Ghana College of Physicians and Surgeons

Faculty of Ophthalmology

OCULAR BIOMETRIC PARAMETERS AND THEIR RELATIONSHIP WITH AGE, GENDER, REFRACTION AND BODY MASS INDEX IN HEALTHY GHANAIAN CHILDREN.

Dr. ABIGAIL NYARKO BOSOMPEM MBChB, MGCPS

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Dr. Abigail Nyarko Bosompem MBChB, MGCPS

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DECLARATION BY CANDIDATE

This dissertation is based on my own research which was conducted under the supervision of my supervisors at Lions International Eye Centre, Korle Bu Teaching Hospital. I declare that apart from references to other people's work which have been duly acknowledged, this work is an original research by me. This dissertation has not been submitted in part or full for the award of any other degree.

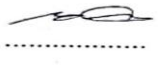
Signed……..... Date: 30th March 2024

Dr Abigail Nyarko Bosompem

ATTESTATION BY SUPERVISOR

Name of supervisor	Signature	Date
Prof Vera Adobea Essuman		01/04/24
Dr Dziffa-Bella Ofori-Adjei		01/04/24

ATTESTATION BY EXTERNAL SUPERVISOR

Name of supervisor	Signature	Date
Dr Grace Meng Wang (Kellog Eye Centre. University of Michigan USA)		1st April 2024

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LIST OF ABBREVIATIONS

ACD	Anterior chamber depth
AMA	Accra Metropolitan Assembly
AL	Axial length
BMI	Body Mass Index
CCT	Central corneal thickness
EP	Evangelical Presbyterian
IOP	Intraocular pressure
IRB	Institutional Review Board
KBTH	Korle Bu Teaching Hospital
RAND	Random number generator
SRM	Simple Random Sampling
LASEK	Laser-assisted sub-epithelial keratectomy
LASIK	Laser-assisted in-situ keratomileusis
PRK	Photorefractive keratectomy
VCD	Vitreous chamber depth

ABSTRACT

Background

Ocular biometry involves measurement of axial length, keratometry-value (K-value), anterior chamber depth, lens thickness, and vitreous chamber depth. These biometric values are of importance in clinical decision making in paediatric cataract surgeries, diagnoses of myopia, paediatric laser surgeries and others. Currently, values used in our clinical setting are based on research from other parts of the world. This is due to the dearth of normative data for ocular biometric values for the Ghanaian paediatric population.

Published data on paediatric ocular biometry exist abundantly for other populations, however, there is a dearth of published data on this topic in sub-Saharan Africa. This necessitates the need to establish the normative ocular biometric value in the Ghanaian population to optimise our clinical decisions.

Aim

The study was carried out to determine ocular biometric parameters and their relationship with age, gender, refraction, and body mass index(BMI) in normal Ghanaian school children in the Ablekuma South sub-Municipality.

Materials and methods

This was a prospective cross-sectional study which measured the ocular biometric values, refraction, and BMI of Ghanaian school children aged 6 to 15 years in the Ablekuma South sub-Municipality.. Informed written consent was obtained from parents/ guardians and assent obtained from children aged 8 years and above. Children with normal eye exam and no history of known eye disease were included in the study. An interviewer-administered pre-designed questionnaire was used to record demographic data such as age, sex, ethnic origin, data on ocular biometric measurements (axial length, anterior chamber depth, lens thickness, vitreous chamber depth,keratometry-value, and cornea radius), and outcome of cycloplegic refraction.

Data handling and statistical analysis

The data was analysed with SPSS version 25. Descriptive statistics were performed for demographic and ocular biometric parameters and results presented with appropriate charts and and tables. Relationship between ocular biometric parameters and demographic and anthropometric factors were assessed with the independent t-test for differences in continuous variables, analysis of variance (ANOVA) for differences between groups such as age and

gender and linear regression for differences in trends. Statistical significance was set at a *p-value* of less than 0.05.

Results

Data on 352 children were analysed (704 eyes). They were aged 6 to 15 years, with 55% being female and 45% being male. They had a mean axial length of 22.73±0.75mm, anterior chamber depth of 3.28±0.29mm, lens thickness of 3.65±0.27mm, vitreous chamber depth of 19.44±0.70mm, cornea radius of 7.79±0.28mm and K-value of 43.39±1.56D. Axial length was 22.99±0.78mm in males and 22.51±0.69mm in females; anterior chamber depth was 3.34±0.32mm in males and 3.34±0.21mm in females; vitreous chamber depth was 19.66±0.78mm in males and 19.27±0.58mm on females; and cornea radius was 7.85±0.32mm in males and 7.74±0.20mm in females. K-value was 43.65±1.61D in females compared to 43.06±1.38D in males. Axial length (p=0.001, F=9.366), anterior chamber depth (p=0.001, F=6.447) and vitreous chamber depth (p=0.001, F=5.937) increased with increasing age. Cornea radius (p=0.644, F=0.556) and lens thickness (p=0.379, F=1.030) did not increase significantly with increasing age. Axial length (p=0.001, r=0.281), anterior chamber depth (p=0.001, r=0.228) and vitreous chamber depth (p=0.029, CI=0.01-0.11) had a significant positive relationship with BMI. Axial length (p=0.007, CI=0.00-0.20), anterior chamber depth (p=0.004, CI=0.00-0.20) were significantly related to hyperopia. while myopia and emmetropia had significant relationships with axial length, anterior chamber depth and vitreous chamber depth

Conclusion

Ocular biometric parameters increased with age, higher in males compared to females. There was a positive relationship between ocular biometry and BMI. Ocular biometry positively correlated with myopia and negatively correlated with hyperopia. Results from this study were similar to that from other studies conducted in sub-Saharan Africa. The findings could support future large population-based study on ocular biometric parameters in the paediatric population to help in the diagnosis and management of serious eye diseases.

Keywords: OCULAR BIOMETRIC PARAMETERS, AGE, GENDER, BMI, REFRACTION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITIONS OF PARAMETERS MEASURED

Axial length: Axial length is the distance from the cornea surface to an interference peak corresponding to the retinal pigment epithelium

Anterior chamber depth: The anterior chamber depth is the space between the posterior surface of the cornea and the anterior surface of the lens.

Lens thickness: Lens thickness is the distance between the anterior and posterior lens surface of the human lens

Vitreous chamber depth: Vitreous chamber depth is the space between the posterior surface of the lens and the internal limiting membrane of the retina

Cornea radius: The radius of curvature of the cornea refers to the distance from the center of the cornea's surface to the point where the curvature of the cornea would form a circle.

Keratometry-value: This is the a measurment of the steepness of the central cornea expressed in dioptres.

1.1. INTRODUCTION

Studies globally have shown that differences exist in ocular biometric parameters from different populations.[1,2] The ocular biometric data used to make clinical decision in our environment comes from studies from other populations. This study seeks to determine the normative ocular biometric values in healthy Ghanaian children.

Normative data are data that characterize what is usual in a defined population at a specific point or period, and are of enormous importance to primary care physicians.[3] Such data, which seek to describe rather than explain phenomena, are essential for:

a) describing the natural history of clinical conditions in the community

b) developing standards of care for primary physicians

c) establishing illness nosologies appropriate for primary care research.[3]

Ocular biometric parameters namely axial length, cornea radius and keratometry values (K-values) are generally accepted standard values that have been established secondary to extensive research in populations.[4] These values are employed in clinical decision making such as determining axial myopia, determining lens power in paediatric cataracts, among others. Ocular biometric values used in the Ghanaian setting are based on normative data from other populations such as North America.[4] Data from North America indicates that from birth till about 13years the eye grows in length in three phases. The first phase (birth to age 2 years) is a period of rapid growth: the axial length increases by approximately 4 mm in the first 6 months of life and by an additional 2 mm during the next 6 months.[4] During the second (age 2 to 5 years) and third (age 5 to 13 years) phases, growth slows down, with axial length increasing by about 1 mm per phase.[4]

Similarly, according to the data from the same setting on corneal parameters, the diametres and dioptric values also change in stages. Studies in that population showed that, with growth of the globe, the corneal diameter increases rapidly during the first year of life.[4] The average horizontal diameter of the cornea is 9.5–10.5 mm in newborns and increases to 12.0 mm in adults.[4] The cornea also flattens in the first year such that keratometry values change markedly, from approximately 52.00 diopters (D) at birth, to 46.00 D by age 6 months, to adult measurements of 42.00–44.00 D by age 12 months.[4]

This study therefore seeks to establish the average normative values for ocular biometric parameters of a section of Ghanaian children examined in this study, and compare with findings in published literature from other populations.

1.2. RATIONALE FOR THE STUDY

Knowledge of the normative value for a particular parameter is important because it helps to validate the policy and clinical decisions that are made based on those normative values.[5] The parameters of interest in this study i.e., ocular biometric parameters , have significant value in determining the dioptric power of intraocular lens for cataract surgery.

Children who belong to the higher quartiles of height are sometimes known to have long axial length and associated axial myopia which could be pathological with its attendant complications including retinal tears and detachments, macular hole, foveal schisis, macular choroidal neovascularization, retinal thinning, etc, all of which leads to significant visual loss.[6–8] Thus it is important to establish whether this association between height and myopia exist among Ghanaian children, and if so, implement a care policy that ensures that these children are monitored and treated appropriately to prevent visual loss. Additionally, laser refractive surgeries such as laser-assisted in-situ keratomileusis(LASIK), laser epithelial keratomileusis(LASEK) and photorefractive keratoplasty(PRK) are gradually becoming a recognized and important part of the management of refractive errors in children, especially in those with significant anisometropia which makes correction with glasses suboptimal.[9,10]
Knowledge of the cornea radius and keratometry values will be of value in diagnosing children who present with abnormalities including conditions such as congenital glaucoma, keratoconus which present with corneal measurement abnormalities.

1.3. STATEMENT OF RESEARCH PROBLEM

There is a dearth of normative data for ocular biometric values among the paediatric population in Ghana. Data exist for entities such as refractive states.[11,12] and prevalence of paediatric ocular pathologies.[13–15] but not for ocular biometric parameters . This study therefore aims to establish normative values for ocular biometric parameters and their relationship with anthropometric features and refractive states among a section of Ghanaian children in the Ablekuma South Sub-Municipality, Accra, a cosmopolitan area with a population which is an amalgamation of various ethnicities that make up the general population of the country.

1.4. HYPOTHESIS

Null hypothesis: There is no significant relationship between ocular biometry and age, sex, BMI and refraction in the population under investigation

1.5. AIM AND SPECIFIC OBJECTIVES OF THE STUDY

Aim: The study aimed to determine ocular biometric parameters and their relationship with age, gender, refraction, and body mass index in Ghanaian children in the Ablekuma South Sub-Municipality.

1.6. SPECIFIC OBJECTIVES:

1. To determine the demography (age, gender, ethnicity and BMI) of school children in the Ablekuma South Sub-Municipality, Accra.
2. To determine the mean values of ocular biometric parameters (axial length, keratometry values, anterior chamber depth, lens thickness and vitreous chamber depth) among school children in the Ablekuma South Sub-Municipality, Accra.
3. To determine the refractive states and visual acuities of school children in the Ablekuma South Sub-Municipality, Accra.
4. To determine the relationship between the biometeric parameters and demography as well as refractive states in school children in the Ablekuma South Sub-Municipality, Accra.

LITERATURE REVIEW

2.1. INTRODUCTION

Ocular biometric parameters are crucial measurements used in the diagnosis and management of various ocular diseases. These parameters include axial length, corneal thickness, anterior chamber depth, lens thickness, and vitreous chamber depth. These parameters are important for the accurate determination of intraocular pressure, lens power, and corneal curvature. Accurate interpretation of these measurements is essential for optimal treatment decisions for patients with ocular pathologies. However, the interpretation of these measurements relies heavily on normative data, which reflects the standard range of values for healthy individuals.[4] Therefore, the establishment of normative data for ocular biometric parameters is essential for accurate diagnosis and management of ocular diseases in a population.

2.2. AXIAL LENGTH VALUES IN PAEDIATRIC POPULATIONS.

Axial length refers to the distance from the cornea surface to an interference peak corresponding to the retinal pigment epithelium.[16] This distance is a combination of anterior chamber depth, lens thickness and vitreous chamber depth.[17] A study carried out in Iran to understand the changes in biometric components during ocular development established the average axial lengths in various age groups as follows; 6-7years (22.65mm), 8-10years(22.80mm), 11-13years(23.21mm), 14-16years(23.39mm), 17-18years(23.49mm) with average axial length among all age groups being 23.13mm.[18] A hospital-based study in Nigeria found the average axial length of children aged less than 10years old to be 20.5±1.9mm,[19] which was shorter than what was found in the Iranian paediatric population. The variation axial lengths between the two populations could partly be explained by genetic differennces.[20] The data from the Western world[4] used as reference is similar to what was found in this Nigerian study

Variations in mean axial length could be attributed to differences in geographic and demographical characteristics of the populations,[21] differences in measurement methods for axial length calculation, race and genetics, the definition of axial length used in the study, the sample size, and the use of 2% homatropine drops in cycloplegia, and also a range of physiological factors such as; diurnal variations[22] (fluctuations that may occur during the day and night cycle), accommodation[22] and changes in intraocular pressure.[23] leading to small, but significant, short-term/transient changes in axial length measurements.[22]

Knowledge of the normative axial length in Ghanaian children is important since axial length is one of the most important factors in determining the right intraocular lens power in paediatric cataract surgery.

2.3. CORNEA RADIUS AND CURVATURE

The cornea radius of curvature is a measurement that characterises the curvature of the anterior cornea surface. It quantifies the radius of the imaginary sphere that would best fit the cornea's curvature. A smaller cornea radius indicates a steeper curvature, while a larger radius suggests a flatter cornea surface.[16] In a study in Iran to investigate ocular biometric changes during growth, the cornea radius for the various ages are as follows: 6–7years (7.75mm), 8–10 years (7.74) , 11–13years (7.78mm), 14–16years (7.79mm), 17–18years (7.79mm) with an average radius of 7.77mm.[18] Thus, cornea radius increased with increasing age. In a study from Australia that looked at ocular biometric parameters between 6 year old and 12 year old groups, the researchers found that average cornea radius of curvature was 7.78±0.25 in both groups with slight variations between the different ethnic groups that were studied.[24] The normal cornea radius and keratometry values in a population is important in diagnosing children with pathologies such as congenital glaucoma, microphthalmos, and keratoconus.

2.4. ANTERIOR CHAMBER DEPTH

The anterior chamber depth is the distance that exist between the posterior surface of the cornea and the anterior surface of the lens.[25,26] Generally the depth of the anterior chamber increases with increasing age. [18,24, 27] A study by Hashemi et al in Iran found that anterior chamber depth increased with age; 6-7years(2.92mm), 8-10years(2.94mm), 11-13years(3.07mm), 14-16years(3.06mm), 17-18years(3.05mm).[18] There is a paucity of published data on anterior chamber in children in sub-Sahara Africa even in studies on ocular biometry. A study by Twelker et al[28] showed differences exist in different races. Afican American children had anterior chamber depth that was deeper than that of Asian children but less than that of Caucasian children.[28]

2.5. LENS THICKNESS

The theory of emmetropisation suggest that approximately 1mm elongation of the axial length is accompanied by a myopic change of -2.50D among the general population.[29,30] However, this is not what is observed normally in the general population, due to the progressive thinning of the crystalline lens with age.[29,30] Also the cornea has not been observed to produce any compensatory changes during this period.[29,30] Analysis of the lens data component of the

Orinda study showed that there is thinning of the crystalline lens from 6 to 10 years of age.[31] This thinning was attributed to axial growth occurring with equatorial ocular growth that results in crystalline lens stretching in the equatorial direction with attendant flattening of the lens surface radii of curvature.[31] This flattening results in reduced lens power which coupled with increasing axial length with age, ensures images form on the retina to achieve optimal vision.[31] Hashemi et al showed that this relationship is more important in children with long axial length compared to those with moderate axial length.[32] Therefore in this study seeks to determine if increasing age correlates with thinning of the crystalline lens in the Ghanaian population.

2.6. VITREOUS CHAMBER DEPTH

Vitreous chamber depth refers to the space between the posterior surface of the lens and the internal limiting membrane of the retina.This space is occupied by the vitreous humour which contributes significantly to the globular shape of the eye. The length of the vitreous chamber is also important because it contributes to most of the axial length of the eye. Generally, researchers have found that the depth of the vitreous chamber increases with increasing age. A cross sectional study in Singapore by Saw et al among 7 to 9 year old children found that among the 7 year old children the vitreous chamber depth was 16.0± 0.9 mm, 16.3 ±0.8 mm in the 8-year-old children, and 16.8±1.0 mm in 9-year-old children.[33] Twelker et al found that boys compared to girls had longer vitreous chambers with boys having an average of 16.29mm while the girls had an average vitreous chamber depth of 15.91mm.[28] Vitreous chamber depth makes up the majority of axial length, therefore the value of the vitreous chamber depth can aid in the diagnosis of conitions such as axial myopia.

2.7. MEASUREMENT OF OCULAR BIOMETRY

Ocular biometry is generally measured using A-scan ultrasound or partial interferometry.[34,35] A-scan biometry employs the use of 10MHz ultrasounsd waves to obtain ocular biometric parameters including axial length, anterior chamber depth, lens thickness, vitreous chamber depth. Ocular ultrasound scan can be performed with either contact between the ocular surface and the ultrasound probe(contact biometry) or through another method where the ultrsound probe is immersed in a water bath on the cornea.[36] An important factor in measurement of ocular biometry is operator error where the operator compresses on the cornea and thus a shorter than normal axial length is recorded as well as alterations in the results of the other

biometric parameters. Some published data suggests that the immersion method is superior to the contact method in the measuement of biometric parameters.[37–39] since this method takes away the corneal compression by the probe. A study by Shamas showed that axial length measurements by immersion method was 0.24mm longer than measurements by the contact method.[40] Some studies however report no significant difference in axial length measurements via immersion and contact methods.[36] A study by Hennesey showed results by contact method was 0.03mm longer than results obtained via immersion method.[39]

Data published by Carkeet suggest that measurements using partial coherence interferometry are about 0.70 mm longer compared to measurements by A-scan method.[34] Other studies also concluded that measurements by partial coherence interferometry were longer than measurements by a scan ultrasound.[41,42] This difference in length is attributed to the absence of indentation of the cornea and the difference between the physical principles of the two instruments. Ultrasound is reflected from the internal limiting membrane, whereas partial coherence interferometry is reflected from the retinal pigment epithelium.[43] A study by Buckhurst et al showed that axial lengths measured by partial coherence interferometry were shorter than those measured by A scan ultasound. One way to overcome this indentation problem is measurements being performed by an experienced person who is able to apply as little indentation to the cornea as possible if an immersion method or partial cohenerence interferometry is not available.[44] Generally axial length cannot be measured in eyes with dense cataracts by the partial coherence interferometry method because the light used in the machine is not able to pass through the lens opacity while A scan ultrasound does not have this limitation.

The A scan ultrasound is generally considered as the gold standard for the measurement of anterior chamber depth, lens thickness and vitreous chamber depth however clinically it is not considered to be superior to measurments by optical coherence interferometry.[44] In this study biometric measurements will be performed using contact A scan ultrasound.

2.8. RELATIONSHIP BETWEEN OCULAR BIOMETRIC PARAMETERS AND AGE, GENDER, BODY MASS INDEX AND REFRACTION

2.8.1. Age

The relationship between the age of children and their ocular biometric parameters have been investigated by various studies with varied results.[28,45,46] In most studies axial length increases with age while at the same time the cornea radius increases, and steepness reduces with age.In a study in Iran, analysis of the data of emmetropic children showed that axial length and

anterior chamber depth increased significantly with age, cornea radius increased, lens thickness decreased.[18] A study in Austrailia found that axial length and anterior chamber depth increased significantly with age while cornea radius remain relatively unchanged amongst the 6year old group as well as the 12year old age group as well as amongst the different ethnic groups that were studied.[24] A number of studies on ocular biometry have been carried out in Africa, however most of these studies were in adult populations.[47–51] Studies from Nigeria in children found that axial length increased with age.[19,48]

Results from the statistical alnalysis of the lens measurements from the Orinda Longitudinal Study of myopia found that there was a general decrease in the thickness of the lens from 6 to 9 years in the group of children who were followed over the period of the study.[31]

2.8.2. Gender

A study in England found axial length to be longer in boys compared to girls of the same age while the girls had steeper corneas compared to the boys.[2] A study in Germany found that cornea curvature was steeper in girls compared to boys of the same age.[49] In Iran a study found boys to have significantly longer axial length compared to girls, also girls had steeper corneas than boys with the cornea radius in boys being longer than in similar aged girls.[18] A study in Australia found that boys had flatter cornea and longer axial lengths than girls.[50] A number of studies have demonstrated longer axial lengths in boys compared to girls of the same age. The results of some of these studies are summaried in Table 1 below. The difference in the sexes that have been observed are partly attributed to the dimorphic appearance of males and females that generally make males taller compared to females.[52] Beyond the X and Y-chromosomes determining sex, variations in genes associated with growth and development manifest differently in males and females, and these factors cause the rapid physical growth seen in males compared to females even before puberty.[50,52] These genetic influences also express in the eye and lead to males having longer axial lengths than females.[53,52] Males and females exhibit different growth rates even before puberty due to the levels of sex hormones like testosterone and oestrogen, and this is believed to also affect ocular development.[54] Oestrogen in girls is thought to protect against elongation of the globe while testosterone is believed to promote elongation of the globe.[55] Other hormones such as insulin-like growth factors (IGF) have been shown to contribute to the difference in axial length in males and females. Variations in IGF levels and sensitivity between boys and girls contribute to the differences in axial length.[56] An interplay of these factors therefore lead to longer axial lengths in males compared to females.

Table 1: Axial length according to gender in previous studies

Country	Year of publication	Author	Axial length in boys	Axial length in girls
Nigeria	2014	Igbinedion et al[19]	20.70 ± 1.9mm	20.50 ± 1.9mm
USA	2009	Twelker et al[28]	23 ±0.67 mm	22.77± 0.78 mm
Singapore	2002	Saw et al[33]	23.40± 0.90 mm	22.80± 0.80 mm
Taiwan	2001	Lin et al[51]	23.02± 0.72 mm	22.55± 0.73 mm
USA	1995	Zadnik et al[31]	22.94 ±0.63 mm	22.49± 0.76 mm
Norway	1971	Larsen[1]	22.09 ±0.62 mm	21.48± 0.63 mm

Anterior chamber depth was found to be deeper in boys compared to girls in a study conducted in Iran to investigate the changes in biometry as children grow.[23]24

2.8.3. Body mass index

In a study by French et al, which sought to describe the relationship between BMI and axial length, a positive correlation was found between AL and BMI in 6–7-year-olds as well as 12–13-year-old from Sydney, Australia.[57] In the same study investigators found a negative correlation between AL and BMI in 12–13-year-olds from Northern Ireland.[57]A study in Singapore found that taller children had longer axial length and flatter corneas compared to children of similar age and gender in lower quartiles of height. In the same study researchers found that boys who were heavier had shorter axial lengths while girls who were obese had longer axial lengths and flatter corneas compared.[33] Again Saw et al found that taller children had longer vitreous chambers, thinner lenses as well as deeper anterior chambers.[33] The authors of this study proposed that increasing axial length, deeper anterior chamber depth and longer vitreous chamber happens at the same time that the body height is increasing rapidly thus leading to the axial myopia that results in these children.[33]

2.8.4. Refraction

A study from England demonstrated South Asian children had 0.4 mm longer axial length, 1D more myopia, and slightly higher levels of negative astigmatism than white European children.[2]A study by Ip et al in Australia which looked at the relationship between ocular biometry and refraction among different ethnic groups in 6-12-year-old children found a strong correlation between increasing axial length and increasing myopia among the Asian cohort of the study compared to the Caucasian cohort.[24] A study in Taiwan noted that myopia generally was associated with longer axial lengths with a positive correlation, thus axial length increased

as myopia worsened.[51] This relationship is further corroborated by Lin in Taiwan who demonstrated that children aged 7-9 years with low myopia had an average axial length of 23.76 mm compared to an average axial length of 24.81 mm for those with high myopia.[51] Li et al from China also showed that 14-year-olds with longer axial lengths and flatter corneas had higher degrees of myopia than 7-year-olds with shorter axial lengths.[58] In Australia, axial length was found to be the strongest factor associated with the development of myopia in all ethnic groups.[24]

A study in Singapore showed that the average lens thickness measured over the 5year duration of the study was higher in hyperopes and thinner in myopes.[59] A study from Australia, found that lens thickness was weakly correlated with the development of myopia.[24.] In a study from Singapore, those with hyperopia had the highest lens power and the myopic group had the lowest lens power.[59] A study in Iran found that myopes had longer axial lengths as well as deeper anterior chamber depths with hyperopes having the thickest lenses.[18]

Despite the aforementioned studies, there is limited published data on ocular biometric parameters in populations in sub-Saharan Africa including Ghana.

