VARIATION OF FETAL BIOMETRY WITH MATERNAL ETHNICITY:

A CROSS-SECTIONAL STUDY IN ACCRA

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DECLARATION

I, James William Ampofo, do hereby declare that this thesis which is being submitted in fulfillment of the requirements for the degree of MSc in Medical Ultrasonography is the result of my own research performed under supervision, and that except where otherwise other sources are acknowledged and duly referenced, this work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree

I hereby give permission for the Department of Radiography to seek dissemination/publication of the dissertation in any appropriate format. Authorship in such circumstances to be jointly held between myself as first author and the project supervisors as subsequent authors.

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DEDICATION

I dedicate this work to my dear wife Maame and blessed children - Phoebe-Grace, Jude-William, David-Richard and Daniel-Dag;

And also to the Medical Imaging fraternity

And finally to all those who offer hope to the sick.

ACKNOWLEDGEMENT

Now thanks be unto God, which always causeth us to triumph in Christ, and maketh manifest the savour of his knowledge by us in every place.

Lord, You are the author of life, my life sustainer and my ever-present help at all times.

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LIST OF ABBREVIATIONS

AC	abdominal circumfrence
ALARA	as low as reasonably achievable
AIUM	American Institute of Ultrasound in Medicine
ART	assisted reproductive technology
BGA	big for gestational age
BMI	body mass index
BPD	biparietal diameter
BPDoi	biparietal diameter outer to inner
BPDoo	biparietal diameter outer to outer
CP	cerebral peduncles
CRL	crown-rump length
CSP	cavum septum pellucidum
EDD	expected date of delivery
F	falx (cerebri)
FL	femur length
GA	gestational age
GSSD	Ghana Statistical Service Department
HDP	hypertension in pregnancy
HC	head circumference

IUGR	intrauterine growth retardation
ISUOG	International Society of Ultrasonographers in Obstetric and Gynaecology
KHz	kilohertz
LGA	large foetus for gestational age
LMP	last menstrual period
MHz	mega hertz
NIDDM	Non-insulin dependent diabetic mellitus
nmol	nonamole
OFD	occipito-frontal diameter
SFH	symphysis-fundal height
SGA	small for gestational age
SOGC	Society of Obstetrician Gynaecologists of Canada
T	thalami
US	ultrasound
WHO	World Health Organization
25(OH)D	25-hydroxyvitamin D

ABSTRACT

Background: Variable fetal biometric values are common in normal fetuses and it is natural to assume that ethnicity might influence this. There is the potential danger of misinterpretation of such observed normal variations.

Aims: The study aim was to determine whether differences in ultrasound-measured fetal biometry exist among pregnant women of the Akan, Mole-Dagbon, Ewe and Ga-Adangbe ethnic groups in Accra.

Methods: This was a prospective cross-sectional study involving 448 women with uncomplicated singleton pregnancies, certain date of the last menstrual period and presenting between 19weeks and 28weeks of gestation. The participants were selected by proportional quota sampling and comprised 148 Akans, 119 Mole-Dagbon, 96 Ewes and 85 Ga-Adangbes. Each woman was scanned by transabdominal ultrasound once for the study. The biparietal diameter, head circumference and femur length were measured. These were compared by Krukal Wallis test for any significant variations among the four ethnic groups. Maternal age, height and parity were also analysed for any association with the fetal biometric variations.

Results: There were significant variations in femur length measurements ($p<0.05$) among the four ethnic groups. There were no statistically significant variations in the biparietal diameter ($p>0.05$) and head circumference ($p >0.05$) measurements. There was no association between maternal characteristics and variations observed in the femur lengths measurements.

Conclusion: The findings suggest that maternal ethnicity influence foetal femur length measurements in second trimester foetuses. However, a further study with a larger sample size selected across the country is recommended to ascertain if the observed fetal biometric variations has a national character.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The use of ultrasonography in the measurement of fetal parameters has become integral to modern obstetric care. These measurements serve for dating pregnancies and assessment of fetal growth. Ultrasound fetal biometry involves the use of high frequency sound waves imaging technology to scan the fetus with the aim of assessing its general health, and includes the measurements of the various segments of the fetal anatomy (Society of Gynaecologists and Obstetricians of Canada/Canada Association of Radiologists, 2014).

