, respectively.

The mean difference between the right and left ONSDs in the male selected participants was 0.02 and the ρ value was 0.48, and for the female selected participants, the mean difference was 0.02 and the ρ value was 0.36.

The mean difference between the males and the females right and left optic sheath diameters was 0.03 mm and the ρ values were 0.38 and 0.36. The mean differences between the males and the females right and left anterior chamber depth were 0.04 mm and 0.03 mm; the ρ values were 0.52 and 0.48.

DISCUSSION

The findings of the current study show that the age of the selected male participants ranged 18–65 years, with a mean value of 34.74 ± 12.345, and for the selected female participants, it was 18–55, with a mean value of 26.46 ± 6.357, as shown in Table 1. The findings of this study are almost similar to the findings of the study conducted by Kolade-Yunusa and Itanyi,[1] which showed that the mean age of male participants was 42.42 ± 15.77 years and that of females was 35.92 ± 9.33 years. It is also similar to the findings of the study conducted by Zong *et al*.[12] that reported a mean age of 36.58 ± 9.51 and age range of 18–65 years. The mean height of male participants was 166.07 ± 7.29 cm and that of females was 160.08 ± 11.83 cm, and the mean weight of the selected male and female participants was 68.00 ± 12.836 kg and 59.66 ± 13.073 kg, respectively, as shown in Table 1. The findings of this study are similar to the findings of the study conducted by Chen *et al*.[6] that reported 163.2 ± 7.7 cm and 60.9 ± 11 kg to be the mean height and the weight of the selected participants. The findings of this study show that the mean BMI of the male and female selected participants was 24.63 ± 4.23 kg/m^2 and 23.15 ± 4.79 kg/m^2 and the mean BSA was found to be 1.76 ± 0.19 m^2 and 1.74 ± 1.55 m^2, respectively, as shown in Table 1. However, most of the published articles did not report the height, weight, BMI, and BSA of the selected volunteers.

The findings of the study show that the mean value of the ONSD for the right and left eyes for the male participants

Table 1: Demographic information of the selected participants

Gender	Demographic variable				
	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)	BSA (m^2)
Males	34.74±12.35 (18-65)	166.07±7.29 (150-190)	68.00±12.84 (40-110)	24.63±4.23 (16-39)	1.76±0.19 (1-2)
Females	26.46±6.36 (18-50)	160.08±11.83 (123-176)	59.66±13.073 (23-95)	23.15±4.79 (12-40)	1.74±0.16 (1-23)

BMI – Body mass index; BSA – Body surface area

Table 2: Mean, standard deviation, and range of the optic nerve sheath diameter and anterior chamber of the eye in both males and females

Variables	Male		Female	
	Right eye	Left eye	Right eye	Left eye
Optic nerve sheath diameter (mm)	4.42±1.38 (3-7)	4.44±1.41 (3-7)	4.39±1.31 (3-7)	4.41±1.31 (3-7)
Anterior chamber of the eye (mm)	3.16±0.37 (2-4)	3.14±0.35 (2-4)	3.12±0.40 (2-4)	3.11±1.39 (2-4)

Table 3: Differences of the right and left optic nerve sheath diameters and anterior chamber depths of the eye in males and females

Variables	Male		Female	
	Mean difference	ρ	Mean difference	ρ
Optic nerve sheath diameter	0.02	0.48	0.02	0.48
Anterior chamber depth	0.02	0.36	0.01	0.52

Table 4: Differences of the optic nerve sheath diameter and anterior chamber of the eye between males and females

Variables	Statistical output	
	Mean difference	ρ
Right optic nerve sheath diameter	0.03	0.38
Left optic nerve sheath diameter	0.03	0.36
Right anterior chamber of the eye	0.04	0.52
Left anterior chamber of the eye	0.03	0.48