MATERIALS AND METHODS

3.1. STUDY DESIGN

This was a prospective cross-sectional observational study which measured the ocular biometric values, refraction, and BMI of healthy Ghanaian children (eyes) aged 6 to 15 years in the Ablekuma South Sub-Municipality.

3.2. STUDY SITES

The study was conducted in some selected basic schools within the Ablekuma South Sub-Metropolitan Assembly in the Greater Accra Region of Ghana.

3.3. ABLEKUMA SOUTH SUB-METROPOLITAN AREA

The Ablekuma South Sub-Metropolitan Area forms part of the Sub-Metropolitan District Councils of Accra Metropolitan Assembly (AMA). The AMA has six Sub-Metropolitan Districts. The Sub-Metro of interest was the largest in the Metropolis and shares its boundaries with Ablekuma Central, Ablekuma North and Ashiedu Keteke. It covers an area of 15.1 km^2. It hosts some business entities like banks, educational institutions, supermarkets, fuel stations, hotels, and major hospitals such as the Korle Bu Teaching Hospital Teaching as well as other smaller public health facilities such as the Mamprobi Hospital, Korle-Bu Polyclinic, and other private health facilities. Its cosmopolitan nature made it ideal for this study since population represents a good amalgamation of the various ethnicities that make up the general population of the country. The Ablekuma South Sub-Metropolitan Area education directorate has 54 basic schools with a total population of 20,724 pupils. This population is composed of 13, 907 pupils from 33 public and 6817 pupils from 21 private schools.

3.3.1. Martyrs of Uganda R/C Basic School

The Martyrs of Uganda R/C basic school is located on Guggisberg avenue on the Martyrs of Uganda catholic church compound and opposite the Mamprobi Post office. It is a public school with an estimated total population of about 924 pupils.

3.3.2. Mamprobi E.P. Church Basic School

The Mamprobi E.P. Church Basic School is a private school located near the Mamprobi Police station, Accra. It is a private school owned and managed by the Evangelical Presbyterian (EP) church. The school's total population was estimated at 792 pupils.

3.3.3. Mamprobi South 3 Basic School

The Mamprobi South 3 Basic School is located near the "Tuesday Market" in Korle Gonno-Accra. This is a public school with an estimated total population of about 483 pupils.

3.4. TARGET POPULATION

Ghanaian children aged 6 to 15 years in selected schools who met the inclusion criteria.

3.5. SAMPLE POPULATION

This included Ghanaian children aged 6 to 15 years from Martyrs of Uganda R/C Basic School, Mamprobi E P Church Basic School, Mamprobi South 3 Basic School who met the inclusion criteria. The minimum age of 6 years was chosen to ensure maximum cooperation for data measurement without sedation.

3.6. INCLUSION CRITERIA

1. Children within the specified age group (6- 15 years) with normal ocular findings on anterior and posterior segment examinations.
2. Children who had parental consent and gave assent.

3.7. EXCLUSION CRITERIA

1. Children with history of ocular trauma,
2. Children with history of prior intraocular surgery
3. Children with any known ocular pathology.

3.8. SAMPLE SIZE DETERMINATION

The study sample size was calculated using the formula for the mean value of a quantitative variable in a population.[26]

$N = [Z^2]x\ [\sigma^2]/\ d^2$

Where;

$Z_{1-\alpha/2}$ = Standardized value for the corresponding level of confidence, at 95% CI, it is 1.96.

d = Margin of error or rate of precision = 7%

σ = the standard deviation (SD), was based on a previous study in Libya[27] where the mean axial length (mm) was 23.99mm and the SD was 0.51mm for population aged up to 19years which was close to the age of our study population and was an African based study.

$N = [Z^2]x\ [\sigma^2]/\ d^2$

$N = (1.96^2) \times (0.51^2) / 0.07^2$

N = 3.8416 x 0.2601/0 0049

Therefore, N = 203.9184

Considering 10% drop out by study participants,

N = 203.91842 + (10%/100) x 203.9184 = 224

N ≈ 224.

Hence, the minimum sample size for the study was 224.

However, this was increased to 352 during the data collection in order to enhance the statistical power of the tests, improve precision and increase the acurracy of statistical estimates.

3.9. SAMPLING TECHNIQUE

A total of 352 Ghanaian children were selected from Basic schools within the Ablekuma South Sub-Metropolitan area. The Ablekuma South Sub-Metropolitan area was chosen because of its proximity to the Korle Bu Teaching Hospital which offered an opportunity for participants to be referred to a tertiary paediatric eye facility in the event of a need for further management. Multistage sampling was used in the sampling procedure in four stages.

3.9.1. The first stage of the sampling technique

At the first stage, stratified sampling technique was used in stratifying the basic schools into private and public schools respectively.

3.9.2. The second stage of the sampling technique

The second stage was the selection of the schools for the study. At the second stage, simple random sampling was used in selecting three Basic schools for the study. To achieve a proportionally representative sample, two public schools and one private school were selected based on the ratio of the total number of public schools to private schools (the ratio of public to private school population was 33:21; which was 1.6:1 ≈ 2:1). The total number of schools (3) were chosen based on time and resource constraints of the study while satisfying the basic representative sample of both public and private schools of a ratio of 2:1.

At this stage, a sampling frame consisting of the list of public Basic schools (33) in the Ablekuma South Sub-Metropolitan Area was obtained from the Ghana Education Service. The names of the schools were entered into a Microsoft excel worksheet. A command was given for the randomization of the list of schools provided using the random number generator command (RAND function) in Microsoft Excel 365Suite software. The first two schools which

appeared on the list were selected. The same procedure was repeated separately for the private schools (21) to select one representative for that stratum.

3.9.3. The third stage of the sampling technique

The third stage was the definition of the number of participants to be selected from each school. To obtain the number of participants selected from each of the three schools, proportional allocation to the size of each school was considered to constitute the total sample of 352 participants. This is illustrated in Table 2 below.

3.9.4. The fourth stage of the sampling technique

At the fourth stage, each school was stratified into three classes [Lower Class Primary (Class one to three), Upper Class Primary (Class four to six), and Junior High School (Form one to three)] categories according to the Ghana Education Service classifications using stratified sampling. Averagely, the normally distributed age range for the three classes according to the Ghana Education Service were as follows: Lower Class Primary (6-8 years), Upper Class Primary (9-11 years), and Junior High School (12-15 years) respectively.

The lists (register) of all participants in each of the three classes were obtained. For each class, pupils who fell within the age group for the class were included. For a fair representation of the age distribution, an equal number of participants were selected from each stratum (class). Systematic sampling was used in selecting participants in each class. For each class, the total number of participants in the class was divided by the number of participants to be selected in that class. The outcome (sampling interval) was used as a random starting point with which other participants were selected in a systematic pattern. Thus, all the participants in each class were numbered from the first to the last using numbered pieces of paper corresponding to the listing in the class register. These were then placed in a container and picked randomly by an independent person until the required number to be selected per class was reached. Where a selected participant did not meet the inclusion criteria, a new number was drawn randomly from the ballot. This was done for all the classes and schools until the total number to be selected was obtained.

Table 2: Sampling distribution table for selected basic schools in Ablekuma South sub-Municipality

School	Total number of students in each school (N)	Sampling ratio (R)	Number expected to be sampled from each school (N*R)	Number sampled from each school
Martyrs of Uganda R/C Basic School	925	224/2600	80	106
Mamprobi E.P. Church Basic School	720	224/2600	62	124
Mamprobi South '3' Basic School	955	224/2600	82	122
Total	**2600**		**224**	**352**

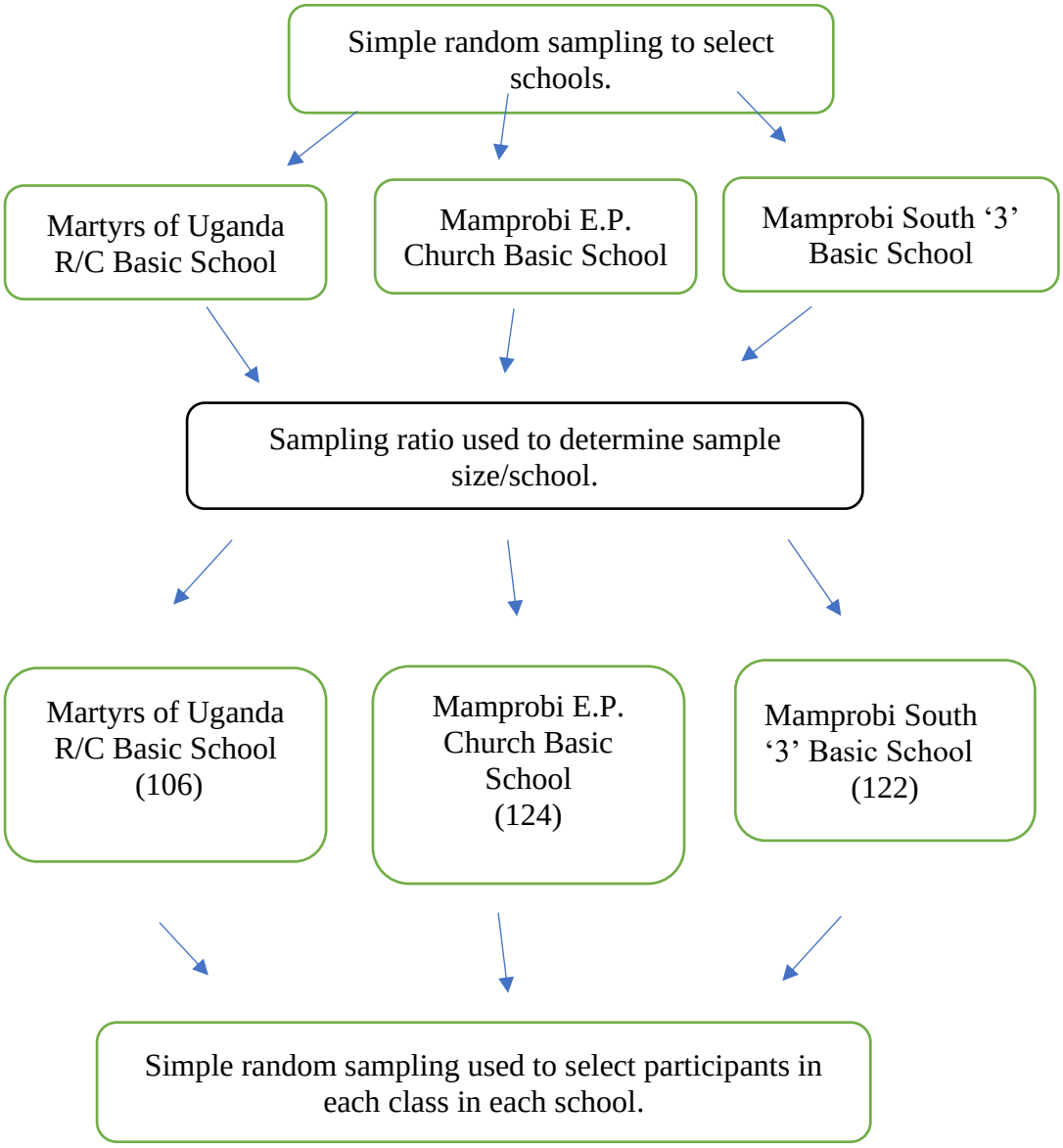

Figure 1: Algorithm Of Sampling Technique for selected basic schools in Ablekuma South sub-Municipality

3.10. PROCEDURES

Data was collected from three schools, including Martyrs of Uganda R/C Basic School, Mamprobi South '3' Basic School and Mamprobi E.P. Church Basic School in the Ablekuma South sub-Municipality. Collection of data commenced after administrative approval was granted by the Ghana College of Physicians and Surgeons(GCPS), ethical clearance was granted by the Scientific and Technical Committee (STC) and Institutional Review Board (IRB) of the Korle Bu Teaching Hospital approval granted by the Accra Metropolitan Educational Office. The headteachers of the three schools involved in the study were informed about the study and the data collection to be held at their schools and their approval sought.

3.10.1. Study team and roles

The research team compromised of the principal investigator(PI), one ophthalmology resident, two opticians, one optometrist and a statistician. Figure 3 summarises the procedures that were undertaken during the data collection period.

The principal investigator performed anterior and posterior segment examination to ensure that every study pariticipant had normal eye findings. These examination findings were recorded on the data collection forms.

Optician 1 undertook measurement and recording of visual acuity. Resident 1 undertook the checking of IOP with the Icare® tonometre and measurement of CCT with the ultrasound pachymetre. Optician 2 was responsible for the instillation of cyclopentolate drops,weight and height measurements as well as recording the values and the BMI value calculated by the combined height and weighting scale.

The principal investigator then undertook the measurement and recording of the ocular biometry parameters icluding axial length, anterior chamber depth, lens thickness, vitreous chamber depth. The optometrist carried out the autorefractions and recorded the results.

Pre-research preparations were conducted by training of the entire research team on the recruitment, consenting process, data collection forms and the examination procedures and skills. The team met twice to discuss the inclusion and exclusion criteria and the order of data capture and examination.

At the study sites, consent forms were given to pupils for parental consent prior to data collection day. Children who brought back signed data collection forms were included in the sampling process. Sampled participants who met the inclusion criteria were then brought to the room prepared for examinations.

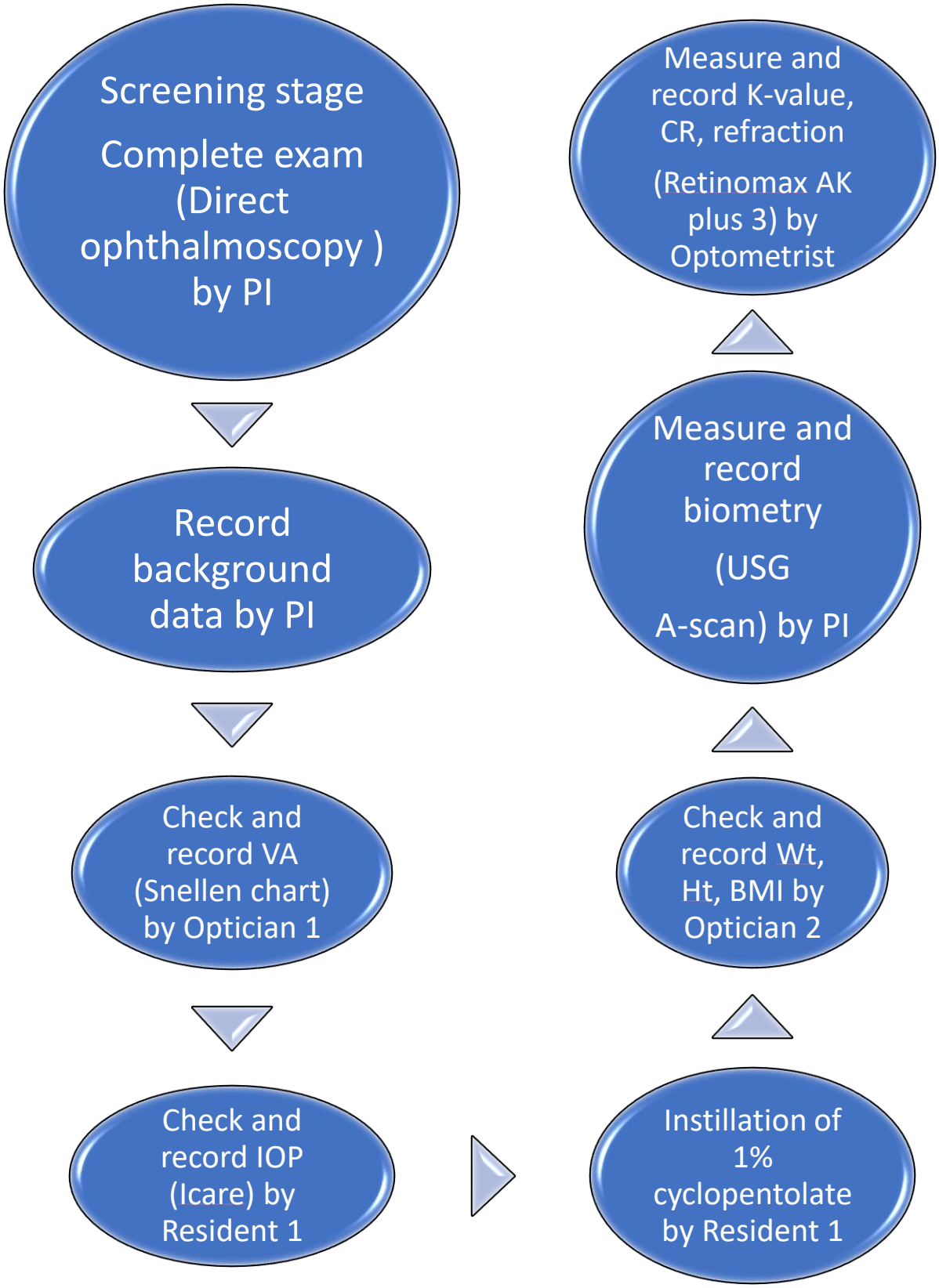

Figure 2: Sequence of study procedures at the study sites in the Ablekuma South sub-Municipality

3.10.2. Screening Stage

A general eye examination, including anterior and posterior segment examination was undertaken using a direct ophthalmoscope to exclude any ocular pathology. This was done by the Principal investigator. Children whose examination findings showed no obvious pathologies were recruited into the study. A cup to disc ratio of more than 0.6 was a criterion for exclusion. Children with this finding were referred to the Lion's International Eye Centre (LIEC), Korle Bu Teaching Hospital (KBTH) for further investigations and follow-up. These participants were replaced with other child from the same class through simple random sampling.

3.10.3. Background data recording

Background demographic characteristics of participants including age, gender and ethnicity were recorded on the data collection forms by the principal investigator.

3.10.4. Measurement of visual acuity

Visual acuity was assessed by Optician 1 using a standard LogMAR chart at 6m in a well lit environment, testing one eye at a time and the result was recorded on the data collection form. Visual impairment was graded according to the WHO guidelines:

Classification of distance visual impairment:

Mild –visual acuity worse than 6/12 to 6/18 (worse than LogMAR 0.3 to 0.5)

Moderate –visual acuity worse than 6/18 to 6/60 (worse than LogMAR 0.5 to 1.0)[61]

Severe –visual acuity worse than 6/60 to 3/60 (worse than LogMAR 1.0 to 1.3)

Blindness –visual acuity worse than 3/60 (worse than LogMAR 1.3)

Figure 3.1: Visual acuity measurement for study participant at Mamprobi South Basic School

3.10.5. Measurement of central cornea thickness and intraocular pressure

Resident 1 measured IOP using Icare® tonometre (ICARE USA INC,Abbe Ave, Kansas City, Missouri, USA). To measure the IOP, each participant was asked to fixate on a target straight ahead. The Icare® was used to record five consecutive readings while the probe was directed to the central 3mm of the cornea and the average calculated by the equipment recorded on the data collection forms. The device was caliberated daily before measurements were taken.

Figure 3.2: IOP measurement for study participant using Icare® at Mamprobi South Basic School

Resident 1 performed the ocular pachymetry using a hand-held pachymeter, *Pachmate*® (DGH Technologies Inc, Exton PA, USA). To measure the CCT, participants were asked to focus on a distant target. Five measurements were taken from the central 3mm of the cornea of both eyes after instillation of topical 0.5% amethocaine in each eye prior to measurement of the central corneal thickness.. Once proper alignment of the tip of the probe to the cornea was made, a series of measurement (five per cornea) were taken automatically by the pachymeter. The displayed results per eye (the average of the 5 readings) were recorded onto the data collection form. The tip of the pachymeter was sterilized with 70% methylated spirit after every use. The device was calibrated daily prior to initiation of measurements.

Figure 3.3: CCT measurement for study participant using Pachmate® at Mamprobi South Basic School

Instillation of Guttae Cyclopentolate was carried out on both eyes twice, 10minutes apart approximately an hour before refraction was done.

3.10.6. Measurement of weight, height and BMI

The next examination was the measurement of height and weight performed by optician 2. Height was measured in metres using a SECA 769 (Seca Gmbh & Co, Hamburg, Germany) measuring height. Weight was measured in kilograms using a SECA 769(Seca Gmbh & Co, Hamburg, Germany) weighing scale, which was calibrated daily. The scale automatically calculated the BMI based on the weight and height.

Figure 3.4: Measurement of weight, height and BMI of study participant at Mamprobi South Basic School

3.10.7. A-scan Measurement

Measurement of the axial length, ACD, lens thickness, and vitreous chamber depth was performed by the PI using a SONOMED PACSCAN 300-A Plus (Escalon Medical Corp, Wayne, Pennsylvania, USA). The participants eyes were anaesthesised with 0.5% amethocaine drops, the tip of the A-scan probe was sterilised with 70% alcohol and allowed to dry. The tip of the probe was applied to the centre of the cornea with mimimal pressure while the machine picked up five consecutive readings of the eye's axial length, ACD, lens thickness, vitreous chamber depth. An average of the five readings was calculated by the machine and the average recorded on the data capture form.

Figure 3.5: Measuremnt of axial length, anterior chamber depth, lens thickness, vitreous chamber depth for study participant using A-scan ultrasound at Mamprobi South Basic School

3.10.8. Measurement of cornea radius, keraatometry-value and cycloplegic refraction

The next measurements were performed by the paediatric optometrist, which included cornea radius, K-values, and cycloplegic refraction. These were done using Retinomax -K plus 3(Righton MFG. CO. LTD, Tokyo). This was carried out by placing the equipment on the participants forehead while they were asked to fixate on a target inside the machine, values were automatically picked up and an average cornea radius, dioptric value and refraction measured. The two eyes were measured simultaneously. The values were then transferred to a printer attached to the equipment and the results printed and recorded on the data collection form. The equipment had no direct contact with the participants' ocular surface. The device was caliberated daily before use. Spherical equivalents (SE) of the refraction results were calculated from the actual results measured, and used for statistical analysis.

The formula for calculation of the SE was: Sphere + ½ cylinder.[57] The conversion of the refraction results to it's spherical equivalence was done on the field using pre-printed conversion tables. Participants were classified based on the SE as either emmetropia (+1.0D to

-1.0D), myopia (>-1.0D) and hyperopia (>+1.0D). This classification was based on groupings used by a previous study on ocular biometry in children.[18]

The study data collection was conducted from 22nd January to 2nd Februray 2024

Figure 3.6: Measurement of cycloplegic refraction, cornea radius, K-value of study participant using Retinomax AK plus 3 at Mamprobi South Basic School

3.11. DATA MANAGEMENT AND QUALITY ASSURANCE

Utmost attention was paid to the security of participants data and confidentiality of information was paramount in the study. Participant data was recorded on pre-designed data collection

forms. Data collected is being kept with only the principal investigator having access to it. Questionnaires were coded. Participants' information was treated as confidential. To ensure confidentiality, the de-identified data was entered into Microsoft Excel on a password-protected computer and examined for completeness. Completed data capture forms are being stored in a locked cabinet for 5 years after completion of the study and then disposed of with.

3.12. STATISTICAL ANALYSIS

Data was exported to SPSS version 25 and analysed. Descriptive analysis on demographic characteristics of participants was done and presented as frequency tables, bar charts and cross-tabulation. The distribution of ocular biometric measurements in the study population was assessed for assumptions of normality using the Kolmogorov-Smirnov test. The mean axial length (mm), K-values (D), cornea radius and curvature (mm), anterior chamber depth (mm), lens thickness (mm), and vitreous chamber depth (mm) were calculated and presented in a table as mean±standard deviation.

Statistically significant differences were assessed with the independent t-test for differences in biometric variables such axial length, and K-values. Pearson correlation co-efficient was used in analysing the relationship between the biometric (axial length, K-values, cornea radius and curvature, anterior chamber depth, lens thickness, and vitreous chamber depth) and anthropometric measurements (BMI). Analysis of variance (ANOVA) was used to determine any difference between the means of independent variables. Statistical significance was set at a *p-value* of less than 0.05.

3.13. ETHICAL AND LEGAL CONSIDERATIONS

The study protocol was presented to the KBTH-IRB for review and approval prior to conduct of the study. Administrative permission was also obtained from the Accra Metropolitan Directorate of Ghana Education Service and the Heads of participating schools as well as GCPS. An informed written consent was obtained from parents or guardians of participants and assent from participants who were 8 years and above prior to inclusion in the study.