Every part of the fetal anatomy may be imaged: fetal head, spine, heart and major vessels, abdomen, and long bones. The most common measurements, however, are crown-rump length in early gestation, the head, abdomen and femur. These biometric measurements can be used to estimate gestational age and fetal weight, assess fetal growth, and identify fetuses who are either growth restricted or macrosomic. These measurements therefore can influence antepartum and intrapartum management and can be used to predict peripartum outcomes. Biometry, as asserted by Mellisa et al (2012), is therefore, an integral and valuable element of obstetrical practice.

The practice has achieved a pre-eminent role in prenatal care in both developed and developing countries. In general, the adequacy of fetal size is assessed by comparing the observed measurements of fetal anatomical parameters at a given gestational age with reference percentiles of fetal size calculated in population of fetuses whose growth is assumed normal.

Variable fetal biometric values are common in normal fetuses. It is natural to assume that parental ethnicity, anthropometric characteristics, and other maternal factors like medical history, exposure to some specific chemicals and parity might influence the variations. Studies have established the influence of these maternal factors and fetal factors on the gestational age assessment based on ultrasound fetal biometry. Lindell et al (2012); Clayton et al (2007); Drooger et al (2005) and Synnøve et al (2004) have established how maternal age, height, body mass index (BMI) and parity influence fetal biometry. Some studies have added that fetal gender has influence on fetal biometric outcome (Lindell et al, 2012 and Synnove et al, 2004). Among the maternal medical history reported to influence measurements of fetal parameters are hypertension and renal pathologies (Shah et al 2014; Mayer et al, 2013) and diabetic mellitus (Campbell, 2014; Teramo, 2014). Another maternal factor which influence fetal biometric outcome is maternal exposure to cigarette smoke during pregnancy which is also reported to influence fetal size, antenatal growth and birth size (Iniguez et al, 2013 and Pringles et al, 2005). While all the above factors contribute to influence fetal measurements one determinant which has gained much currency is parental race or ethnicity. Many studies have specifically confirmed the impact of maternal ethnicity on fetal biometry (Kwon, 2014; Parikh et al, 2014; Zaki et al, 2012; Albouy-Llaty et al, 2011; Bottomley et al 2008). These studies showed fetal biometric variations with maternal race. Parikh (2014) showed how the abdominal circumference, (AC), of the fetuses of Caucasian mothers varied with those of African-American. As AC contributes heavily to estimated fetal weight calculations, it can be concluded that physicians may be wrongly over-estimating or underestimating the growth rate in one of the group of fetuses. Kwon et al (2014) have also shown how fetal biometric parameters vary between the Asian race and the Caucasians. They report that although most of the parameters they observed were similar to those for the Italian population but in comparison with the North American and United Kingdom populations, Korean fetuses had greater BPD, HC, and AC in the first half of pregnancy but tended to measure progressively smaller with advancing gestational age. This is similar to the findings in another inter-racial study in North Africa, Egypt by Zaki et al (2014). This group also concluded that their fetal biometric measurements were significantly different from those of western populations. The main difference they observed in the biometric results between the Egyptian population and those of the European fetuses was in the FL measurements. In analyzing the parameters of fetuses born to Asian, African-American and Caucasian mothers Shipp et al (2001) and Weiz et al (2001) independently had shown earlier that fetuses of mothers of the Asian race have shorter femurs and those of African-American mothers have longer femurs compared with fetuses of white mothers.

Though not much has been published on the variation of fetal biometry within population of the same subregional and racial group yet variations have been observed in some studies among fetuses of different ethnic groups of the same country. (Jacquemyn et al, 2010) reported of differences in the head circumference (HC), the abdominal circumference (AC), the femur length (FL) and the estimated fetal weight (EFW) among different ethnic groups in Belgium.