was 4.42 ± 1.38 mm and 4.44 ± 1.41 mm and for the female participants was 4.39 ± 1.31 mm and 4.41 ± 1.31 mm, respectively, as shown in Table 2. The findings of this study are in agreement with the findings of the studies conducted by Kolade-Yunusa and Itanyi[1] that showed mean values of 4.21 ± 1.2 mm and 4.22 ± 1.5 mm to the right and left ONSDs for males and 4.20 ± 1.0 mm and 4.21 ± 1.6 mm in females. The findings of this study are also in agreement with the findings of the studies conducted by Toscano *et al.*[7] and Maude *et al.*[13] that reported a mean ONSD of 4.50 mm in both males and females and a value of 4.24 mm and 4.83 mm for the right and left. It is also similar to the findings of the study conducted by Chan and Mok[14] that reported a mean value of 4.06 ± 0.18 mm for males and 4.03 ± 0.20 mm for females. However, the findings of the study conducted by Chen *et al.*[6] reported a mean value of ONSD of 5.1 ± 0.5 mm which was higher than what was reported in the current study and previously published articles. The possible reasons of the differences might be as a result of geographical location and ethnicity. Furthermore, the findings of the study show that the ONSD is slightly higher in males than in females, and in both cases, the left is slightly than the right. This is also similar to the findings of the studies conducted by Kolade-Yunusa and Itanyi[1] and Maude *et al.*[13] that reported higher values in males than females and higher values of the left eye than the right. However, the findings are contrary to what was reported by Toscano *et al.*[7] that reported the same values of the right and left eyes. Furthermore, the findings of this study show that there was no significant difference between the right and left ONSDs in both males and females ($\rho = 0.48$) and ($\rho = 0.48$) and between males and females ($\rho = 0.38$) and ($\rho = 0.36$), as shown in Tables 3 and 4. The findings of this study are in agreement with the findings of the studies conducted by Kolade-Yunusa and Itanyi[1] and Chen *et al.*[6] that showed no significant difference of the ONSD between the right and left eyes and also between males and females. The findings of this study show that there was no significant relationship between ONSD and all the demographic variables in both males and females, as shown in Tables 5 and 6. This is also in agreement with the study conducted by Kolade-Yunusa and Itanyi[1] that reported no significant relationship between the ONSD and age and weight of the studied participants. It is also similar to the findings of the study conducted by Chan and Mok[14] that reported no significant relationship between the ONSD and age. The findings of this study are also similar to the findings of the study conducted by Asghar *et al.*[15] which reported that there was no relationship between ONSD with age, gender, and the measurements taken between the right and left eyes.

The findings of this study show the mean ACD of the right and left eyes in males to be 3.16 ± 0.37 mm and 3.14 ± 0.35 mm and in females 3.12 ± 0.40 mm and 3.11 ± 1.39 mm, respectively, as shown in Table 2. The findings reported in this study are in agreement with the findings of the study conducted by Sedaghat *et al.*[16] that reported a mean ACD of 3.29 ± 0.27 mm and 3.23 ± 0.26 mm in males and females, respectively. However, the findings of this study are slightly higher than the findings of the study conducted by Zong *et al.*[12] that reported a

Table 5: Correlation of optic nerve sheath diameter and anterior chamber of the eye with anthropometric variables in male participants

Variables	Demographic variables									
	Age		Height		Weight		BMI		BSA	
	r	ρ	*r*	ρ	*r*	ρ	*r*	ρ	*r*	ρ
Right optic nerve sheath	0.06	0.38	0.02	0.79	0.13	0.08	0.13	0.08	0.12	0.11
Left optic nerve sheath	0.01	0.85	0.13	0.08	0.10	0.15	0.05	0.52	0.12	0.13
Right anterior chamber of the eye	0.01	0.18	0.08	0.26	0.02	0.80	0.02	0.77	0.04	0.57
Left anterior chamber of the eye	0.22	0.16	0.08	0.25	0.03	0.64	0.08	0.28	0.01	0.87

BMI – Body mass index; BSA – Body surface area

Table 6: Correlation of optic nerve sheath diameter and anterior chamber of the eye with anthropometric variables in female participants

Variables	Demographic variables									
	Age		Height		Weight		BMI		BSA	
	r	ρ	*r*	ρ	*r*	ρ	*r*	ρ	*r*	ρ
Right optic nerve sheath	0.05	0.31	0.04	0.68	0.17	0.06	0.12	0.07	0.15	0.24
Left optic nerve sheath	0.01	0.81	0.11	0.06	0.13	0.14	0.07	0.56	0.10	0.27
Right anterior chamber of the eye	0.02	0.23	0.90	0.22	0.19	0.12	0.02	0.80	0.03	0.49
Left anterior chamber of the eye	0.18	0.79	0.07	0.21	0.05	0.59	0.06	0.31	0.02	0.77

BMI – Body mass index; BSA – Body surface area

mean ACD of 2.88 ± 0.32 mm and a range of 1.56–3.81 mm. Furthermore, both studies showed that the ACD is shallower in females than the males and is also shallower in the left eye than the right eye. It also shows that there is no significant difference between the right and left ACDs in both males and females (ρ = 0.36 and ρ = 0.52, respectively), as shown in Table 3. The findings of this study also show that there is no significant difference in the ACD between males and females (ρ = 0.48 and ρ = 0.52), as shown in Table 4. The findings of this study show that there was no significant relationship between ACD and all the demographic variables in both males and females, as shown in Tables 5 and 6. The findings of this study are contrary to the findings of the study conducted by Zong *et al.*[12] that reported a significant relationship between ACD and age of the selected participants.

CONCLUSION

The study has established normative values for the ONSD and ACD of the eye in Kano metropolis. There is no significant difference between males and females, and there is no significant relationship between ONSD and ACD with the demographic variables.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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