RESULTS

4.1. Introduction

Chapter four of this dissertation presents the results from the analysed data. The data analysis process followed the specific objectives outlined in the methodology. The aim of the study was to determine ocular biometric parameters and their relationship with age, gender, refraction, and body mass index in Ghanaian children in the Ablekuma South Sub-Municipality.

Data analysis was done using SPSS version 25. Details of the data analysis plan were presented in the methodology section of this dissertation. Ocular biometric data was analysed using the average of the two eyes.

4.2. Demographic characteristics of the school children in the Ablekuma South Sub-Municipality

4.2.1. Total number of school children in the study

Three hundred and fifty-two (352) children aged 6 to 15 years were recruited from selected schools in the Ablekuma Sub-Metropolitan area at the basic level of education (class 1 to Junior High School). A total of 124 (35.2%) were from Evangelical Presby Basic Schools, 106 (30.1%) form Martyrs of Uganda Basic School, and 122 (34.7%) from Mamprobi South Basic School.

4.3. Mean ocular biometric values

A summary of the measured parameters is presented in Table4.1

Table 4.1: Summary of means of parameters measured in school children in Ablekuma South sub-Municipality

Parameter	**Mean**
Age	10.0±2.9 years
Sex	
Male	45%
Female	55%
BMI	16.9kg/m^2
Ethnicity	
Ga	44.9%
Akan	28.7%
Ewe	17.6%
Northerner	8.8%
Ocular biometric value	
Axial length	22.73±0.75mm
Anterior chamber depth	3.28±0.29mm
Lens thickness	3.65±0.27mm
Vitreous chamber depth	19.44±0.70mm
Cornea radius	7.79±0.28mm
Keratometry value	43.39±1.56D

4.3.1. Age

Table 3.2: Summary statistics of the age of study participants in the Ablekuma South sub-Municipality

Statistics	Value (years)
Mean	10±2.9
Median	10.0
Mode	6.0
Standard deviation	2.9
Minimum	6.0
Maximum	15.0
Lower quartile	7.0
Upper quartile	12.0
Interquartile range	5.0
Skewness	0.197
Kurtosis	-1.105

Age was analysed descriptively and tested for normality using the Kolmogorov-Smirnov test. Findings from the test of normality showed that the age of the children was not normally distributed (p-value = 0.001) hence, the median (interquartile range) age range values were recorded. Table 4.3 and Figure 4.1 also demonstrate the non-normality of the age distribution as the data points are deviating from the 45-degree reference line. To compare the results with other studies, the mean age with standard deviation was also presented. The analysis showed that the mean age standard deviation and median (interquartile range) ages of these children was 10.0±2.9 years and 10.0 (5) years respectively. The minimum age was 6.0 years, and the maximum age was 15.0 years. Many (121, 32.5 %) of the school children were between 6-8 years compared to the other age categories. (Table 4.2, Figures 4.2).

Table 4.3: Test of normality of the age of study participants in the Ablekuma South sub-Municipality

Demographic characteristics	Kolmogorov-Smirnov		
	K-S Statistic	Degree of freedom	Significance
Age	0.106	352	.000

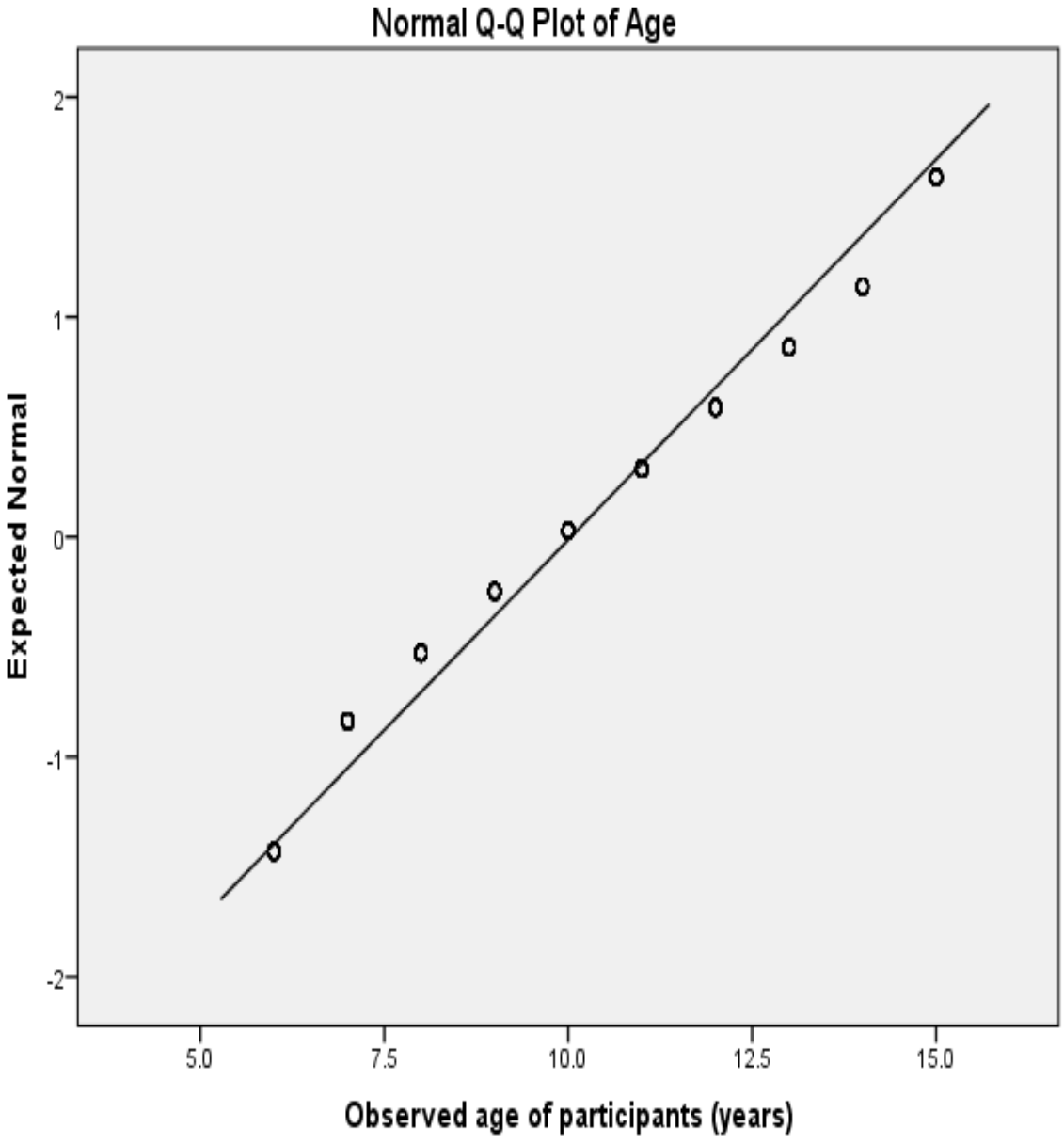

Figure 4.1: Normal quantile-quantile plot showing non-normal distribution of age of school children in the Ablekuma South sub-Municipality.

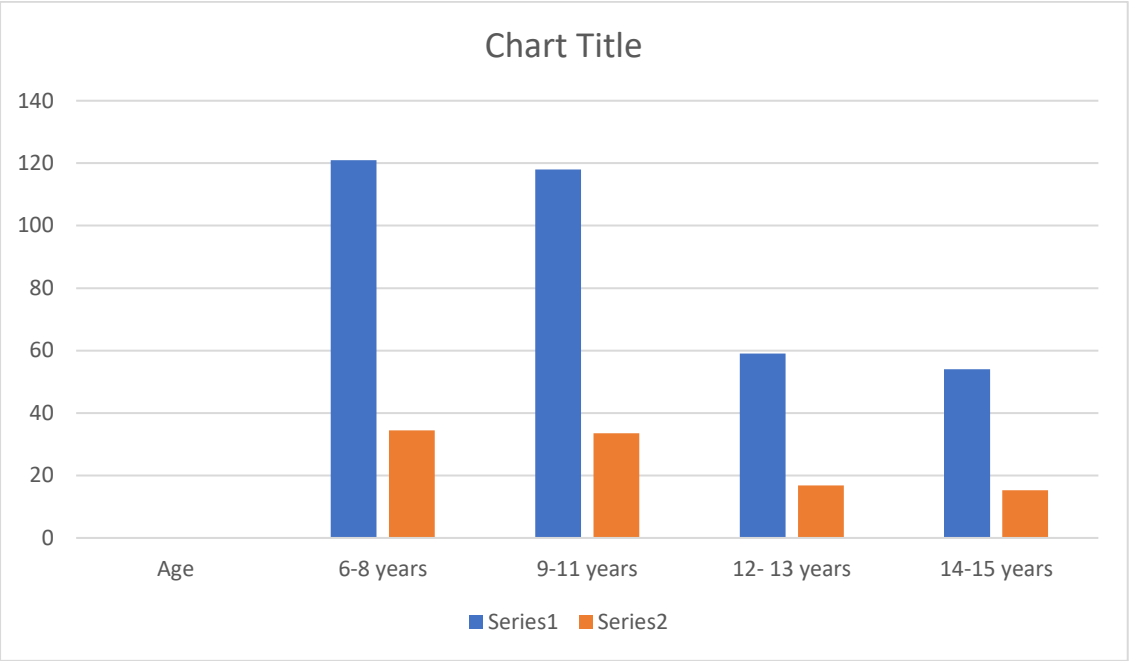

Figure 4.2: Distribution of age groups of school children in the Ablekuma South sub-Municipality

4.3.2. Sex

Fifty-five percent (195) of the study participants were females. Figure 4.3 presents the sex distribution of the study participants.

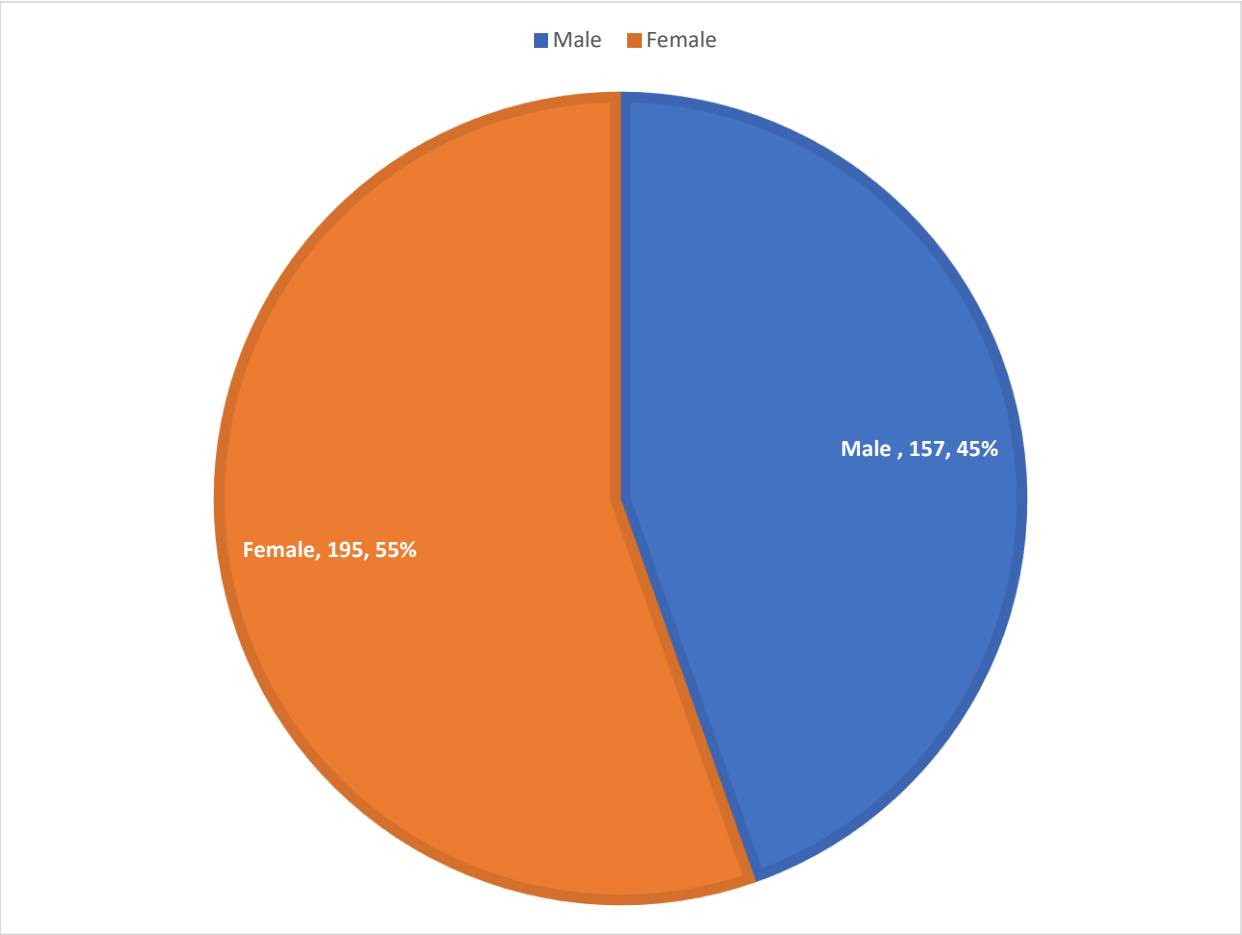

Figure 4.3: Sex distribution of school children in the Ablekuma South sub-Municipality

4.3.3. Body Mass Index (BMI)

From the Kolmogorov-Smirnov test, the BMI of the school children was not normally distributed (K-S test = 0.122; p-value = 0.001). (Tables 4.4) Table 4.5 and Figure 4.4 also demonstrates the non-normality of the BMI distribution. BMI was non-normally distributed as the data points are deviating from the 45-degree reference line.

Table4.4: Summary statistics of the BMI of school children in the Ablekuma South sub-Municipality

Statistics	**BMI (Kg/m^2)**
Mean	16.9
Median	16.2
Mode	15.5
Standard deviation	4.4
Minimum	6.5
Maximum	38.7
Lower quartile	14.8
Upper quartile	18.6
Interquartile range	3.8
Skewness	0.91
Kurtosis	3.20

Table 4.5: Normality test of the BMI of school children in Ablekuma South sub-Municipality

	Kolmogorov-Smirnov		
Characteristics	Statistic	Degree of freedom	Significant
BMI	0.122	352	0.000

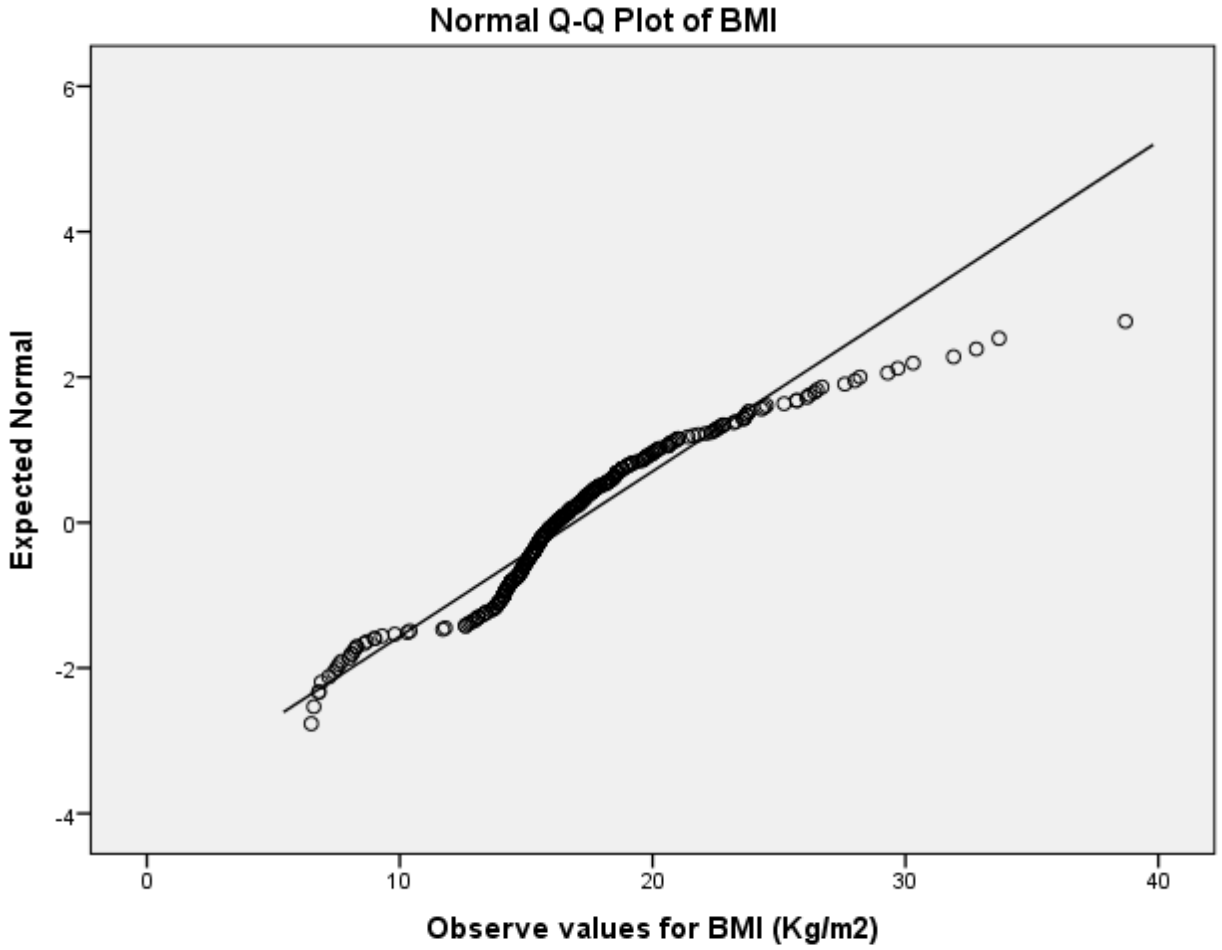

Figure 4.4: Normal Quantile-Quantile plot of the distribution of the BMI of school children in the Ablekuma South sub-Municipality

4.3.4. 4.4.4 Ethnicity of the study population

Among the study population, the Ga ethnic group had the highest representation with 158 children making up 45% of the study population. Table 4.6

Table 4.6: Ethnic distribution of school children in Ablekuma South sub-Municiaplity

Ethnicity	Frequency	Percent
Ga	**158**	**44.9**
Akan	**101**	**28.7**
Ewe	**62**	**17.6**
Northerner	**31**	**8.8**

4.4. Ocular biometric parameters of study participants

*4.4.1. Test of normality for **ocular biometric parameters***

Test of normality for the clinical characteristics revealed AL of both eyes, ACD of both eyes, VCD both eyes, K-values both eyes, CR both eyes were normally distributed using the Kolmogorov-Smirnov test for normality (p-values >0.05). Table 4.7

Table 4.7: Normality test for ocular biometric parameters characteristics of school children in the Ablekuma South sub-Municipality

Ocular biometric parameters	Kolmogorov-Smirnov		
	Statistic	Degree of freedom	Significance
VA right eye	0.518	352	0.000
VA left eye	0.529	352	0.000
AL right eye	0.028	352	0.200*
AL left eye	0.047	352	0.060*
AL both eye	0.033	352	0.200*
ACD right eye	0.062	352	0.003
ACD left eye	0.053	352	0.017*
ACD both eyes	0.032	352	0.200*
LT right eye	0.087	352	0.000
LT left eye	0.076	352	0.000
LT both eyes	0.049	352	0.040
VCD right eye	0.034	352	0.200*
VCD left eye	0.029	352	0.200*
VCD both eyes	0.033	352	0.200*
K-value/OD	0.043	352	0.188*
K-value/OS	0.035	352	0.200*
K-value both eyes	0.034	352	0.200*
CR right eye	0.046	352	0.068*
CR left eye	0.036	352	0.200*
CR both eyes	0.040	352	0.200*
Refraction right eye	0.104	352	0.000
Refraction left eye	0.101	352	0.000
Refraction both eyes	0.119	352	0.000

*Normally distributed variable. AL = axial length; ACD = anterior chamber depth; LT = lens thickness; VCD = vitreous chamber depth; K-value = keratometry values; CR = cornea radius.

4.4.2. Histogram of ocular biometric properties

Figures 4.5 to 4.10 shows the histograms of the distribution of ocular biometric properties of the school children in the study. The Kolmogorov-Smirnov tests outcome for all ocular

biometric parameters were significant, ($p < 0.001$) except for lens thickness. Thus, all biometric parameters were normally distributed except lens thickness which was not normally distributed.

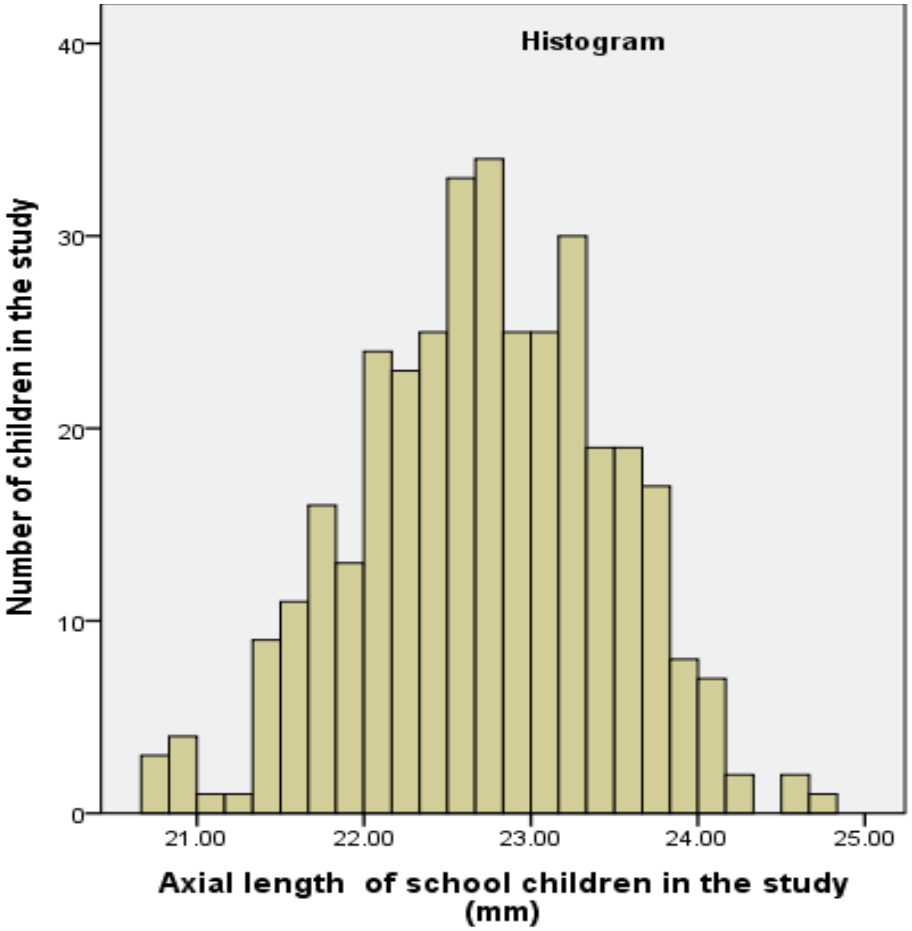

Figure 4.5: Axial length of school children in the Ablekuma South sub-Municipality