Published formulas for expected fetal biometric parameters exist in the literature. Most of the commonly used reference charts of size by gestational age have been obtained from populations of European and American fetuses. There is, however, the on-going debate on whether to use customized fetal growth chart or non-customized charts. Proponents of the former argue that non-customized growth charts might not be appropriate for use in populations of different ethnicities that could show different patterns of fetal growth. There is the potential that calculation of adequate fetal biometry at a given gestational age could generate concerns regarding diagnostic and management decisions made on the basis of ultrasonographic fetal growth assessments (Figueras et al, 2011).

Earlier researchers have shown how fetal biometric parameters vary in the second trimester according to maternal ethnicity (Jacquemyn, 2010, Zelop et al, 2003; Kovac, 2002;).

The Ghanaian population is multi-ethnic and according to the 2010 National Population and Housing Census, the four principal ethnic groups consist of Akan (47.5%), Mole-Dagbon (16.6%), Ewe (13.9%), Ga-Dangme (7.4%), and a few minor ones constituting the balance of 15.4% (Ghana Statistical Service Department, 2010).

Going through published works it was observed that most of the researches that had been carried out in the area of fetal biometry with ultrasound imaging were actually on the variation of fetal biometry with maternal race rather than with maternal ethnicity (Kwon et al, 2014; Zelopp et al 2003; Kovac et al 2002; Shipp et al 2001; Hadlock et al, 1985). Little has therefore been done to verify how fetal parameter measurements with ultrasound vary among ethnic groups of the same race. Currently no data is available to show the phenomenon of variation of fetal biometry with maternal ethnicity pertains in a Ghanaian society.

The goal of the study was therefore to determine whether differences in ultrasound-measured fetal biometry existed among pregnant women of the different ethnic groups in a typical Ghanaian community. It was also to find out if such variations were significant enough to merit ethnic-specific formula for expected biometric measurement for any of these main ethnic groups. The study was carried out to also set the tone for further research into finding out whether there will be the need to formulate a customized Ghanaian fetal growth chart which will be adopted in place of reference charts that accompany ultrasound scanners from other jurisdictions.

1.2 PROBLEM STATEMENT

One important danger in ultrasound fetal biometry is misinterpretation of measured parameters. Factors which can significantly impact on the outcome of fetal biometric findings must be considered in the final analysis of fetal calculations. Non-recognition of such determinants can lead to wrong assessment or dating of the foetus. It can lead to difficulty in establishing for instance, the difference between a constitutionally small foetus and one suffering from restricted growth. Failure to identify and subsequently factor in normal variations among populations of different ethnic background can pose a challenge in distinguishing between constitutionally short femur and one resulting from Down‘s syndrome or skeletal dysplasia, as explained by Kovac et al (2002). The problem can also adversely affect peripartum decision which has been based on wrong dating of gestation or post-partum intervention for instance in cases of preterm delivery. Most ultrasound equipment have in-built growth charts generated from studies of normal foetus population in other countries. Such tables do not take into consideration variation in fetal biometry as a result of the ethnicity of the mother. Studies have been performed in some countries which have enabled them to develop growth charts peculiar to the region. Some multi-ethnic populations have developed charts which take into consideration the different ethnic characteristics of the fetuses. Cosmopolitan Accra is a multiethnic community (Agyei-Mensah et al, 2010). There is, however, no existing data to show how fetal biometry is influenced by maternal ethnicity in this community. Again, ultrasound equipment as used in a typical Ghanaian health facility or diagnostic imaging centre has no inputs which consider the multiethnic variations which the measured fetal parameters may reflect. The absence of data to show the variation of fetal biometry with maternal ethnicity in a multiethnic Ghanaian community therefore poses potential dangers not only to the fetuses but also to the pregnant mothers consequent of misinterpretation and wrong decisions. The absence such data and input corresponding input in the equipment can also lead to the danger of skewing findings to conform to equipment-preset values.