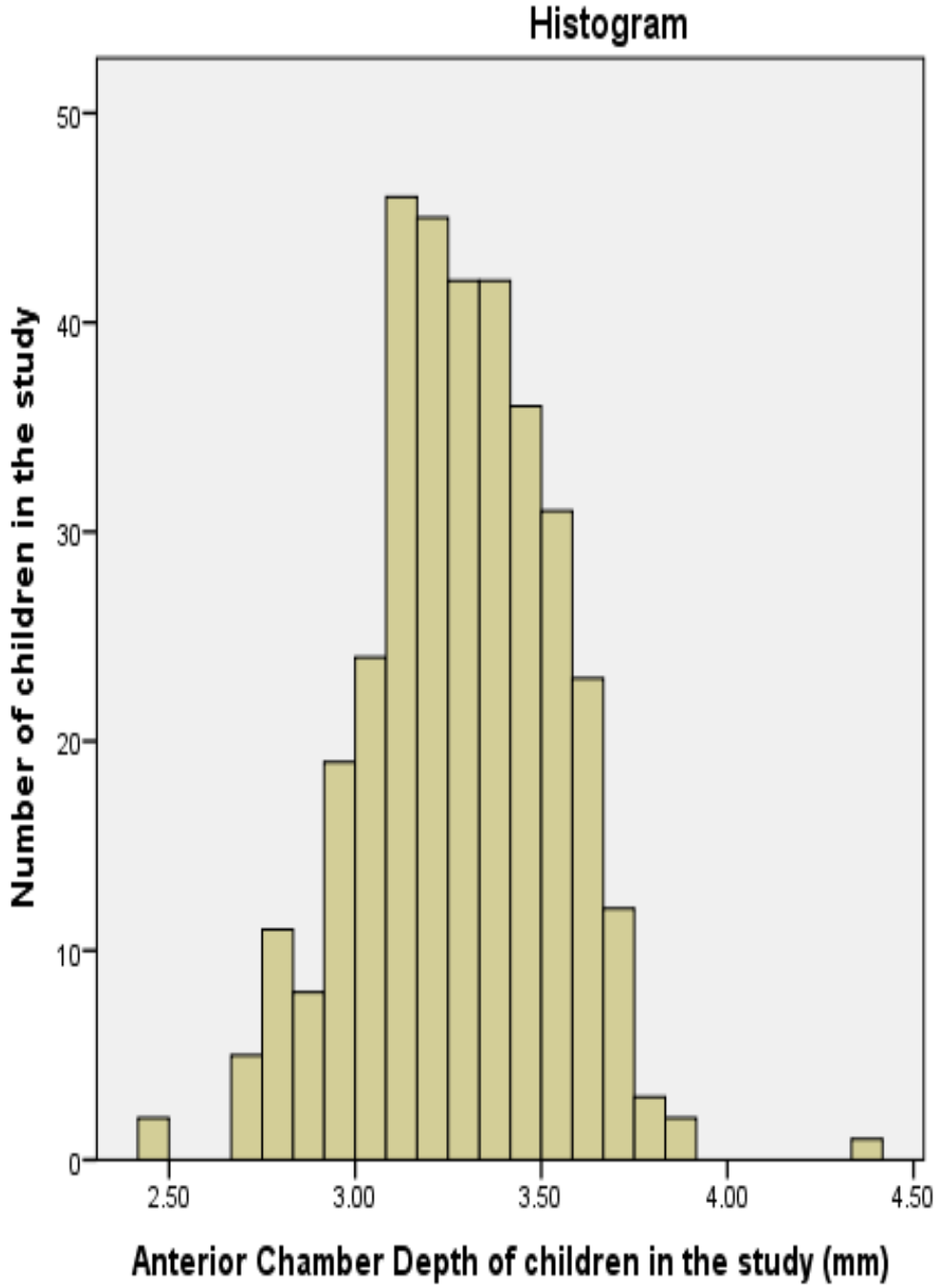

Figure 4.6: Anterior chamber depth of school children in the Ablekuma South sub-Municipality

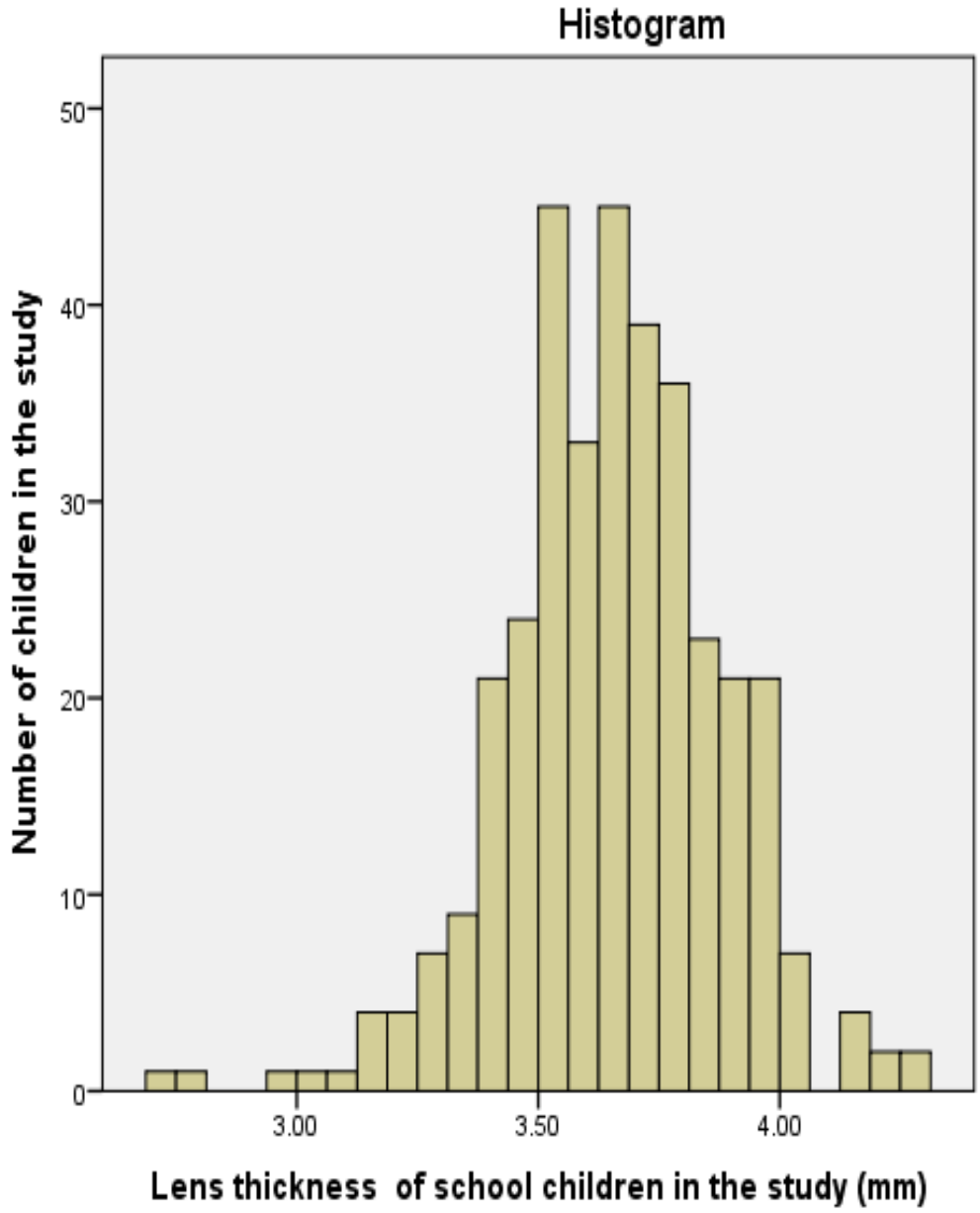

Figure 4.7: Lens thickness of school children in the Ablekuma South sub-Municipality

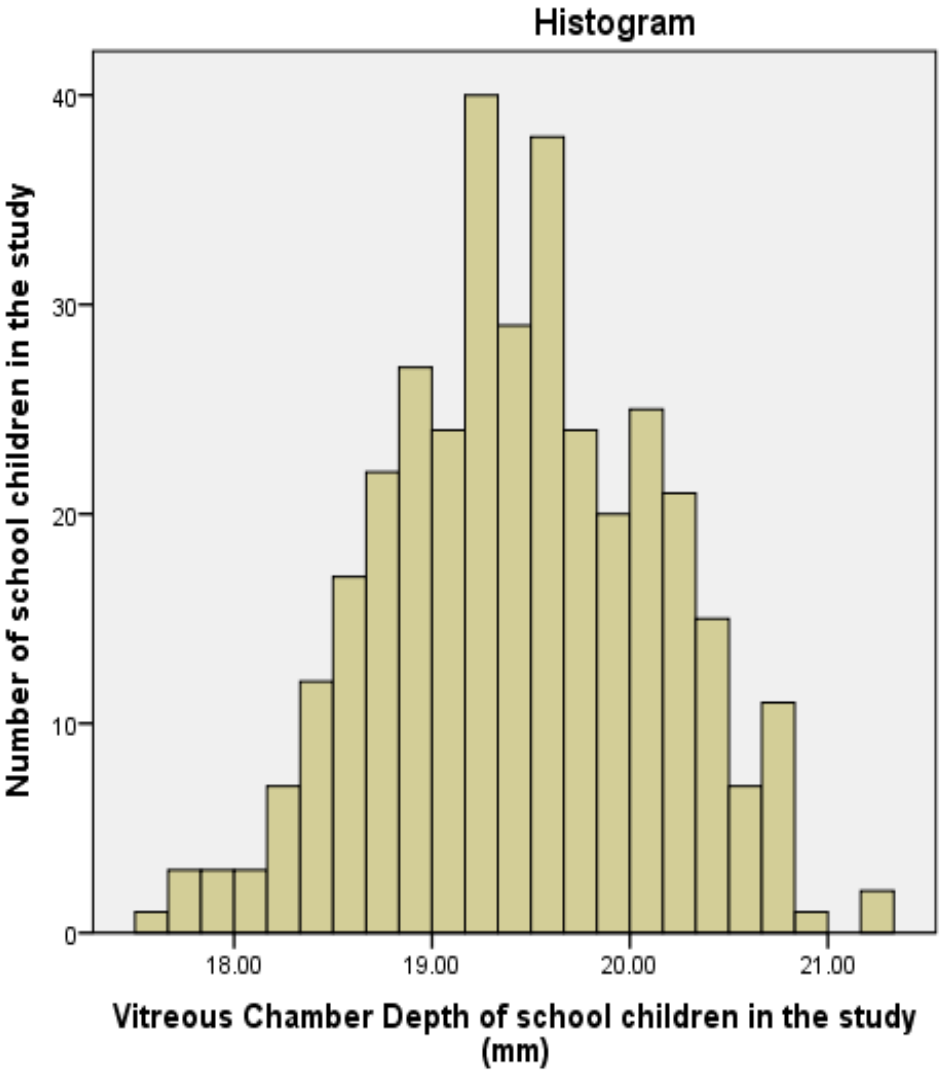

Figure 4.8: Vitreous chamber Depth of school children in the Ablekuma South sub-Municipality

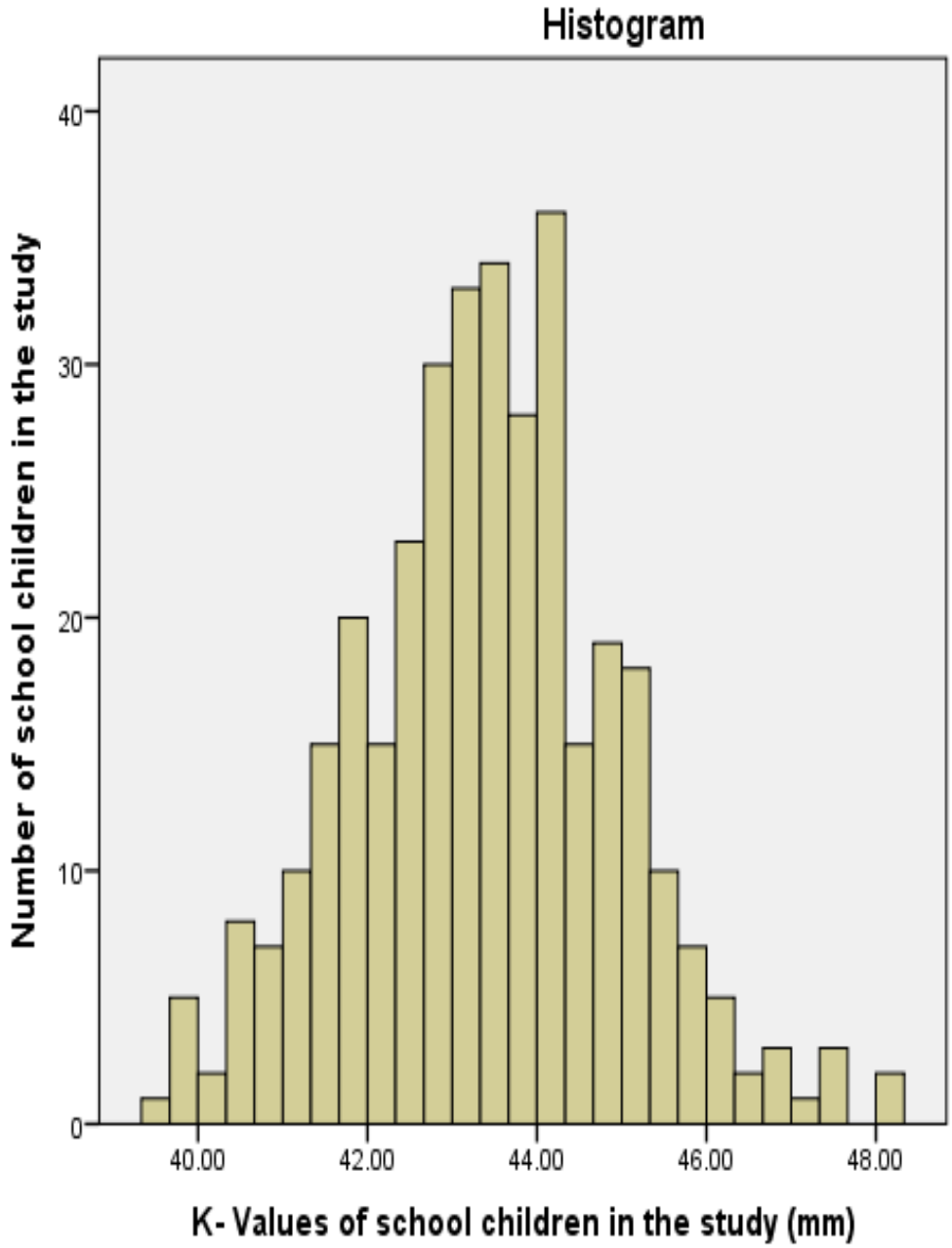

Figure 4.9: Keratometry values of school children in the Ablekuma South sub-Municipality

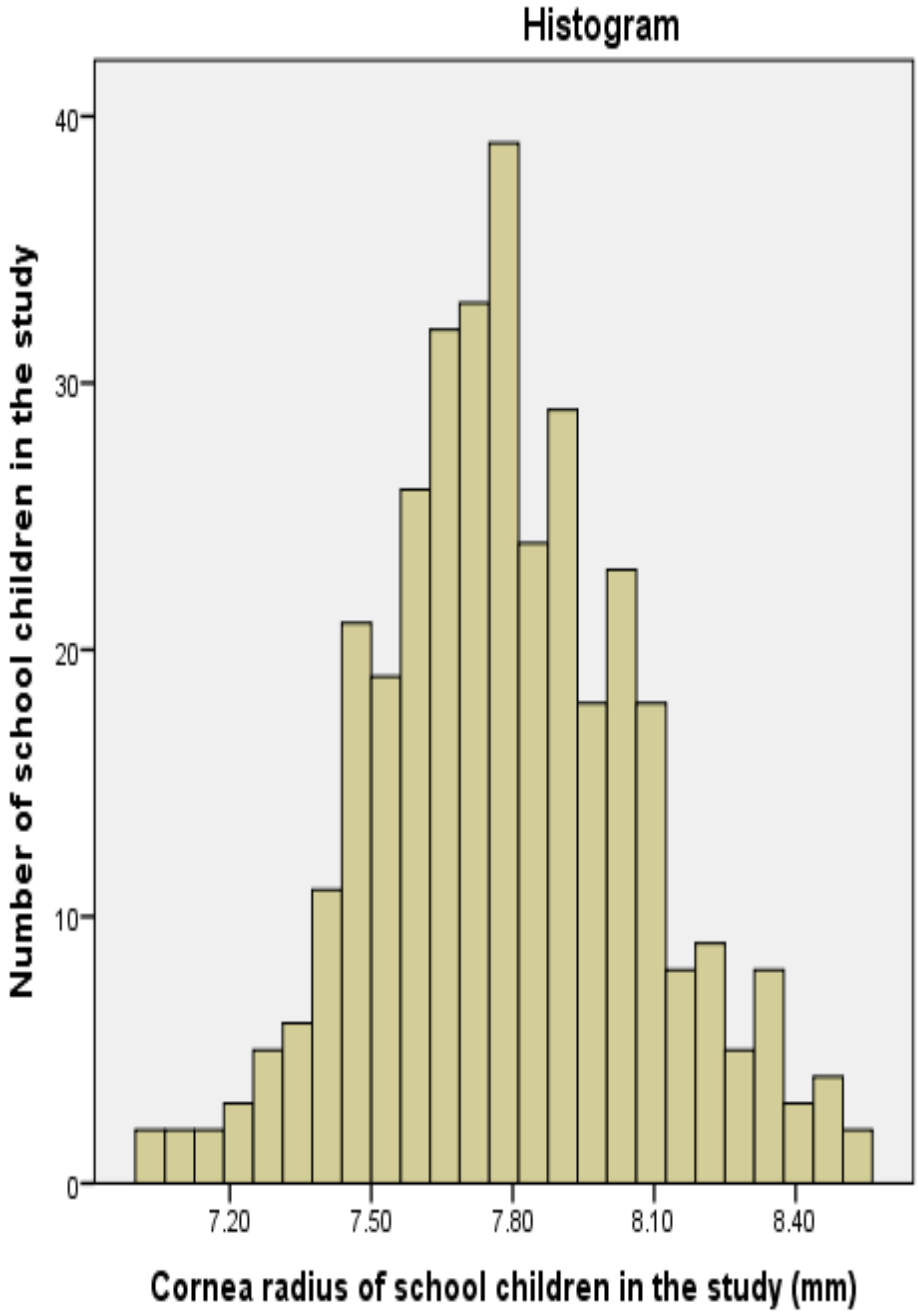

Figure 4.10: Cornea radius of school children in the Ablekuma South sub-Municipality

4.4.3. Relationship between sex and mean biometric values

The mean values of the biometric parameters are presented on Table 4.8. Using the Independent sample t-test, there was a significant difference in sex for the mean AL, ACD, VCD, K-values, CR respectively ($p < 0.05$).

Table 4.8: Correlation between mean biometric values and sex of school children in Ablekuma South sub-Municipality

Biometric Characteristics	**Sex**		**P-value**	**All**
	Male (n=157)	**Female (n=195)**		
AL (mm)	23.0±0.7	22.5±0.7	0.001*	22.7±0.7
ACD (mm)	3.3±0.2	3.2±0.2	0.001*	3.3±0.3
LT (mm)	3.7±0.2	3.6±0.2	0.248	3.7±0.2
VCD (mm)	19.7±0.7	19.3±0.7	0.001*	19.4±0.7
K-value (D)	43.1±1.6	43.6±1.5	0.001*	43.4±1.5
CR (mm)	7.8±0.3	7.7±0.3	0.001*	7.8±0.3

***Independent sample t-test.**

4.4.4. Correlation between mean biometric values and age

Using the One-Way ANOVA test, there was a significant difference in age for the mean AL, ACD, and VCD, respectively ($p < 0.05$). (Table 4.19).

Table 4.9: Correlation between mean biometric values and age of school children in Ablekuma South sub-Municipality

Biometric Characteristics	Age (years)				P-value	All
	6-8 (N=121)	9-11 (118)	12-13 (59)	14-15 (54)		(N=352)
AL (mm)	22.5±0.7	22.8±0.7	22.9±0.7	23.0±0.7	**0.001***	22.7±0.7
ACD (mm)	3.2±0.3	3.3±0.2	3.3±0.3	3.3±0.2	**0.001***	3.3±0.3
LT (mm)	3.6±0.3	3.7±0.2	3.6±0.2	3.7±0.2	**0.379**	3.7±0.2
VCD (mm)	19.3±0.7	19.4±0.6	19.6±0.7	19.7±0.7	**0.001***	19.4±0.7
K-value (D)	43.4±1.5	43.5±1.5	43.3±1.8	43.2±1.5	**0.738**	43.4±1.5
CR (mm)	7.8±0.3	7.8±0.3	7.8±0.3	7.8±0.3	**0.644**	7.8±0.3

***Statistically significance with One Way ANOVA.**

4.4.5. Relationship between demography and type of school

There was significant difference in mean age and mean BMI between private and public school. The mean age and mean BMI were higher in public schools compared to private schools. (Table 4.10).

Table 4.10: Correlation between demographic factors and type of schools

Demographics	Type of school		P-value
	Private	Public	
Mean age (mean±SD)	9.1±2.6	11.7±2.7	0.001*
Sex: Male	97(27.6)	60(17.0)	0.217
Female	133(37.8)	62(17.6)	
Mean BMI (mean±SD)	16.5±4.7	17.6±3.7	0.026*

*Independent t-test.

4.4.6. Relationship between mean axial length, cornea radius and sex, age

Table 4.11: Correlation between demographic factors and ocular biometric factors in school children at Ablekuma South sub-Municipality

Demographic characteristics	Number of participants	CR(mm) Mean (95%CI)	Number of participants	AL (mm) Mean (95%CI)
Total	352	7.79(7.76-7.82)	352	22.73(22.65-22.81)
Sex				
Male	157	7.85(7.80-7.89)	157	22.99(22.89-23.11)
Female	195	7.74(7.70-7.78)	195	22.51(22.4-22.61)
T-test		P = 0.001*; T = 3.594		P = 0.001*; T = 6.431
Age (years)				
6-8	121	7.78(7.73-7.83)	121	22.48(22.34-22.61)
9-11	118	7.77(7.72-7.82)	118	22.75(22.63-22.88)
12-13	59	7.81(7.73-7.89)	59	22.93(22.73-23.13)
14-15	54	7.82(7.74-7.90)	54	23.02(22.83-23.21)
ANOVA-test		P = 0.644; F = 0.556		P = 0.001*; F = 9.366

CR = Cornea Radius; AL = Axial Length; CI = Confidence Interval. *Significant difference.

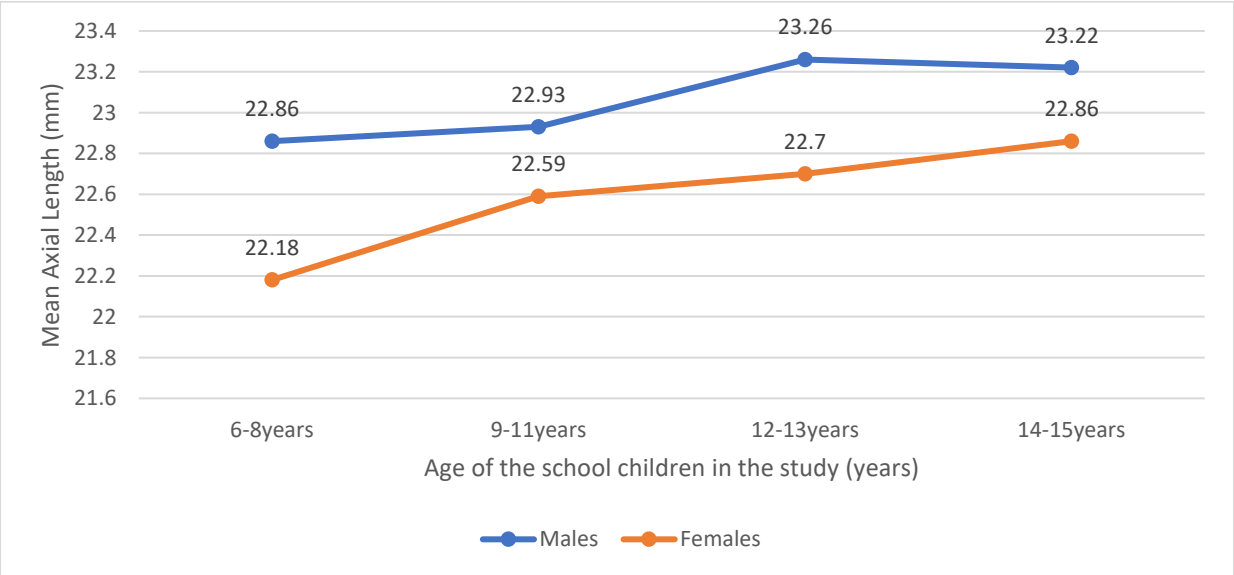

Figure 4.11: The distribution of mean axial length (mm) by age according to sex of the study population in the Ablekuma South sub-Municipality

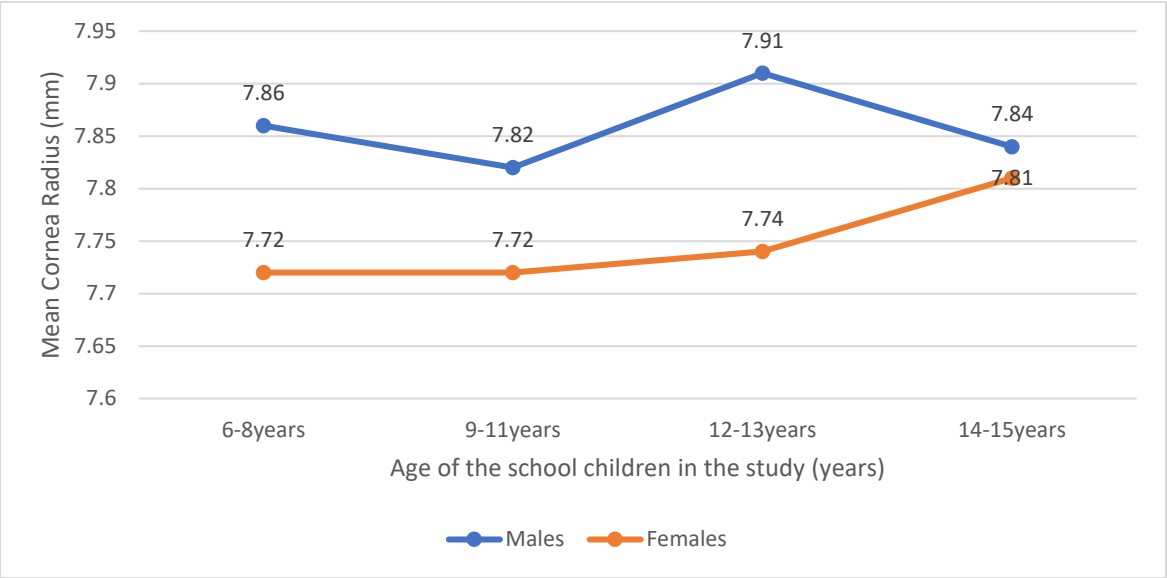

Figure4.12: The distribution of mean cornea radius (mm) by age in different sexes of school aged children in the Ablekuma South sub-Municipality

The study recorded a mean cornea radius(CR) of 7.79 mm with a range of (7.76-7.82). The cornea radius was different in males compared to females [7.85 mm (7.80-7.89) vs. 7.74 mm (7.70-7.78); P = 0.001; T = 3.594]. Males had a higher CR compared to females. The ANOVA-test did not show any significant difference in mean CR within the age groups of the children (P = 0.644; F = 0.556). Table 4.11 and Figure 4.12

The mean AL of the school children was 22.73 mm (22.65-22.81). There was a significant difference in mean AL between the males and the females [22.99 mm (22.89-23.11) vs 22.51 mm (22.4-22.61); p = 0.001; T = 6.431]. Thus, the mean AL was higher in males than in females. The ANOVA-test demonstrated a significant difference in mean AL with respect to the ages of the children (P = 0.001; F = 9.366). Table 4.11 and Figure 4.11. The results showed that as age increased among the study population, axial length also increased.

4.4.7. Relationship between mean anterior chamber depth and lens thickness with sex and age

Table 4.12: Correlation between demographic factors and ocular biometric factors in school children at Ablekuma South sub-Municipality

Demographic characteristics	Number of participants	ACD(mm) Mean (95%CI)	Number of participants	LT (mm) Mean (95%CI)
Total	352	3.28(3.26-3.31)	352	3.65(3.63-3.68)
Sex				
Male	157	3.34(3.30-3.38)	157	3.67(3.63-3.70)
Female	195	3.24(3.21-3.27)	195	3.64(3.61-3.67)
T-test		P = 0.001*; T =3.614		P = 0.248; T = 1.158
Age (years)				
6-8	121	3.20(3.15-3.25)	121	3.64(3.60-3.69)
9-11	118	3.31(3.27-3.35)	118	3.67(3.64-3.71)
12-13	59	3.34(3.27-3.40)	59	3.62(3.56-3.67)
14-15	54	3.34(3.28-3.40)	54	3.67(3.61-3.73)
ANOVA-test		P = 0.001*; F=6.447		P = 0.379; F = 1.030

ACD = Anterior Chamber Depth; LT = Lens Thickness; CI = Confidence Interval; *Significant difference.

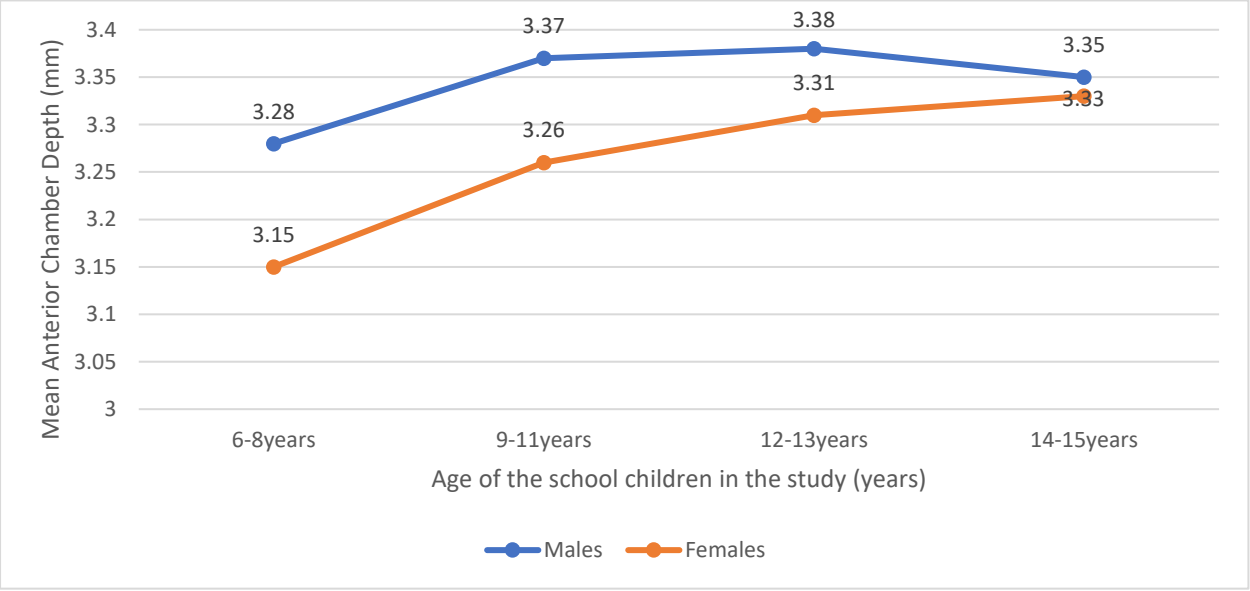

Figure 4.13: The distribution of mean anterior chamber depth (mm) by age in different sexes of the study population in the Ablekuma South sub-Municipality

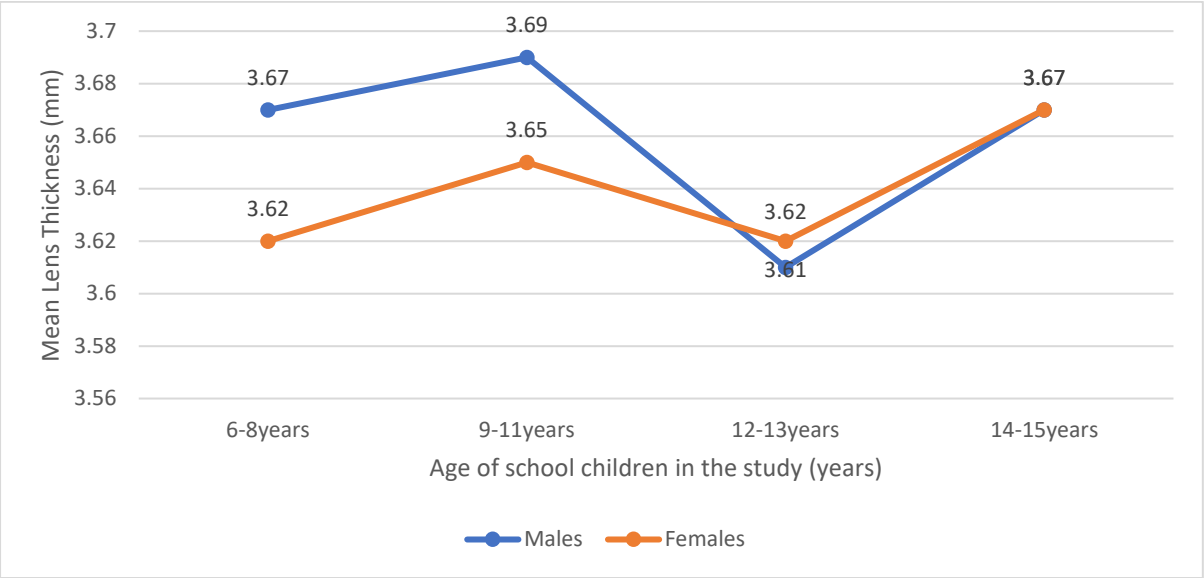

Figure 4.14: The distribution of mean lens thickness (mm) by age in different sexes of the study population in the Ablekuma South sub-Municipality

The mean ACD recorded in the study was 3.28 mm (3.26-3.31), which was significnatly different in males and females [3.34 mm (3.30-3.38) vs. 3.24 mm (3.21-3.27); p = 0.001; T =3.614]. Males have significantly higher ACD compared to females. The ANOVA-test showed a significant difference in mean ACD in terms of the age of children (P = 0.001; F=6.447). Table 4.12 and Figure 4.13.

The mean LT from the study was 3.65 mm (3.63-3.68), which was different in males compared to females [3.67 mm (3.63-3.70) vs. 3.64 mm (3.61-3.67); P = 0.248; T = 1.158]. The ANOVA-test did not show any significant difference in mean LT in terms of the age of children (P = 0.379; F = 1.030). Table 4.12 and Figure 4.14.

4.4.8. Relationship between mean vitreous chamber depth and keratometry value with sex and age

Table 4.13: Correlation between demographic factors and ocular biometric factors in school children at Ablekuma South sub-Municipality

Demographic characteristics	Number of participants	VCD(mm) Mean (95%CI)	Number of participants	K-value (D) Mean (95%CI)
Total	352	19.44(19.37-19.51)	352	43.39(43.23-43.55)
Sex				
Male	157	19.66(19.55-19.76)	157	43.06(42.82-43.31)
Female	195	19.27(19.18-19.36)	195	43.65(43.44-43.86)
T-test		P = 0.001*; T = 5.516		P = 0.001*; T = -3.604
Age (years)				
6-8	121	19.27(19.15-19.39)	121	43.41(43.14-43.68)
9-11	118	19.43(19.32-19.55)	118	43.48(43.21-43.76)
12-13	59	19.59(19.41-19.77)	59	43.30(42.84-43.75)
14-15	54	19.68(19.50-19.87)	54	43.23(42.81-43.64)
ANOVA-test		P = 0.001*; F = 5.937		P = 0.738; F = 0.420

VCD = Vitreous Chamber Depth; K-value = Keratometry value; CI = Confidece Interval; * = Significant difference.

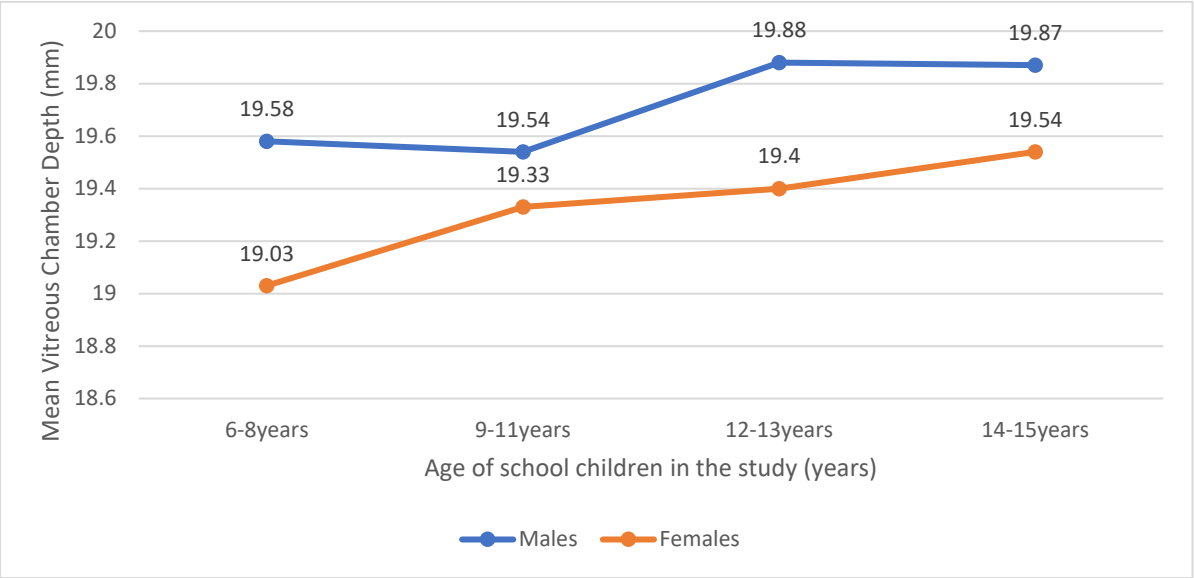

Figure 4.15: The distribution of mean vitreous chamber depth (mm) by age of school aged children in the Ablekuma South sub-Municipality

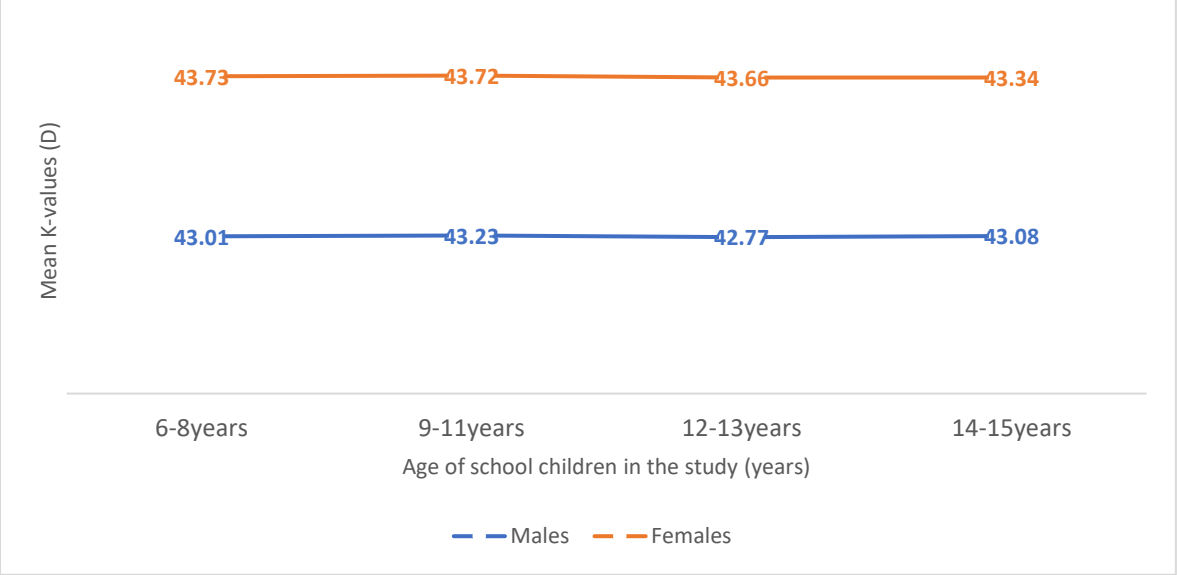

Figure 4.16: The distribution of mean Keratometry values (D) by age in school children in the Ablekuma South sub-Municipality

The mean VCD was 19.44(19.37-19.51). Vitreous chamber depth was deeper in males compared to females [3.34 mm (3.30-3.38) vs. 3.24 mm (3.21-3.27); P = 0.001; T =3.614]. The ANOVA-test showed significant differences in mean VCD in terms of the age of children (P = 0.001; F = 5.937). Table 4.13 and Figure 4.15.

The mean K-value (D) from the study was 43.39 D (43.23-43.55), which was different in males compared to females [43.06 D (42.82-43.31) vs. 43.65 D (43.44-43.86) respectively; P = 0.001; T = -3.604]. Females had sligthtly higher mean K-value compared to males. Table 4.13 and Figure 4.16

4.4.9. Scatter plots of biometric parameters and age of participants

The scatter plots showed that as age increased among the study population, axial length (fig 4.17), anterior chamber depth (Figure 4.18), vitreous chamber depth (Figure 4.20), and cornea radius (Figure 4.22) also increased, and the associations were statistically significant.

As age increases, keratometry value tend to increase. However, the increase is not statistically significant (Figure 4.21).

Lens thickness does not show any positive association with age (Figure 4.19).

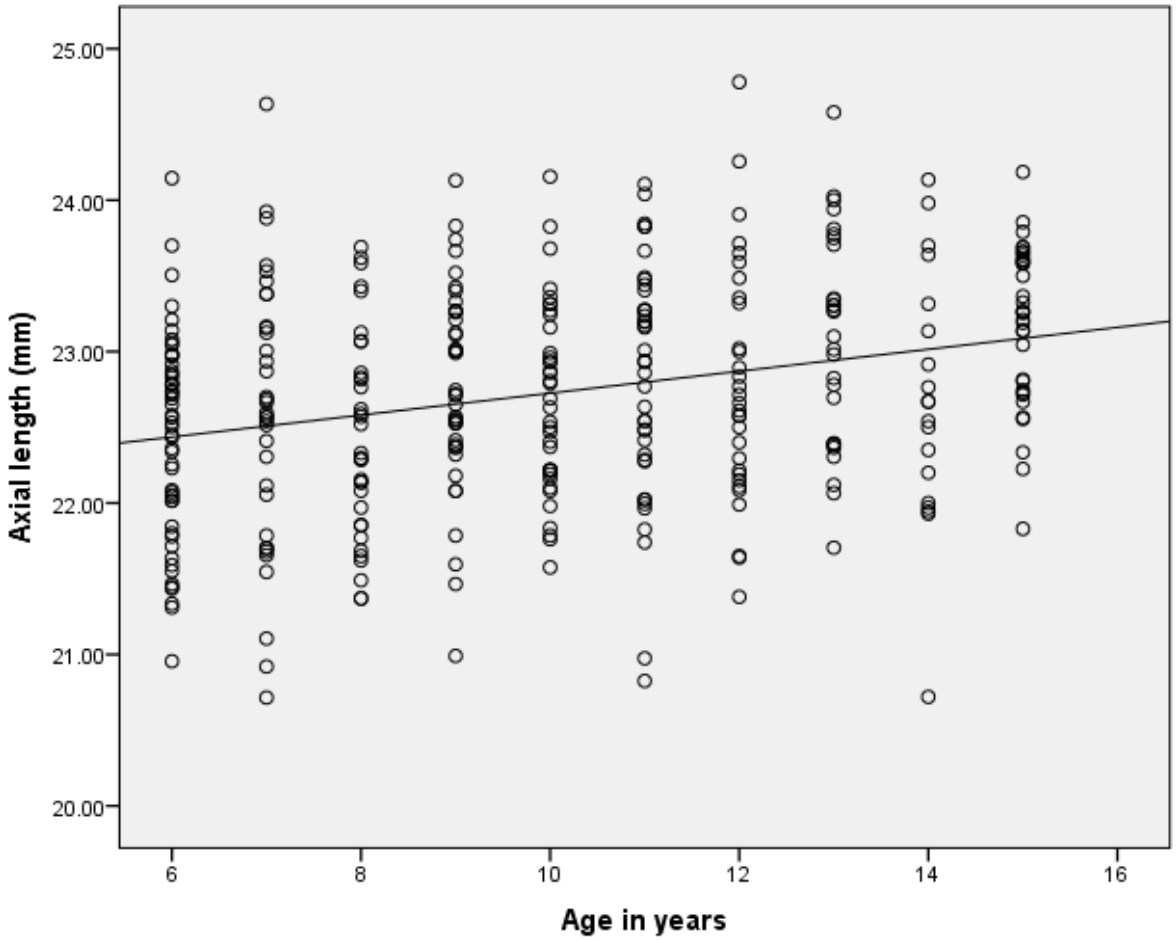

Figure 4.17: Scatter plot of axial length and age of school children in the Ablekuma South sub-Municipality

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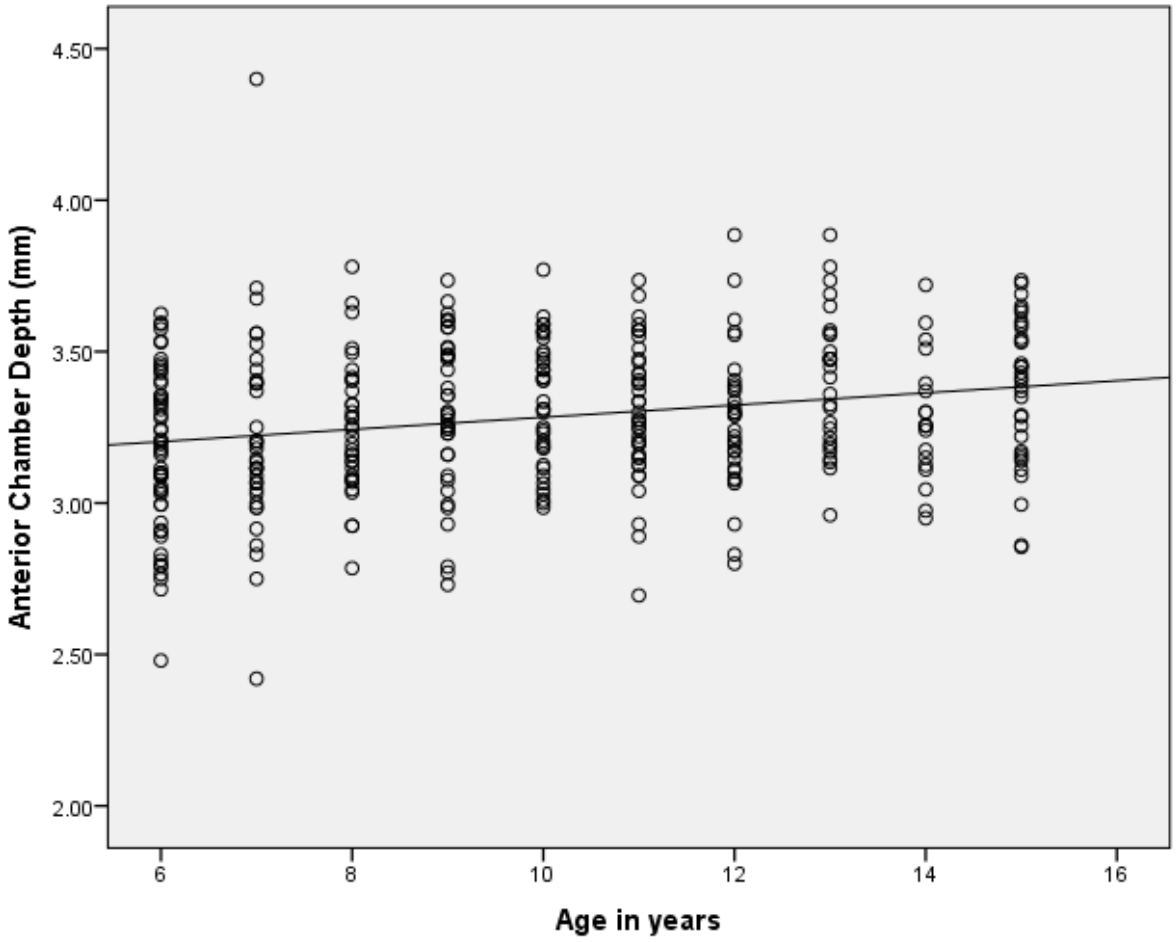

Figure 4.19: Scatter plot of anterior chamber depth and age of school children in the Ablekuma South sub-Municipality