1.3 SIGNIFICANCE OF STUDY

The outcome of the study was expected to reveal any normal variations in second trimester fetal measurements among the four selected ethnic groups in cosmopolitan Accra. The research was to establish further, whether the variations were significant enough to merit the proposal of ethnic-specific fetal biometry charts. This would help eliminate the potential dangers posed by misinterpretation of findings which have not taken into account the normal ethnic variations. It will help reduce misdiagnosis of fetal conditions. The study was carried out to help sonographers make confident impressions on fetal assessment and dating. The findings in this work will help obstetrician gynecologist make informed and reliable decision in fetal and maternal management during antepartum, peripartum and postpartum care. It will also impart professional competence and confidence in obstetric sonographers in their biometric findings and thereby reduce the tendency to skew findings to conform to the preset values in the equipment.

1.4 HYPOTHESIS

Three hypotheses proposed for the present study include:

i. ultrasound measured fetal biometry vary among the Akan, Mole-Dagbon, Ewe and Ga-Adangbe ethnic groups
ii. the differences in the ultrasound measured fetal biometry among the ethnic groups are due to maternal anthropomorphic characteristics
iii. the variation in the ultrasound measured fetal biometry is statistically significant

1.5 AIM

The aim of this study was to determine the existence of differences in ultrasound-measured fetal biometry among pregnant women of Akan, Mole-Dagbon, Ewe, and Ga-Adangbe ethnic groups.

1.6 SPECIFIC OBJECTIVES

The objectives identified to achieve the aim of this research work were:

i. to measure by ultrasound the BPD, HC, and FL of 19 to 28weeks old fetuses whose parents belong to the four principal ethnic groups
ii. to compare the measured fetal biometry among the four main ethnic groups
iii. to determine how much variation exists in the measured fetal biometry among the four ethnic groups
iv. to determine if there is any association between maternal demographics characteristics such as age, height and parity on one hand and the observed fetal biometry on the other.
v. to determine the necessity for ethnic-specific formula for calculating fetal BPD, HC, and FL for any of the ethnic groups.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The current chapter shows the literature reviewed on the subject of maternal ethnicity and its influence on fetal biometry. The benefits of the application of ultrasound-based fetal biometry, the role of maternal and fetal characteristics on the outcome of fetal biometry, the debate on customized and non-customized fetal growth charts, maternal ethnicity and its influence on fetal biometry have been reviewed in this research work. The review was also extended to the ethnic structure of the Ghanaian population and in particular, the ethnic mix of the population of cosmopolitan Accra which was selected as the reference city for the study.

2.2 EVALUATION OF FOETUS SIZE AND AGE

There are different methods for evaluating the size or gestational age of the foetus. These could either be by direct measurements of fetal anatomy or by indirect measurement through reliance on maternal features and menstrual records. The direct evaluation is based on ultrasound measurement of several parts of the fetal anatomy referred to as fetal biometry (Degani, 2001) while the indirect evaluation includes clinical palpation, fundal height measurement and the last menstrual period of the pregnant woman (Mongelli, 2014).

2.2.1 Clinical Palpation

This involves manual examination of the pregnant abdomen by using the physical landmarks of the xiphisternum, the umbilicus and the symphysis pubis. It includes fundal palpation, lateral palpation and pelvic palpation. It is done for signs of pregnancy and parity, assess the fetal size and growth and to detect deviations from the normal. The size of the uterus through abdominal or pelvic examination can be roughly correlated with the gestational age, however, factors affecting uterine size like fibroids and maternal body characteristics such as obesity will affect such an estimate (Mongelli, 2014).

2.2.2 Symphysis-Fundal Height (SFH) Measurement with tape

This is a measurement of the pregnant abdomen from the highest point of the uterus (fundus) to the symphysis pubis as shown in Fig 2.1. It is simple, convenient, safe, inexpensive and widely used during antenatal care. (Morse et al, 2009; Nielson, 2009). Fundal height, as it is commonly called, is a measure of the size of the uterus, fetal growth and development (Fig.2.2).