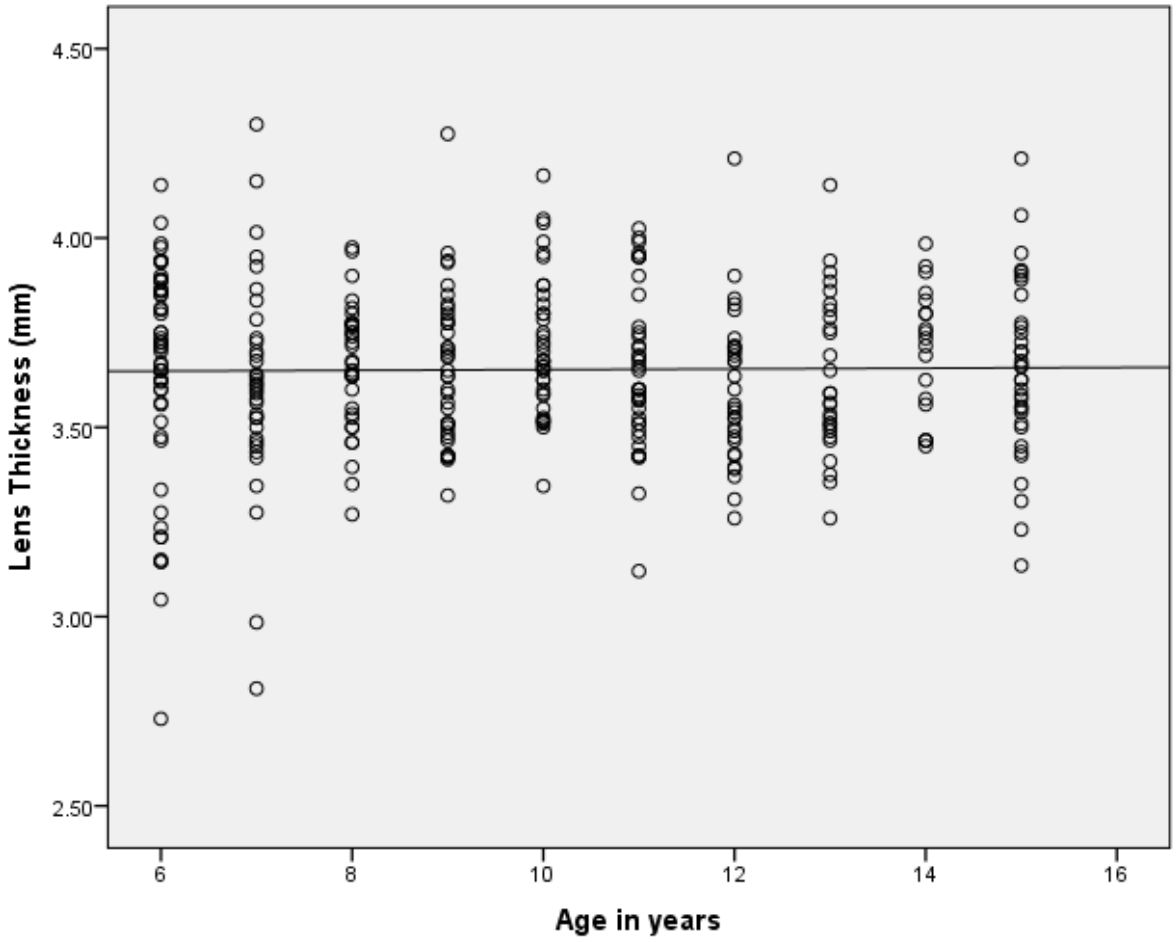

Figure 4.19: Scatter plot of lens thickness and age of school children in the Ablekuma South sub-Municipality

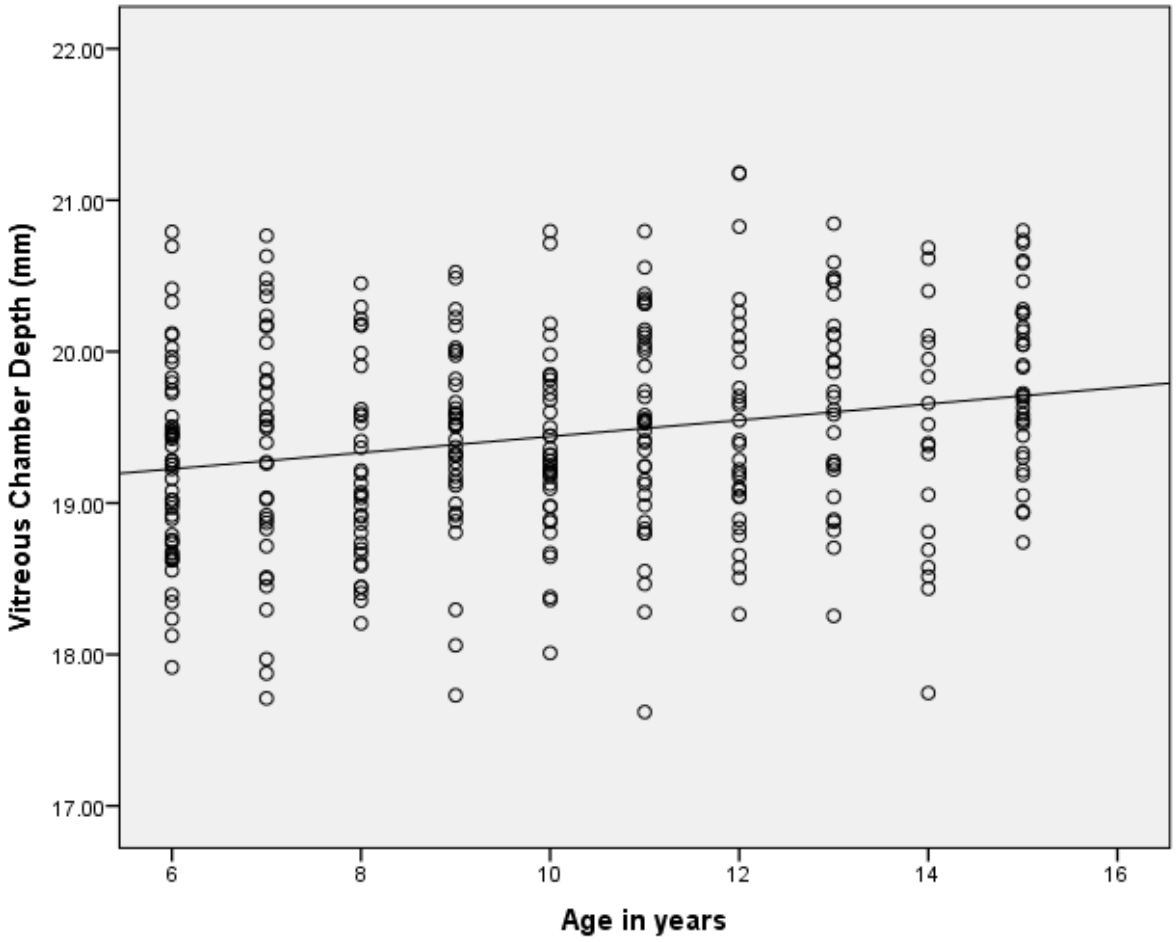

Figure 4.20: Scatter plot of vitreous chamber depth and age of school children in the Ablekuma South sub-Municipality

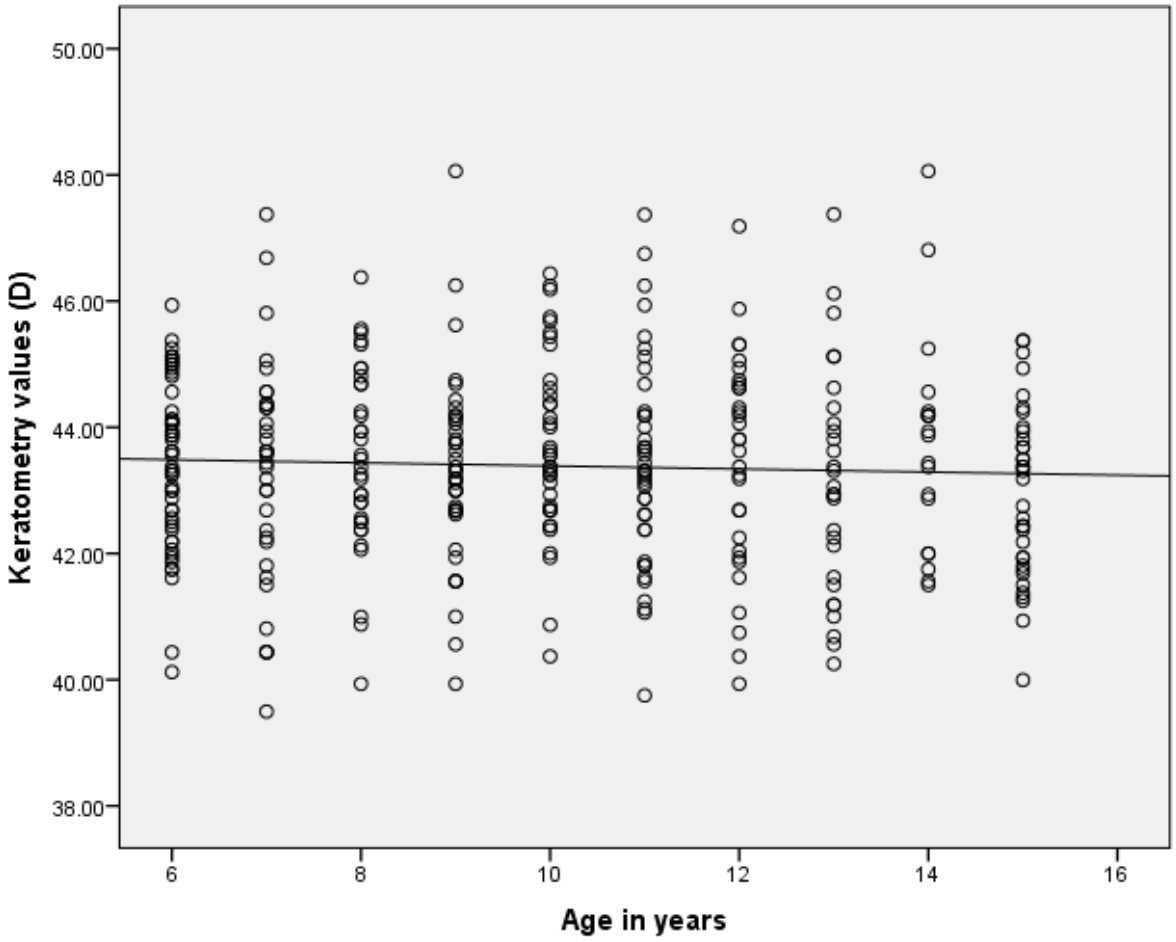

Figure 4.21: Scatter plot of keratometry values and age of school children in the Ablekuma South sub-Municipality

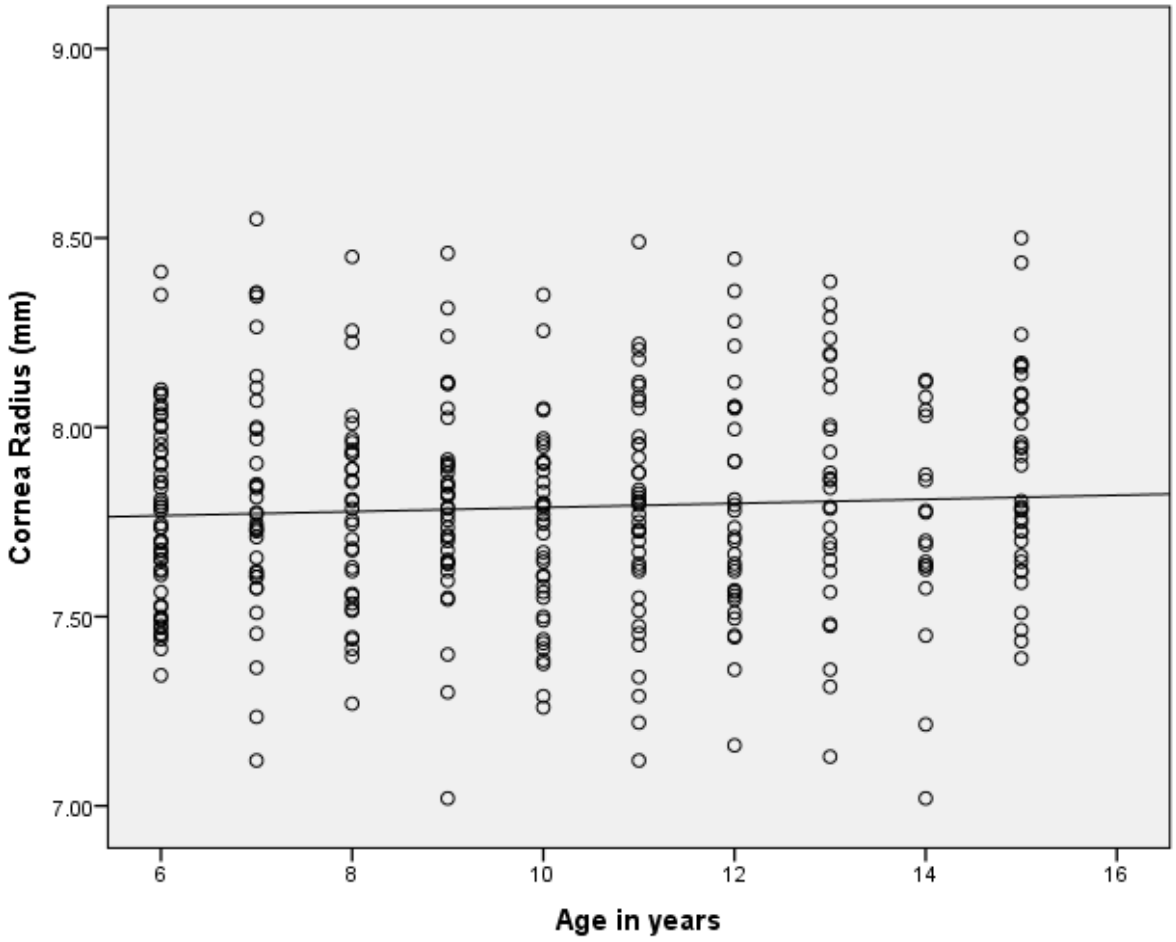

Figure 4.22: Scatter plot of cornea radius and age of school children in the Ablekuma South sub-Municipality

4.4.10. Percentiles, interquartile range, and biometric properties of the children

Mean values of the biometric properties of the school children and their corresponding percentiles are presented on Table 4.14. Axial length, ACD, VCD, K-value, and CR were normally distributed following the Kolmogorov- Smirnov test ($p > 0.05$).

Following the indices of the normal distribution (skewness and kurtosis), K-value, and CR were slightly skewed to the right direction of the normal distribution, whereas AL, ACD, LT, and VCD were negatively skewed slightly to the left. (Table 4.15).

The 95 percentiles of the mean AL, ACD, LT, VCD, K-value, and CR values in this study corresponded to 23.89 mm, 3.68 mm, 3.99 mm, 20.59 mm, 45.94 D, and 8.30 mm respectively. Thus, 95% of the mean AL, ACD, LT, VCD, K-value, and CR values in the population of the school children in the selected schools fell below 23.89 mm, 3.68 mm, 3.99 mm, 20.59 mm, 45.94 D, 8.30 mm respectively. (Table 4.14).

Table 4.14: Summary statistics of ocular biometric parameters of school children in the Ablekuma South sub-Municipality

Percentiles	Biometric characteristics					
	AL (mm)	ACD (mm)	LT (mm)	VCD (mm)	K-value (D)	CR (mm)
5%	21.48	2.83	3.28	18.33	40.72	7.35
10%	21.72	2.98	3.42	18.58	41.50	7.45
25%	22.22	3.12	3.51	18.95	42.38	7.62
50%	22.73	3.28	3.65	19.45	43.37	7.78
75%	23.27	3.47	3.80	19.96	44.31	7.97
90%	23.69	3.60	3.94	20.35	45.31	8.15
95%	23.89	3.68	3.99	20.59	45.94	8.30
IQR	1.06	0.36	0.29	1.01	1.94	0.35
Skewness	-0.11	-0.02	-0.30	-0.03	0.10	0.15
Kurtosis	-0.23	0.75	1.21	-0.33	0.10	0.01
K-S value	0.033	0.03	0.05	0.03	0.03	0.04
Significance	0.200*	0.200*	0.040	0.200*	0.200*	0.200*

AL = Axial Length; ACD = Anterior Chamber Depth; LT = Lens Thickness; VCD = Vitreous Chamber Depth; K-value = Keratometry values; CR = Cornea Radius; IQR = Inter Quartile Range; K-S = Kolmogorov- Smirnov; *Normally distributed variable.

Table 4.15: Normality test for ocular characteristics of school children in the Ablekuma South sub-Municipality

Clinical characteristics	Kolmogorov-Smirnov		
	Statistic	Degree of freedom	Significance
VA right eye	0.518	352	0.000
VA left eye	0.529	352	0.000
AL right eye	0.028	352	0.200*
AL left eye	0.047	352	0.060*
AL both eye	0.033	352	0.200*
ACD right eye	0.062	352	0.003
ACD left eye	0.053	352	0.017*
ACD both eyes	0.032	352	0.200*
LT right eye	0.087	352	0.000
LT left eye	0.076	352	0.000
LT both eyes	0.049	352	0.040
VCD right eye	0.034	352	0.200*
VCD left eye	0.029	352	0.200*
VCD both eyes	0.033	352	0.200*
K-value/OD	0.043	352	0.188*
K-value/OS	0.035	352	0.200*
K-value both eyes	0.034	352	0.200*
CR right eye	0.046	352	0.068*
CR left eye	0.036	352	0.200*
CR both eyes	0.040	352	0.200*
Refraction right eye	0.104	352	0.000
Refraction left eye	0.101	352	0.000
Refraction both eyes	0.119	352	0.000

*Normally distributed variable. AL = axial length; ACD = anterior chamber depth; LT = lens thickness; VCD = vitreous chamber depth; K-value = keratometry values; CR = cornea radius.

4.4.11. Presenting distance vision (unaided) right eye of study participants

Presenting distance visual acuities (unaided) right eye of study participants was assessed. A total of 338 (96 %) participants had normal vision at presentation. Ten (2.8 %) had mild visual impairment (worse than LogMAR 0.3 to 0.5),[60] and 4 (1.2 %) had moderate visual impairment (worse than LogMAR 0.5 to 1.0)[60] (Table 4.16, Figure 4.23).

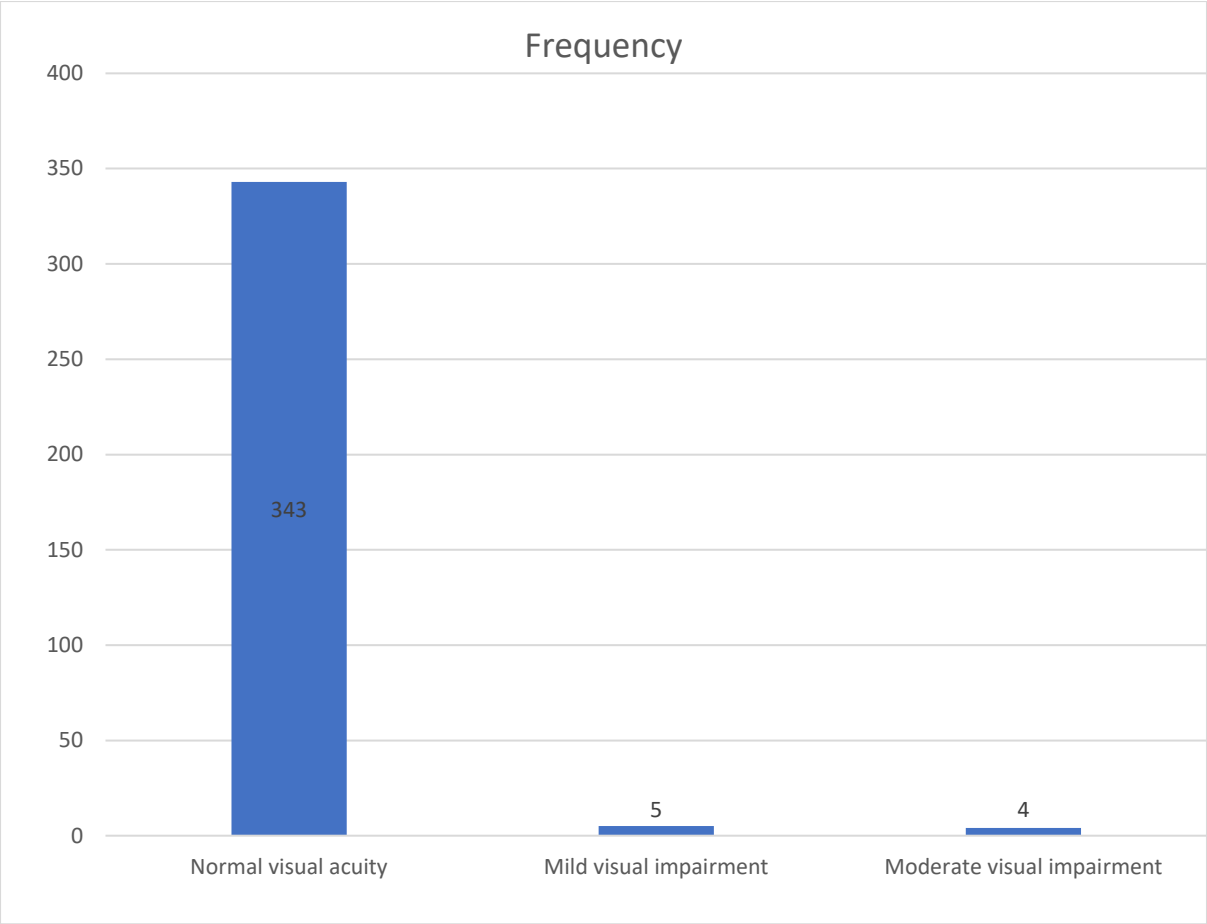

Figure 4.23: Presenting distance vision (unaided) of the right eye of study participants in the Ablekuma South sub-Municipality

4.4.12. Presenting distance vision (unaided) left eye of study participants

Presenting distance visual acuities (unaided) left eye of study participants were assessed. A total of 337 (95.7 %) participants had normal vision at presentation and 15 (4.3 %) had mild visual impairment. Figure 4.24

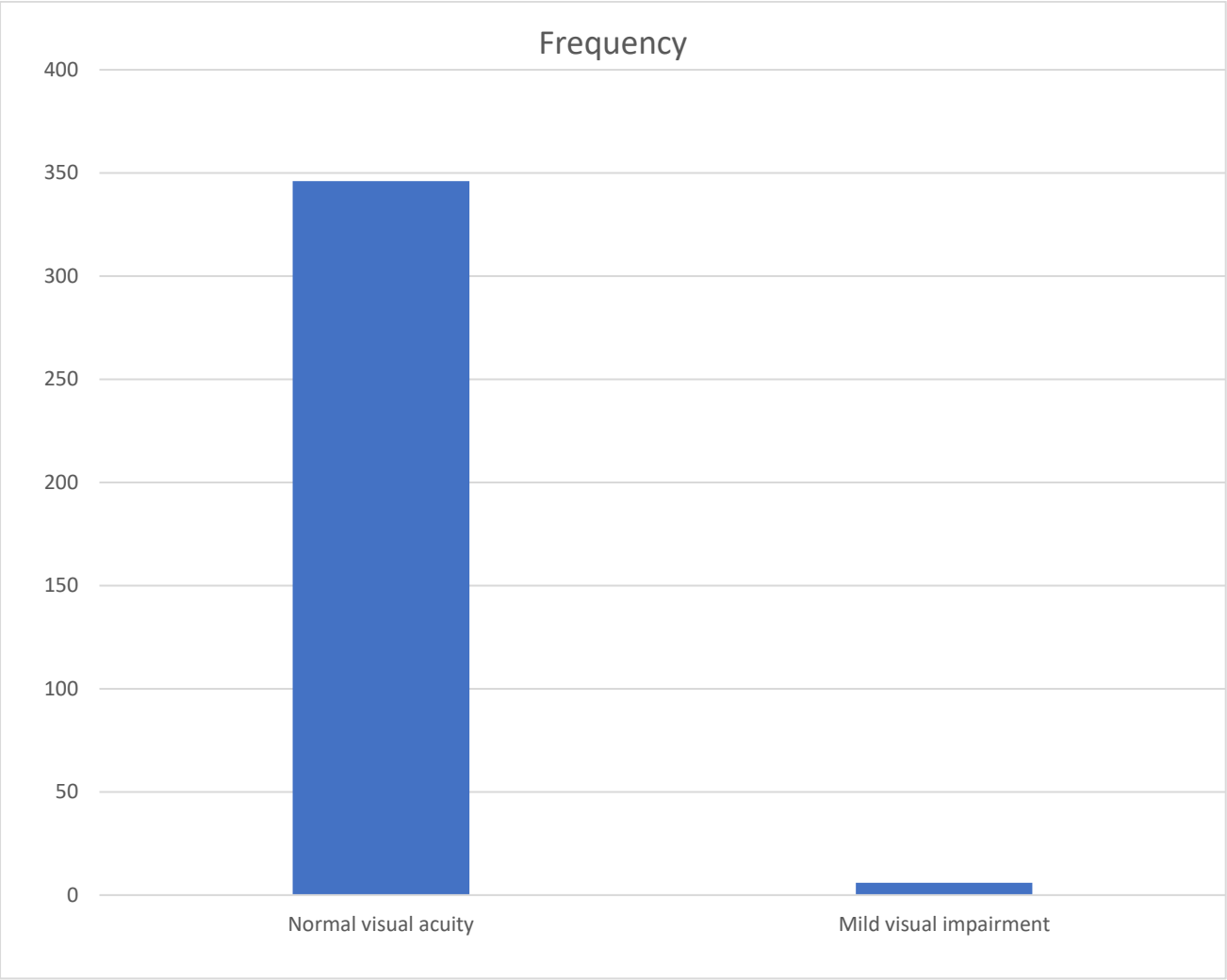

Figure 4.24: Presenting distance vision (unaided) of the left eye of study participant in the Ablekuma South sub-Municipality

Table 4.16

Table 4: Summary statistics of presenting visual acuity (unaided) of school children in Ablekuma South sub-Municipality

Statistics	OD	OS
Mean	0.03	0.02
Median	0.00	0.00
Mode	0.00	0.00
Standard deviation	0.10	0.08
Minimum	0.00	0.00
Maximum	0.78	2.00
Lower quartile	0.00	0.00
Upper quartile	0.00	0.00
Interquartile range	0.00	0.00
Skewness	4.69	4.16
Kurtosis	24.32	17.44

4.4.13. Distribution of types of refractive error among school children in the Ablekuma South sub-Municipality

Emmetropia was the main refractive state among participants with hyperopia being the least.Table 4.17

Table 4.17

Table 5Distribution of refractive errors among school children in the Ablekuma South sub-Municipality

Refractive error	Frequency	Percentage
Emmetropia	161	45.74
Myopia	121	35.38
Hyperopia	70	19.89
Total	352	100

4.4.14. 4.10.2 Relationship between ocular biometry, demography and emmetropia

Table 4.18

Table 6: Correlation between biometric parameters, demography and emmetropia in school children in the Ablekuma South sub-Municipality

Biometric characteristics	Emmetropia		
	Coefficients (β)	95% CI	P-value
AL (mm):			
Age	0.10	0.0 to 0.20	0.001*
Sex (male/female)	-0.60	-0.80 to -0.40	0.001*
Constant	23.00	22.60 to 23.40	0.001*
ACD (mm):			
Age	0.02	0.01 to 0.03	0.002*
Sex (male/female)	-0.09	-0.16 to -0.03	0.004*
Constant	3.26	3.11 to 3.41	0.001*
LT (mm):			
Age	0.0001	-0.01 to 0.01	0.986
Sex (male/female)	-0.05	-0.11 to 0.01	0.122
Constant	3.73	3.58 to 3.88	0.001*
VCD (mm):			
Age	0.05	0.02 to 0.07	0.002*
Sex (male/female)	-0.49	-0.66 to -0.32	0.001*
Constant	19.70	19.33 to 20.13	0.001*
K-value (D):			
Age	0.01	-0.05 to 0.08	0.756
Sex (male/female)	0.80	0.39 to 1.21	0.001*
Constant	42.04	41.06 to 43.01	0.001*
CR (mm):			
Age	-0.01	-0.01 to 0.01	0.879
Sex (male/female)	-0.14	-0.22 to -0.07	0.001*
Constant	8.02	7.84 to 8.20	0.001*

AL = Axial Length; ACD = Anterior Chamber Depth; LT = Lens Thickness; VCD = Vitreous Chamber Depth; K-value = Keratometry values; CR = Cornea Radius; *Significant relationship. M = Male; F = Female.

According to the multivariate regression model, among children with emmetropia, AL, ACD, and VCD increased with age. Males had longer AL, ACD, VCD than females. (This was confirmed by Figures 4.14, 4.15, 4.17).

Keratometry-values had a significant relationship with the sex. Females had higher k-values compared to males (confirmed by Figure 4.18).

Cornea radius had a statistically significant inverse relationship with the sex. Males had higher values of cornea radius compared to females (confirmed by Figure 4.19). (Table 4.12).

4.4.15. Relationship between ocular biometry, demography and myopia

Table 4.19

Table 7: Correlation between the biometric parameters, demography, and myopia in school children in Ablekuma South sub-Municipality

Biometric characteristics	Myopia		
	Coefficients	95% CI	P-value
AL (mm):			
Age	0.10	0.00 to 0.10	0.018*
Sex (male/female)	-0.30	-0.60 to -0.10	0.041*
Constant	22.60	21.90 to 23.40	0.001*
ACD (mm):			
Age	0.01	-0.01 to 0.03	0.274
Sex (male/female)	-0.15	-0.25to -0.04	0.009*
Constant	3.41	3.13 to 3.68	0.001*
LT (mm):			
Age	0.01	-0.01 to 0.02	0.652
Sex (male/female)	0.06	-0.03 to 0.15	0.165
Constant	3.50	3.29 to 3.72	0.001*
VCD (mm):			
Age	0.06	0.01 to 0.11	0.029*
Sex (male/female)	-0.14	-0.41 to 0.14	0.334
Constant	19.18	18.48 to 19.88	0.001*
K-value (D):			
Age	-0.06	-0.18 to 0.06	0.339
Sex (male/female)	0.21	-0.46 to 0.88	0.526
Constant	43.59	41.90 to 45.28	0.001*
CR (mm):			
Age	0.01	-0.01 to 0.03	0.306
Sex (male/female)	-0.05	-0.17 to 0.07	0.443
Constant	7.75	7.45 to 8.06	0.001*

AL = Axial Length; ACD = Anterior Chamber Depth; LT = Lens Thickness; VCD = Vitreous Chamber Depth; K-value = Keratometry values; CR = Cornea Radius; *Significant relationship. M = Male; F = Female.

From the multivariate regression model, among children with myopia, AL directly increased with increasing age ($p = 0.018$).

Also, among children with myopia, AL and VCD increased with age.

In children with myopia, AL and ACD were higher in males than in females

4.4.16. Relationship between ocular biometry, demography and hyperopia

Table 4.20

Table 8: Correlation between the biometric parameters, demography, and hyperopia in school children in Ablekuma South sub-Municipality

Biometric characteristics	Hyperopia Coefficients	95% CI	P-value
AL (mm):			
Age	0.10	0.00 to 0.20	0.007*
Sex (M/F)	-0.40	-0.80 to -0.10	0.046*
Constant	22.20	21.40 to 23.00	0.001*
ACD (mm):			
Age	0.05	0.02 to 0.08	0.004*
Sex (M/F)	-0.04	-0.02 to 0.12	0.600
Constant	2.89	2.57 to 3.21	0.001*
LT (mm):			
Age	0.01	-0.01 to 0.04	0.362
Sex (M/F)	-0.12	-0.25 to 0.02	0.085
Constant	3.75	3.50 to 4.02	0.001*
VCD (mm):			
Age	0.06	-0.02 to 0.15	0.147
Sex (M/F)	-0.37	-0.80 to 0.06	0.088
Constant	19.31	18.45 to 20.16	0.001*
K-value (D):			
Age	-0.13	-0.31 to 0.05	0.149
Sex (M/F)	0.41	-1.51 to 1.33	0.371
Constant	44.01	42.18 to 45.85	0.001*
CR (mm):			
Age	0.03	-0.01 to 0.06	0.136
Sex (M/F)	-0.07	-0.24 to 0.098	0.404
Constant	7.66	7.32 to 7.99	0.001*

AL = Axial Length; ACD = Anterior Chamber Depth; LT = Lens Thickness; VCD = Vitreous Chamber Depth; K-value = Keratometry values; CR = Cornea Radius; *Significant relationship. M = Male; F = Female.

The multivariate regression model showed children with hyperopia, AL directly increased as age increased (p = 0.007) but was shorter in males compared to females (p = 0.046).

4.5. Pearson correlation co-efficient analysis of the relationship between biometric and anthropometric measurements

Table 4.21

Table 9: Correlation between age, BMI and ocular biometric parameters in school children in the Ablekuma South sub-Municipality

Biometric characteristics	Age (years)			BMI (kg/m^2)		
	N	Pearson (r)	P-value	N	Pearson (r)	P-value
AL (mm)	352	0.281	0.001*	352	0.148	0.005*
ACD (mm)	352	0.228	0.001*	352	0.149	0.005*
LT (mm)	352	0.012	0.817	352	0.024	0.657
VCD (mm)	352	0.227	0.001*	352	0.109	0.041*
K-value (D)	352	-0.46	0.394	352	-0.34	0.529
CR (mm)	352	0.56	0.298	352	0.043	0.419

BMI = Body Mass Index; AL = Axial Length; ACD = Anterior Chamber Depth; LT = Lens Thickness; VCD = Vitreous Chamber Depth; K-value = Keratometry values; CR = Cornea Radius; *Significant relationship

Axial length, ACD, and VCD had a direct and significant relationship with age ($p < 0.05$). Thus, increasing age corresponded to an increase in AL, ACD, and VCD.

Axial length, ACD, and VCD had direct and significant relationship with BMI ($p < 0.05$). Thus, an increase in BMI corresponded to an increase in AL, ACD, and VCD significantly. (Table 4.15).

4.6. Correlation between ocular biometric parameters and ethnicity in the study

Eta correlation (η) showed no association between ocular biometric parameters and ethnicity in the study (η less < 0.2). (Table 4.20).

Table 4.22

Table 10: Correlation between ocular biometric parameters and ethnicity of school children in the Ablekuma South sub-Municipality

Biometric characteristics	Ethnicity		
	N	Eta correlation (η)	Strength of association
AL (mm)	352	0.167	No association
ACD (mm)	352	0.098	No association
LT (mm)	352	0.036	No association
VCD (mm)	352	0.145	No association
K-value (D)	352	0.099	No association
CR (mm)	352	0.106	No association

Note: Eta correlation (η) less than 0.2 denotes no association between ethnicity and ocular biometric characteristics.

DISCUSSION

5.1. Introduction

This final chapter links the results of all the specific objectives together to answer the main objective of the study. It probes into the meaning, importance, and the significance of the results. It focuses on explaining or interpreting and evaluating what was found, how it relates to available literature and states implications of the results in clinical practice to make an argument that will support the overall conclusion of the study. The strength and limitations of the study are the elements of the methodology that impact the interpretation of the outcome of this study. The conclusion of this chapter gives a clear understanding of the main findings and answers to the research questions. The recommendations are linked with the limitations of the study to provide suggestions for further research to be done.

This study sought to determine the normative ocular biometric values in healthy Ghanaian children aged 6-15 years in the Ablekuma South sub-Metropolitan area using ultrasound biometry. For most subspecialties in ophthalmology handling congenital conditions such as cataract, retinopathy of prematurity (ROP), glaucoma, and development abnormalities, this is an interesting area that could generate data for referencing in diagnosis and management of ocular conditions in this paediatric population.

5.2. Age distribution of study population

The mean age recorded in this study was (10.0±2.9 years) which was similar to that established by Isawumi et al[48] (9.13±3.70 years) in Nigeria and Hashemi et al[18] (9.73±1.68 years) in Iran. The age similarity to these two studies could be due to similar age brackets for most of the children in this current study.[18] However, Gul et al[46] in Turkey recorded a lower mean age of 6.54±3.42 years. The difference between our current study and that of Gul et al could be because more than one-third of the children were below 6years of age thus driving the average age to a lower number in their study.

5.3. Sex distribution of study population

In this current study there was a female preponderance of 55% of the population. The male to female ratio of the current population was 1:1.2. This current sex ratio was comparable to that of study from Nigeria that looked at ocular biometry in children, which had a gender distribution of male to female ratio of 1:1.7.[48 61] The population of this current study has a sex

ratio that is consistent with that of other studies. [28,49, 48] Our sex ratio was contrary to that of Gul et al in Turkey where the ratio of males to females was 1.7:1, with males being 115 (63%) and 67 (37%) females. Parental concern about not letting a particular sex be exposed to researchers and scientific measurements could explain differences in sex representation.[62] Other factors include research sampling methodology error where appropriate measures are not taken to ensure that equal numbers of both sexes are enrolled into the study[63] and socio-cultural factors that lead to a reduced enrolment of a particular sex into schools.[64]

5.4. Normative biometric values

5.4.1. Axial length

The mean axial length in this current study was 22.73mm. The mean axial length of this study corroborated results from some studies from Nigeria,[19,48] German in a study among children aged 4 to 17 years (22.81 mm)[49] and in Turkey (22.02mm).[46] Axial length is estimated to be around 22 to 24mm in children aged 5 to 15 years in the United States of America[4] and the results of this current study is similar to it

The mean axial length in this current study however, differed from that recorded in other studies.[18,51] A study in Iran[18] and another in Taiwan[51] both recorded higher axial lengths (23.13 mm and 24.02 mm respectively).

5.4.2. Anterior chamber depth

The mean anterior chamber depth in this current study was 3.28 mm. The mean ACD in this study was higher than what was recorded by Rauscher et al in Germany[49] and Hashemi et al in Iran.[18] The mean value however is lower than what was found by Lin et al in Taiwan (3.70mm).[51] Anterior chamber depth is estimated to be 3 to 3.5mm in children aged 5 to 15years in the United States of America[4] and results of this study corroborated their results.

Anterior chamber depth in the current study is more similar to Caussian populations than to Asian populations who have deeper anterior chamber depths.[28] These differences between our result and results from other parts of the globe could partly be attributed to genetic variations in different ethnicities.[28.,65–67] The differences in anterior chamber depth could also be atrributable to the different equipments that were used in measurements. The IOLMaster was found to measure a longer anterior chamber depth than A-scan ultrasound.[68] This difference may be due to the compression that is likely to be introduced with the use of contact A-scan measurements.[69,70] Koranyi et al demonstrated that mean ACD measured by A-scan ultrasound was shorter compared to that measured by Schiempflug imaging.[71] The sample size of the different studies may also explain partially the differences in anterior chamber depth

established in the current study compared to other studies. This study had a sample size of 352 compared to 683 from the study in Iran with ACD of 3.01mm.[18] Exposure to sunlight has been associated with a reduced rate of deepening of the anterior chamber depth.[72] Environmental and occupational factors such as near work is also known to affect ocular biometric values including anterior chamber depth.[55,73,74]

5.4.3. Lens thickness

Lens thickness is estimated to be 3.5mm at 5years and thins to 3.1mm at 10years, stabilising after that[4] in the United States of America and this value is similar to the results of this study. The mean lens thickness in this study was 3.65 mm. The mean of this study was similar to what was measured in Iran[18] and Turkey.[46] Racial differences in lens thickness was demonstrated by Twelker et al in a study that compared ocular biometry among children from different ethnicities which showed that black childrren had a mean lens thickness of 3.48mm compared to lens thickness of 3.51mm in Caucassian children, while Asian children had the thinnest lenses with a mean of 3.28mm.[28]

The difference in our mean lens thickness and other study results could also be due to the methods of measurements. A-scan ultrasound measurements has been found to vary from results of measurements by anterior segment optical coherence tomography.[75] Some studies have also shown that cycloplegia causes a decrease in lens thickness,[76] however in this study the ultrasound mesurements were taken immediately after the cycloplegic drop was applied and thus not likely to have had an effect on the lens thickness since the onset of action is between 15 to 30 miutes and also onset is relatively later in heavly pigmented irides[77] as was present in our study population.

5.4.4. Vitreous chamber depth

Paediatric vitreous chamber depth is estimated to be 17mm at 5 years and 19mm at 10 years[4] in American paediatric population and corroborated with the results of this current study. In this current study, the mean vitreous chamber was 19.44mm. Results of this study is similar to that measured in black children by Twelker et al.[28] The mean VCD of this study was also higher than what was found in Caucasian children in the study by Twelker et al,[28] and Gul et al.[46] These differences could be attributed to racial differences among populations.[28, 45, 78] Environmental factors such as exposure to sunlight, and outdoor play have been shown to mitigate against excess elongation of vitreous chamber depth.[72] This effect is thought to be due to the release of dopamine in the retina when a person is exposed to sunlight which inhibits excessive elongation of the globe.[79, 80] Occupational factors such as constant near work has

also been shown to cause elongation of vitreous chamber depth.[73] Methods of measurement of vitreous chamber depth can also partly explain the differences between our mean vitreous chamber depth and that of other studies.[81] Different methods of measurement affects results, ultrasound values are statistically significant from results obtained using swept source OCT measurement.[82,83] Genetic factors have also been postulated to be part of the reason why differences in vitreous chamber depth within and between populations exist, for example why Asians have longer vitreous chamber depths than Caucasians and Blacks.[53]

5.4.5. Cornea radius

The average cornea radius is estimated at 7.8mm at 5years and increases to 8.0mm at 12years[4] in American children and was similar to what this study measured. This study recorded a mean cornea radius of 7.79 mm. Results of this study was comparable to the results of an Iranian (7.77mm).[18] Our results also differed from results of other studies[84–86] These differences could be explained by several factors including race.[87–89] Genetic factors affect the radius of the cornea. Children who genetically have bigger body structures tend to have larger flatter, longer cornea and vice versa.[108-110] Nutritional factors have also been postulated to be one of the factors for variability in cornea radius within and between populations. Generally, paediatric populations that have poor nutritional status tend to have lower weights and heights and this will in turn lead to smaller, more curved cornea and vice versa.[90] Vitamin A and riboflavin are important for corneal health and development, thus deficiencies in these nutrients could affect corneal development and curvature.[85,90,91] The equipment used in measuring the cornea radius in a study could partly explain the variability found in study results. Sayantan et al showed that different equipment gave different results when used to check for repeatability.[92]

5.4.6. Keratometry value

Average paediatric K-value is estimated to be 43-45D at 5years of age and 42-44D at 10years of age.[4] The mean K-value for this study was 43.39 D. This mean was lower than that of Caucasian children (43.93D) but higher than that of African American children (42.50D) in a study in United States of America.[28] Twelker's study looked at ocular biometry in chidren from different ethnicities.[28] Racial differences could partly account for the difference in our mean K-value compared to other studies, as shown by Twelker et al[28] where children from different races exposed to similar environmental and geograhical conditions demonstrated significantly different K-values. Nutritional factors have also been suggested to affect K-values.[85, 90, 91] Deficieny in vitamin A and riboflavin have been shown to affect cornea development,[85,90] thus this affect children from sub-Saharan Africa where nutritional deficiencies are commoner. [93,94]

The measurement methods used in different studies may also influence the means among populations in different studies.[92]

5.5. Relationship between demographic characteristics and ocular biometric parameters

5.5.1. Axial length and Age

Although this current study had a similar age distribution (6-15 years) compared to the study from Taiwan (7-15 years),[51] the outcomes of the mean axial length show some differences which may be explained by other factors such as the sample size used as well as the demographic structure of the two populations. This current study had a lower sample size of 352 children whiles the Taiwanese study had 10,882participants.

Differences in the method of measurement of the axial length may also account for these variations. For example, reported studies in the literature used A-scan ultra-sonography,[95] Compact touch AB Scan Biometer,[96] IOL master, LENSTAR/BioGraph,[97] and Alladdin optical biometer[27] in measuring the axial lengths. However, the use of the A-scan ultrasound method is known to decrease axial length values by an average of 0.24 mm compared with the immersion method.[98] Thus, the use of the A-scan may introduce a risk of axial length measurement errors from corneal compression. In another study, Ben-Zion et al[99] compared immersion and contact axial length measurement in children and recorded an axial length of 21.20 mm in the contact group compared to the 22.26 mm in immersion group, the difference being significantly ($P = 0.0015$). Also, axial length measurements with the contact method had an average of 0.27 mm shorter compared to the immersion method.[98] This situation may occur as the probe touches the cornea in the contact method which may result in corneal compression. The findings from this current study are important in that the measurement of axial length in ophthalmic biometry plays a crucial role in the management and diagnosis of some ophthalmic conditions. For example, to diagnose and prevent ocular abnormalities such as progressive axial myopia[100,] and changes in choroidal thickness, the use of a normative data for a paediatric axial length is key to supporting ophthalmologists in diagnosing and monitoring such conditions including congenital glaucoma. The deterioration of the optic nerves in glaucomatous eyes occurs alongside elongation of the axial length. Therefore, observing changes in the axial length when compared to normative data could serve as an additional tool in the management of avoidable blinding ocular complications.

Axial length has been shown to increase with increasing age.[4] Results of the current study agreed with this observation. This has also been confirmed in several studies [REFS]. A study

from China showed axial length to be 1.7mm longer in 14-year-olds compared to 7-year-olds.[58] Studies from Nigeria,[48]Australia,[24] United States of America,[28] Germany[49] have all confirmed this observation.

Although variations in measurement techniques exist among studies, a systematic review of 27 studies showed that axial length increases rapidly in infancy and plateaus around age 2.[101] The early years of development is a critical period for visual development during which visual centres are highly plastic and responsive to sensory input.[102] During this period the axial length must grow proportionally to ensure that images are focused precisely on the retina to facilitate normal visual development. This may explain the significant changes in the rate of change in axial length in the early years with the rate slowing down in adolescence.[18,24] The findings of the average axial length in different age groups in this study can also be used as a guide to identify children who are at risk of axial myopia and its attendant complications. These children can be monitored to identify complications early and manage them appropriately to prevent visual loss. Additionally, the average axial length in the different age groups in this study can serve as a reference lens power estimation for cataract surgery where the required equipment for measurement may not be available.

5.5.2. Anterior chamber depth and Age

Anterior chamber depth has been observed to increase with increasing age. In this study, anterior chamber depth increased with increasing age. In our study, ACD increased by 0.05mm per year compared to a study by Rauscher et al in Germany, where ACD increased by 0.047mm per year (p-value:0.00).[49] Our results also corroborates results from Taiwan,[51] Iran,[18] United States of America,[29] and Turkey.[46] Anterior chamber depth is considered to make an important contribution to axial length. Axial length's ubiquitous increment with increasing age comes with increment in anterior chamber depths as well.[103,104] This is what was observed in this study. Growth of the dimensions of the eye including axial length occurs alongside general body growth. [105]As children grow, their anterior chamber depths grow with them; thus, this may explain the pattern of anterior chamber deepening observed in this study. Anterior chamber depth is closely related to the axial length, a high anterior chamber depth may be indicative of axial myopia helping in diagnosis.[103]

5.5.3. Lens thickness and Age

Lens thickness tends to thin with age stabilizing in later childhood.[4] This study found no consistent pattern of increase or decrease in lens thickness with age. Our results differed from that of Twelker in the United States of America,[28] Rauscher in Germany,[49] Lin in Taiwan[51] and

Hashemi in Iran,[18] in which lens thickness decreased with age and stabilised after age 10. The lack of a consistent pattern in our study could be attribued to racial differences on our study population as compared to Asian populations who have a decreasing lens thickness with age.[51, 106] Mutti et al in their study on lens growth in children postulated a mechanical model whereby increasing axial length with age occurs together with equatorial expansion which leads to thinning and flattening of the lens.[107–109] The aim of this process is to achieve emmetropisation. The increasing axial length predisposes to myopia, and this is counteracted by decreasing lens power as the lens thins and flattens. Thus, based on this postulated model, the eye has interacting signals which work together to optimize lens thinning with the elongating globe to achieve a refractive state of emmetropia.[107–110] This process may not always be optimised, and children may end up with hyperopia or myopia.[111]

5.5.4. Vitreous chamber depth and Age

Vitreous chamber depth is known to increase with increasing age,[4] a finding that is corroborated by this current study. . Results of this current also agreed with what was observed in the CLEERE study from the United States of America,[28] a study from Germany,[49] Zadnik et al,[112] Gul et al in Turkey.[61] The vitreous chamber depth makes up the majority of the axial length of the eye.[49,109]Thus, as axial length increases with increasing age, vitreous chamber depth also increases in depth with increasing age.[113,114] As children grow, certain hormones including insulin-like growth factor-1(IGF-1) act on the eye to cause elongation of the globe and this also contributes to the deepening of the vitreous chamber with age.[56] In children, the sclera and extracellular matrix composition, particularly the type and arrangement of collagen fibres affect the eye's ability to stretch and lead to elongation of the globe as well as vitreous chamber depth.[115] The vitreous chamber depth is a proxy for axial length[116] and thus knowledge of this value is important in ocular pathologies such as congenital glaucoma, axial myopia and treatment of paediatric cataracts.

5.5.5. Cornea radius and age

Cornea radius is known not to change significantly after 2years of age.[4] In this current study, the cornea radius increased very marginally from age 6 through to age 15. There was no statistically significant relationship between age and cornea radius. Our results were comparable to the results of studies from Taiwan,[51] Iran,[18] United States of America,[29,108] Germany[49]This observation may be due to the finding that children generally achieve the adult dimensions of cornea radius after two years of age.[107–109] Thus, the changes that take place after this age are not significant in magnitude as compared with changes with axial length and

lens thickness, hence the lack of correlation[60, 117,118] It is believed that the cornea achieves adult dimensions early in childhood in order to enhance the formation of clear retinal images to promote visual maturation and prevent amblyopia.[21]Extremes of cornea radius maybe indicative of pathologies such as congenital glaucoma or microphthalmos, thus important in diagnosing and managing these conditions.