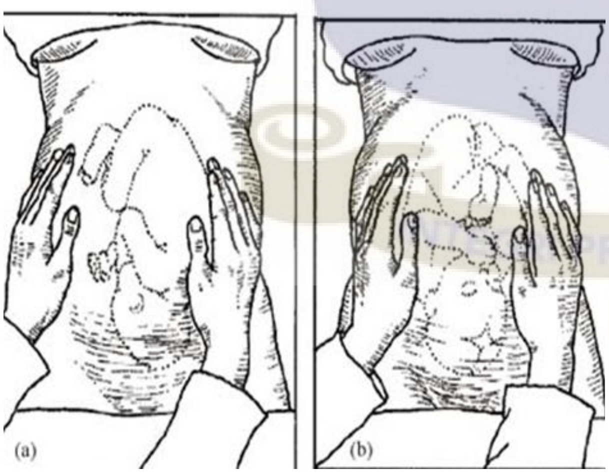

Fig 2.1: Clinical palpation
(Source: WHO, 2008. Managing prolonged and obstructed labour, Figures 7.4 and 7.5, pages 115 and 116). Used by permission.

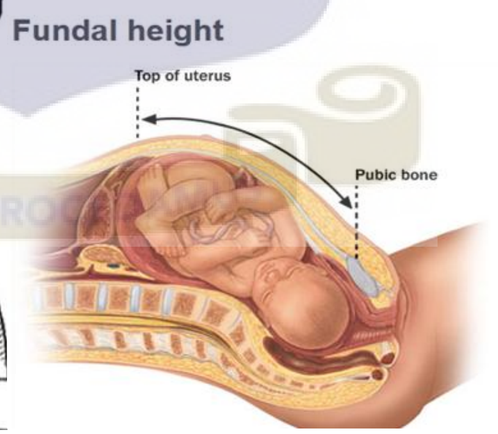

Fig 2.2: Fundal Height measurement
(Source: Mayo Clinic , 2014. Healthy lifestyle: Pregnancy week by week). Used by permission.

It is used to estimate the gestational age of a fetus, to detect fetuses that are poorly grown and also has the potential to facilitate the detection of multiple pregnancies and of fetuses that are unusually large. It has been established that between 20 to 34 weeks gestation the height of the uterus correlates closely with measurements in centimetres, however obesity has been shown to distort the accuracy of these measurements.(Nielson, 2009). Abnormal fundal height (smaller or larger than gestational age) may indicate abnormal uterus, fetal growth, and amniotic fluid development. Fundus smaller than gestational age may indicate intrauterine growth restriction (IUGR), small for gestational age (SGA), or oligohydramnios, while fundus larger than gestational age may reflect large fetus for gestational age (LGA), polyhydramnios, twins, or uterine tumor (Wood, 2004). It is reported that in many settings, symphysis-fundal height measurement has replaced clinical assessment of fetal size by abdominal palpation because the latter has been reported to perform poorly, in observational studies during routine antenatal care, in detecting fetuses that were small for gestational age at delivery.

Despite the continuous application of SFH in most developing countries and its recommendation by WHO Reproductive Health Library (Buchmann, 2003) for its use as tool for estimating gestational age and detecting SGA it has a lot of limitations. Fundal height is not considered to be a very accurate measurement to determine baby's weight. It has other severe limitations in its use as it has been reported that it cannot be measured by different observers with sufficient agreement to separate small fundal heights from those that are not small (Nielson, 2009). Neilson's Cochrane review concludes that there is not enough evidence to evaluate the use of SFH during antenatal care (ANC). It is therefore being replaced by ultrasound biometry (Morse, 2009).

2.2.3 Last Menstrual Period (LMP)

This is a maternal parameter based on the menstrual history of the pregnant woman. Gestational age calculation from LMP was based on Nägele's theory which stated that the average human pregnancy was 266 days from conception, or 280 days (40 weeks) from the start of the last menstrual period. To calculate GA, one should begin with the first day of the last period (LMP) add 7 days, and then subtract 3 months.