5.5.6. Keratometry value and age

The K-value among the study population in this current study did not show a statistically significant relationship with age. Our results was comparable to what was found by Twelker et al[28] and Zadnik et al in the United States of America.[112] The K-values in children have been shown to largely stabilize quite early in childhood around 2years and thus may explain the lack of correlation between K-value and increasing age in this study.[117, 118] This stabilisation of the cornea dioptric power in the early years may be necessary for the process of maturation of the visual centre.[21] The cornea contributes two-thirds of the refractive power of the eye[119] thus it helps in the formation of clear images early which prevent amblyopia. Knowledge of the cornea dioptric power in different age groups in Ghanaian children could help to clinically identify and manage children presenting with abnormal values in conditions such as keratoconus.

5.6. Relationship between Ocular biometry and sex

5.6.1. Axial length and Sex

Generally, axial length has been shown to be longer in males compared to females of the same population.[4] The results of this current study showed that boys had a longer mean axial length of 22.78±0.71mm while girls had a mean axial length of 22.70±0.78mm and the difference was statistically significant, p = 0.001. Our results was comparable to the results of most published literature including that from Nigeria,[19] China,[58] studies by Twelker et al[28] and Zadnik et al[112] in the United States of America, Lin et al in Taiwan,[51] Rauscher et al in Germany,[49] Gul et al in Turkey,[61] and Hashemi et al in Iran.[18] This difference between the two sexes has been partly attributed to genetic differences that generally make males taller compared to females.[52] Beyond the X and Y-chromosomes determining sex, variations in genes associated with growth and development manifest differently in males and females, and these factors cause the rapid physical growth seen in males compared to females even before puberty.[50,52] These genetic influences are also believed to express in the eye and lead to males having longer axial lengths than females.[53,52] Males and females exhibit different growth rates even before puberty due to the levels of sex hormones like testosterone and oestrogen, and this is believed to also affect ocular development.[54] Oestrogen in girls is thought to protect against elongation of the globe

while testosterone is believed to promote elongation of the globe.[55] Other hormones such as insulin-like growth factors (IGF) have been shown to contribute to the difference in axial length in males and females. Variations in IGF levels and sensitivity between boys and girls contribute to the differences in axial length.[56] An interplay of these factors therefore lead to longer axial lengths in males compared to females. Thus, clinically in a female whose axial length is excessively high there is the need for further investigations to rule out axial myopia in order to treat appropriately.

5.6.2. Anterior chamber depth and Sex

Anterior chamber depth has been observed, generally, to be longer in males compared to females.[18] For this current study, the ACD was 3.24 mm (3.21-3.27) in females, but longer at 3.34mm(3.30-3.38) in males with the difference between the sexes being statistically significant[58](p=0.001). Our result was similar to that of Rauscher et al,[49] Zadnik[112] et al and Twelker et al [28] in the United States of America, Gul et al in Turkey.[61] These results have been partly attributed to the positive correlation between axial length and anterior chamber depth in males where anterior chamber depth increases as axial length becomes longer. Factors including genetic,[50,52] sex hormones[55,54] and growth hormone influences[56] that were mentioned earlier for axial length are responsible for this finding between sex and anterior chamber depth. Clinically, a female whose anterior chamber depth is excessively high there is the need for further investigations to rule out axial myopia in order to treat appropriately.

5.6.3. Lens thickness and Sex

In this current study the lens thickness of boys was slightly higher at 3.67mm(3.63-3.70) compared to girls at 3.64mm (3.61-3.67) but this difference was not statistically significant. Our results were opposite to that of a Chinese study by Li et al,[58] Rauscher et al in Germany[49] and Lin et al in Taiwan[51] who found that lens thickness was higher in females than in males. Our results were like what was found in the United States of America by Twelker et al[28] as well as Zadnik et al[112] and Gul et al in Turkey.[61] The finding concerning gender's influence on lens thickness in this study agrees with most other prior studies, where there is no statistically significant difference between the two genders. Lens thickness even though it contributes to the process of emmetropisation, it may not be the most important factor, when compared to axial length and cornea power.[120] This may be the reason for the lack of a significant relationship between lens thickness and sex that was found in this study. Further study is recommended to substantiate this postulation in the Ghanaian paediatric population.

5.6.4. Vitreous chamber depth and Sex

Vitreous chamber depth is longer in males compared to females.[18] Vitreous chamber depth in males was 19.66mm(19.55-19.76) and in females was 19.27mm(19.18-19.36) in the current study. The difference between the two sexes being statistically significant,p=0.001. Our resluts were similar to that of the CLEERE study in the United States of America,[28] Isawumi et al in Nigeria,[48] Rauscher et al in Germany,[49] Zadnik et al in the United States of America,[112] Hashemi et al in Iran[18],[18] Gul et al in Turkey,[61] and Li et al in China.[58] Vitreous chamber depth has been identified to be the major contributor to the axial length of the eye.[121] Axial length is generally longer in males compared to females, mainly because of genetic, hormonal and growth factors [105].[53, 52, 122], these factors lead to a deeper vitreous chamber depth in males compared to females as was observed in this current study and other studies. This comes about since the higher levels of growth hormones and elongating effect of testosterone causes the vitreous chamber depth to grow at a faster rate in males than in females.[50, 123]

5.6.5. Cornea radius and Sex

Cornea radius is generally shorter in females compared to males of the same age.[4] In this study males had a mean cornea radius of 7.85mm(7.80-7.89) , while the females had a mean cornea radius of 7.74mm(7.70-7.78), being 0.11mm longer in boys with the difference being statistically significant. The results of this study is similar to findings from China which demonstrated that boys had average cornea radius that was 0.14mm longer,[58] Taiwan,[51] and Germany by Rauscher et al.[49] The difference in cornea radius between males and females can be attributed to the fact that the eye is regulated to achieve an emmetropic state. Since males generally have longer eyes, their corneas tend to be flatter to reduce its refractive power so that images will fall on the retina.[121, 124] Girls have comparatively shorter axial length due to genetic and hormonal factors and thus tend to have shorter corneas that provide higher refractive power to ensure images fall on the retina.[50 116 ,117, 124, 103] A female with a relatively longer cornea radius may be at risk of hyperopia while a male with a relatively shorter cornea radius cornea radius will be at risk of myopia thus warranting further investigation in both cases in order to optimise vision.

5.6.6. Keratometry-value and Sex

Females generally have higher K-value compared to males of the same age.[58] Keratometry - value in maless was 43.06D(42.82-43.31), and in femaless was 43.65D(43.44-43.86) in this study. The difference between males and females was statistically significant(p = 0.001). Results in this study corroborate study results from the United States of America,[28,112] and by

Hashemi et al in Iran.[18] The K-value of the cornea is directly related to the cornea radius of the eye, thus longer cornea radius observed in males, lead to less cornea power compared to girls [53].[125, 121,] Oestrogen has been shown to lead to thicker and more curved cornea in females compared to males who have relatively lower levels of oestrogen and therefore flatter thinner cornea.[126] Sexual dimorphism predisposes males to grow larger bodily dimensions due to their increased sensitivity to growth hormones like IGF which leads to flatter cornea and lower K-values in them. [105,53] These factors therefore interact together to cause higher K-values in females compared to males. Males who record keratometry values that are excessively higher than what is normal for their demographic group may be at risk of pathologies such as keratoconus and thus will need investigation and diagnosis to aid treatment.

5.6.7. Ocular biometry and Body Mass Index

This current study found a direct positive and statistically significant relationship between body mass index and axial length, anterior chamber depth and vitreous chamber depth. In terms of lens thickness, K-value, and cornea radius there was no statistically significant relationship with BMI. Our results were similar to that from studies by French et al[57] and Ip et al[24] in Australia. Our results agreed with a number of authors who have established that children with higher percentiles for weight, height, BMI tend to have longer axial lengths with attendant longer anterior chamber depths and vitreous chamber depths.[33,57,32] Genetic studies have shown that people with the genetic predisposition to a high weight and height also tend to develop higher measurements for ocular biometry; long axial length, deep anterior chamber depth, deep vitreous chamber depth, high cornea radius and low K-value and vice versa.[105, 114, 127,] A study by Wojciechowski et al showed that people with high BMI have relatively higher circulating levels of IGF and thyroid hormones, all of which have a proliferative effect on the tissues of the eye and thus lead to high ocular biometric dimensions.[20] Clinically it may be prudent to investigate the axial length of children with high BMI or order to detect those with myopia and treat them appropriately.

5.7. Ocular biometry and refraction

5.7.1. Emmetropia

This study found that for children who were emmetropic, there was a positive relationship between axial length, anterior chamber depth, vitreous chamber depth and cornea radius in males, however the relationship between emmetropia and K-value as well as lens thickness was not significant. Our results corroborate findings from Iran [18] and Australia. [24]

Emmetropisation is considered to be a complex process that involves various coordinating components such as axial length, lens thickness and cornea curvature, that have to be synchronized in order to achieve emmetropic refractive state in a child.[95, 107,128,] Thus the elongation of axial length and by inference that of anterior chamber depth and vitreous chamber depth have to be regulated together with the lens thickness and cornea radius in an optimal way for the eye to achieve emmetropia. Our study demonstrated that children with mid-level axial length end up with emmetropia as compared with those with shorter axial length who end up with hyperopia and those with longer axial length develop myopia. Studies have shown that several genes work in tandem to regulate axial length and cornea curvature in order to achieve an emmetropic state of the eye [84].[86,] Other studies have shown that there is coordinated scaling of ocular biometric components which is achieved by hundreds to thousands of common genetic variants, each contributing a small pleiotropic effect to achieve an emmetropic state.[53,125, 129]

5.7.2. Myopia

In this current study, myopia was significantly associated with axial length, anterior chamber depth, vitreous chamber depth, K-value in males and inversely with cornea radius in males. The relationship between myopia and lens thickness was not statistically significant.

This study showed an association between myopia and axial length. This results is similar to what was found in Australia,[24] Iran,[32] and China. [58] Myopia has been postulated to result from a failure of the process of emmetropisation where the growing axial length outmatches the lens's ability to thin enough so that images fall on the retina or where the radius of the cornea is not flat enough leading to the production of excess refractive power with images falling in front of the retina resulting in myopia.[29–31 ,106,120,130,131] A study by Plotnikov et al showed that there are genes associated with controlling eye size as well as genes that predispose a person to developing myopia by causing elongation of the axial length and in patients with myopia, the myopic genes triumph.[127] Other researchers have shown the existence of genes that cause excessive axial length growth that overcomes the normal checks and balances resulting in myopia.[53, 125] Environmental factors including excess indoor time and near work predispose to myopia. [55]

This current study demonstrates an association between myopia and anterior chamber depth. Our results was similar to what was found in China,[58] Iran,[18] and Nepal.[132] This correlation is believed to be because of deepening of the anterior chamber depth occurring as axial length elongates. Thus, studies by Guggenheim et al[125] , Han et al[129] and Gordon et al[118] which looked at the genes involved in the development of myopia, found that these genes also affected the

depth of the anterior chamber depth positively. Environmental factors such excess near work and reduced outdoor activities were also associated with deepening of the anterior chamber depth.[54, 133]

In this current study, myopia did not have a significant relationship with lens thickness. Our results were contrary to what was found in Iran[18] and Nepal[132] where myopia was associated with lens thinning.

Results of this study showed that vitreous chamber depth was significantly associated with myopia, p = 0.029. This result with findings by Garner in a longitudinal study in Nepal,[132] and Sorsby et al in Norway.[107] The vitreous chamber depth is estimated to make up 65 to 70% of the axial length of the eye.[121] This makes vitreous chamber depth important in myopia as there is excess elongation of the axial length. Genetic studies have shown that genetic factors contribute to the depth of the vitreous chamber depth in those with myopia.[118] Environmental factors including excess indoor stay and near work have postulated to contribute to longer axial length and by extension vitreous chamber depth.[81, 54]

This current study found males with myopia to have longer cornea radius. Our results agree with results of Garner.[132] In a study in Asian populations researchers found the existence of the FKBP12-rapamycin complex-associated protein 1 (FRAP1) gene located at chromosome 1p36.2.[129] Again, in Caucasian and Asian populations the platelet-derived growth factor alpha (PDGFRA) gene on chromosome 4q12 have been found to be involved in the development of myopia.[124] These FRAP 1 gene is associated with development of myopia through modification of the axial length by enhancing cell proliferation and cornea radius and curvature, while the PDGFRA gene brings about cell growth indirectly by enhancing vascular growth which leads to cellular proliferation,[124, 129,] and this partially explain the high incidence of myopia in Asian populations. Future genetic studies are needed to determine if there exist in our population a gene that acts opposite to what FRAP1 and PDGFRA do to overcome the myopic state of the eye.

Our study found an association between myopia and K-value in males, a finding that corroborates results by Garner in Nepal[132] Our result however was contrary to what Ip et al found in Australia.[24] In this study the association between myopia and K-value in males could be since the longer axial length in males would require a lower K-value to position images on the retina and prevent amblyopia. This assertion requires further research to ascertain it.

5.7.3. Hyperopia

Results of this study showed hyperopia had an inverse relationship with axial length, anterior chamber depth and lens thickness in males. This study's results agree with findings by Hashemi

in Iran[18] and Ip et al in Australia.[24] Genetic factors have been found to contribute to the short axial length and anterior chamber depth in some genetic research. [86, 116]People with generally small body stature tend to have shorter axial legth as part of their general growth expression.[53] Hyperopia has been found to be associated with short anterior chamber depth due to genetic factors that determine growth rate in an individual [124, 129]

This study's results showed an association between hyperopia and high lens thickness in males. Our results was similar to what was found in Iran among school children.[18] Several studies have found hyperopia to be associated with thicker lenses.[134, 135, 136] This finding could be due to excess refractive power from thicker lenses necessary to focus images on the retina, because of the shorter eye in hyperopia.

5.7.4. Ocular biometry and ethnicity

In Ghana, there are different ethnicities but all Ghanaians. The study site with its cosmopolitan constitution, yielded different ethnic groups from different art of the country. However, the current study demonstrated that ethnicity had no effect on ocular biometry. There was a paucity of published data on the relationship between ocular biometry and ethnicity. Other studies have looked at the relationship between ocular biometry and different races but with little emphasis on ethnic groups within a particular race or population. Studies by Rudnicka et al,[2] Ip et al,[24] Twelker[28] all looked at ocular biometry among different races and found significant differences between the races but within the races there were no significant differences. These results seem to suggest significant genetic differences between races to lead to differences in ocular biometry but not enough within the same race to cause a significant difference in results. These results however need to be replicated on a larger scale across the various ethnicities within the country to validate it.

5.7.5. Strengths of the study

This study is a pioneering study in Ghana that has documented the mean axial length, anterior chamber depth, lens thickness, vitreous chamber depth, cornea radius and keratometry values in healthy Ghanaian children aged 6 to 15years.

The sample size of this study of 352children (704 eyes) on paediatric ocular biometry is one of the largest in the sub-Saharan African region.

Published data on paediatric ocular biometry and its relationship with anthropometric factors in sub-Sahara Africa is scanty and this study will contribute to the body of knowledge on this topic.

In this study the population was stratified into age groups and thus results could be compared with results from other studies and populations.

5.7.6. Limitations of the study

The following limitations were encountered during this study:

Anticipated lack of cooperation from children led to setting the minimum age at six years, thus data in younger children was not determined.

This current study being a cross-sectional study may not adequately show the trends of progression since data was taken at a point in time.

Additionally, the setting of the study in only one region, the Greater Accra region out of the 16 in Ghana, findings may not be a perfect representation of the country. However, the city of Accra being the capital city with its cosmopolitan setting, has a good amalgamation of the different ethnic groups that make up the country and thus as was seen in the study, the study population represented different ethnic groups, even though majority were from the Ga ethnicity.

CONCLUSIONS OF THE STUDY

1. The mean ocular biometric values in a section of healthy Ghanaian children ages 6-15 years were: axial length -22.73±0.75mm, anterior chamber depth-3.28±0.29mm, lens thickness- 3.65±0.27mm, vitreous chamber depth-19.44±0.70mm, cornea radius-7.79±0.28mm and keratometry value- 43.39±1.56D.
2. Axial length, anterior chamber depth, and vitreous chamber depth increased with age and was higher in males compared to females, difference was statistically significant. Keratometry values however were higher in females.
3. Higher body mass index was associated with higher axial length, anterior chamber depth and vitreous chamber depth.
4. Higher axial length, anterior chamber depth and vitreous chamber depth were associated with myopia, the reverse was true for hyperopia.
5. Null hypothesis was rejected because there is a significant relationship between ocular biometry and age, sex, BMI and refraction in the population under investigation.

RECOMMENDATION

The results of this study will provide baseline data for a larger national studies that could ultimately lead to the development of national normative values for axial length, anterior chamber depth, lens thickness, vitreous chamber depth, cornea radius and k-values in the Ghanaian paediatric population, which may lead to improvement in the diagnosis, prognostic prediction and management of conditions such as pathological myopia and attendant complications such retinal detachments in children, cataract surgery outcomes in the absence equipment to measure axial length.

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APPENDICES

Appendix A

LOGISTICS AND TIME SCHEDULE

OBJECTIVE/ ACTIVITY	2022			2023												2024					
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
PROPOSAL WRITING																					
ETHICAL CLEARANCE																					
DATA COLLECTION AND ENTRY																					
DATA CLEANING																					
DATA ANALYSIS																					
WRITE UP																					
SUBMISSION OF COMPLETD WORK																					

Appendix B

BUDGET/RESOURCES

ITEM	**QUANTITY**	**UNIT COST (GH ¢)**	**TOTAL COST (GH ¢)**
Printing and binding of proposals, data capture forms and dissertation			1000
Allowance for research assistants	6 personnel	500	3000
Amethocaine	10 bottles	100	1000
Cotton	5 rolls	30	150
Gloves	4 boxes	50	200
Alcohol pads	10 boxes(100pcs/box)	30	300
Batteries (AAA)	6x 5	50	300
Transportation for study team			500
Stationery			100
IRB fees			1000
TOTAL			7250
Contingency cost	5%		363
TOTAL			7913

Source of funding:

The research was self-funded.

Appendix C

Participant's Informed Consent

Name of Principal Investigator: Dr. Abigail Nyarko Bosompem

Name of Organization: Lion's International Eye Centre, Korle-Bu Teaching Hospital.

Project title: Determination of ocular biometric parameters and their relationship with age, gender, refraction, and body mass index

I.....have been invited to allow my child to take part in the study above. It was explained to me that the study aims to **determine ocular biometric parameters and their relationship with age, gender, refraction, and body height and weight in Ghanaian children.**

I have been told the procedures of the study will involve:

- a general eye examination to detect any abnormality.
- measurement of refraction and the shape of the front of the eye
- measurement of eye pressures using an Icare tonometer
- instillation of an anaesthetic eye drops and using the ultrasound pachymeter to measure the thickness of the central cornea (the front glassy window of the eye).
- Measurement of the length of the eye

Risk or dangers and discomfort:

Risk, dangers, and discomfort are mild with this study. This includes mild risk with this study involves the use of cyclopentolate drops to achieve dilatation of the eyes which can cause blurring of vision for about 24 hours after use of the drops. Anaesthetic drop will instilled in the eye to ensure minimal discomfort with the use of contact eqipment such as pachymetre and B-scan probe. There is no documentation of participant name as well.

Benefits:

My child will benefit from a free eye screening and will be referred for further assessment if any eye disease is diagnosed. There are no financial benefits from this study. However, findings from the study will serve as a guide in the management of children with ocular conditions that may cause visual impairment or blindness such as refractive errors, cataracts and glaucoma.

Confidentiality:

Information obtained from me would be treated as confidential and kept in a file which will not have my child's name on it but a code number assigned to it which will not be disclosed to anyone. Outcome of this study would be reported at meetings and in journals, but my child's name will not be reported.

My right to refuse or withdraw:

I understand the information given me on the above-mentioned research and voluntarily consent. I understand that if I change my mind I can withdraw my child from the study.

Persons to contact:

I have been told that the proposal will be reviewed and approved by the Ethical and Protocol review committee at the Korle Bu Teaching Hospital teaching hospital whose mandate is to protect participants from harm. If I wish to find out more about this committee, I may contact The Chairperson of the Ethical and Protocol Review Committee of the Korle Bu Teaching Hospital Teaching Hospital.

Contact Information:

If I have any questions, I may ask those now or later. If I wish to ask questions later, I may contact:

The Chairperson,
Ethical and Protocol Review Committee
Korle Bu Teaching Hospital Teaching Hospital

Dr.. Abigail Nyarko (The Principal Investigator)
Lion's International Eye Centre,
Korle Bu Teaching Hospital Teaching Hospital
Tel.: 0242104851

Signature (participant's parent or guardian): .....
Place: .....
Date: .....

If illiterate:

Thumbprint .....

Date: .....

Place: .....

Signature (researcher): .....

Place: .....

Date: .....

Appendix D

Participant's Informed Assent form (for child)

Name of Principal Investigator: Dr. Abigail Nyarko Bosompem
Name of Organization: Lion's International Eye Centre, Korle-Bu Teaching Hospital.

Project title: Determination of ocular biometric parameters and their relationship with age, gender, refraction, and body mass index in Ghanaian children.

I.....have been invited to take part in the study above. It was explained to me that the study aims to **determine ocular biometric parameters and their relationship with age, gender, refraction, and body height and weight in Ghanaian children.**

I have been told the procedures of the study will involve:

- a general eye examination to detect any abnormality.
- measurement of refraction and the shape of the front of the eye
- measurement of eye pressures
- instillation of drops that takes away pain and using the ultrasound pachymeter to measure the thickness of the central cornea (the front glassy window of the eye).
- Measurement of length of the eye using an A-scan ultrasound

Risk or dangers and discomfort:

Risk, dangers, and discomfort are mild with this study. This includes mild risk with this study involves the use of cyclopentolate drops to achieve dilatation of the eyes which can cause blurring of vision for about 24 hours after use of the drops. A drop wil be instilled in the eye to ensure minimal discomfort with the use of contact eqipment such as pachymetre and B-scan probe. There is no documentation of participant name as well.

Benefits:

I will benefit from a free eye screening and will be referred for further assessment if any eye disease is diagnosed There are no financial benefits from this study. However, findings from the study will serve as a guide in the management of children with cataracts and refractive errors, glaucoma and other eye conditions.

Confidentiality:

Information obtained from me would be treated as confidential and kept in a file which will not have my name on it, but a code number assigned to it which will not be disclosed to anyone. Outcome of this study would be reported at meetings and in journals, but my name will not be reported.

My right to refuse or withdraw:

I understand the information given me on the above-mentioned research and voluntarily consent. I understand that if I change my mind I can withdraw from the study.

Persons to contact:

I have been told that the proposal will be reviewed and approved by the Ethical and Protocol review committee at the Korle Bu Teaching Hospital Teaching Hospital whose mandate is to protect participants from harm. If I wish to find out more about this committee, I may contact the chairperson of the Ethical and Protocol Review Committee of the Korle Bu Teaching Hospital Teaching Hospital.

Contact Information:

If I have any questions, I may ask those now or later. If I wish to ask questions later, I may contact:

The Chairperson
Ethical and Protocol Review Committee
Korle Bu Teaching Hospital Teaching Hospital

Dr. Abigail Nyarko
Lion's International Eye Centre, Korle Bu Teaching Hospital Teaching Hospital
Tel.: 0242104851

Signature (participant): .....
Place: .....
Date: .....

Signature (researcher): .....
Place: .....
Date: .....

Appendix E

QUESTIONNAIRE

Date:

Study ID number:

Study site:

Demography

Age:

Class:

Sex:

Ethnicity:

Medical history:

Past history of ocular disease	: (a) YES	(b) NO
Family history of glaucoma	: (a) YES	(b) NO
Family history of blindness	: (a) YES	(b) NO

Examination:

Weight : kg

Height : metres

BMI. : …….

	Right eye	Left eye
Visual acuity		
Conjunctiva		
Cornea		
Anterior chamber		
Iris		
Pupil		
Lens		
Vitreous		
Retina		
IOP		
CCT		
Axial length (mm)		
ACD (mm)		
Len thickness (mm)		
VCD (mm)		
K-value (D)		
Cornea radius (mm)		

Cyclopleegic Refraction **a) Actual reading**		
b) Spherical Equivalent		

Appendix F

Images of Equipments used for study

SECA 769 weight and height scale. Source: Seca Gmbh & Co, Hamburg, Germany

Icare 100.

Source: ICARE USA INC,Abbe Ave, Kansas City, Missouri, USA

Pachmate®

Source: DGH Technologies Inc, Exton PA, USA

SONOMED PACSCAN 300-A Plus

Source: Escalon Medical Corp, Wayne, Pennsylvania, USA

Retinomax AK plus 3

Source: Righton MFG. CO. LTD, Tokyo