A chart of a typical 28-day menstrual cycle showing the ovulation period with respect to the hormonal phases and the endometrial histology is shown in Fig 2.3.

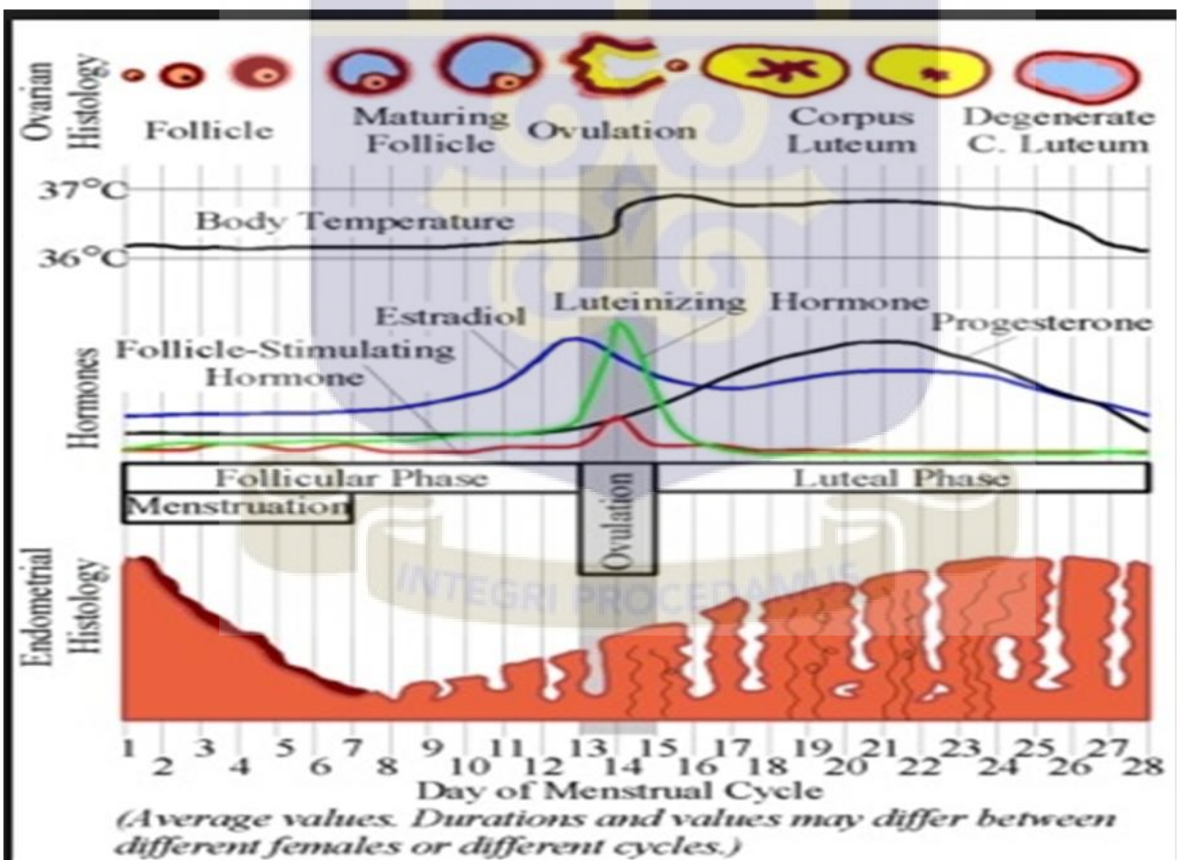

Fig 2.3: Menstrual cycle chart

Source: http://www.gov.im/media/253277/menstrual_cycle.jpg. Used by permission

Women, however, vary greatly in their awareness of their internal functions, including ovulation, and this self-knowledge can sometimes be very accurate. Campbell et al (1985) demonstrated that 45% of pregnant women are uncertain of menstrual dates as a result of poor recall, irregular cycles, bleeding in early pregnancy, or oral contraceptive use within 2 months of conception. Savitz et al (2002) re-echoed this assertion in stating that in about 40% of pregnancies the LMP is either not known or the information is not reliable. The only truly certain clinical history is one in which the dates of ovulation, fertilization and implantation are precisely known, as in assisted reproductive technology (ART), in which records include the date of oocyte retrieval, and other methods of timed ovulation and fertilization. (Butt et al, 2014).

Thus, in some cultures, particularly where literacy levels are low, LMP can be very unreliable (Rijken, 2009). Hence Nakling et al, (2005) categorically stated that ultrasound assessment of gestational age up to 24 weeks provides the most accurate assessment of the fetus and the most accurate prediction of the expected date of delivery (EDD) and is more reliable than the last menstrual period (LMP).

2.3 IMPORTANCE OF ULTRASOUND FETAL BIOMETRY AND PRENATAL ASSESSMENT

The usefulness of ultrasound imaging in modern obstetric care and specifically fetal biometry cannot be overemphasized. The prenatal assessment of gestational age and fetal growth by means of ultrasonography has achieved a pre-eminent role in prenatal care both in developed and developing countries (Merialdi et al, 2005). This imaging technique is useful in assessing fetuses for anomalies, ensuring fetal health, and assessing fetal growth and development. When performed with quality and precision, ultrasound alone is more accurate than a ―certain" menstrual date for determining gestational age in the first and second trimesters (≤ 23 weeks) in spontaneous conceptions. According to Butt et al., (2014) and Cherveanak et al., (1998), it is the best method for estimating the delivery date. The former further argued that in the absence of better assessment of gestational age, routine ultrasound in the first or second trimester reduces inductions for post-term pregnancies. The practice also helps to identify and manage cases of preterm delivery which are public health priority especially in developing countries where 98% of neonatal deaths occur (Black, 2003).

It is also an important technology in education and research. With the help of this technology every part of the fetal anatomy can be imaged. In the early gestation the crown-rump length, (CRL) can be measured. Measurements of the fetal head, spine, abdomen, long bones, cardiac function and fetal vascular caliber can be made. Most commonly used measurements for biometry are that of the head, abdomen and the femur. These biometric measurements can be used to estimate gestational age and fetal weight, evaluate interval fetal growth, and identify fetuses who are either growth restricted or macrosomic. These measurements may influence antepartum and intrapartum management and may be used to predict peripartum outcomes. (Mellisa et al, 2012). Biometry is therefore an integral and valuable element of obstetrical practice.

Fetal parameters evaluated by ultrasound in the second trimester of gestation are, the bi-parietal diameter (BPD) of the fetal skull, the fetal head circumference (HC), the fetal abdominal circumference (AC) and the length of the diaphysis of fetal femur (FL).

2.3.1 Biparietal Diameter of Fetal Skull

The fetal biparietal diameter (BPD) was the first sonographic parameter used to determine gestational age and to assess fetal growth, according to Degani (2001). This is a measurement taken in the axial plane at the level of the thalami where the continuous midline echo is broken by the cavum septi pellucidi in the anterior third and both thalami are seen symmetrically (Chitty et al 1994). Care should always be taken to ensure that the calvarium appears smooth and symmetrical bilaterally. BPD measurements may be made from the leading edge of the echo from the proximal fetal skull to the leading edge of the echo from the distal fetal skull. This is referred to as _outer to inner‘ BPD (BPDoi). Measurements of BPD _outer to outer‘ (BPDoo) is made from the leading edge of the echo from the proximal fetal skull to the outer edge of the echo from the distal fetal skull (Hadlock et al, 1982).

2.3.2 Fetal Head Circumference (HC)

This parameter is measured by placing elliptical calipers over the BPDoo and the occipitofrontal diameter, (OFD). The OFD is measured in the same plane between the leading edge of the frontal bone and the outer border of the occiput. (Chitty et al, 1994).

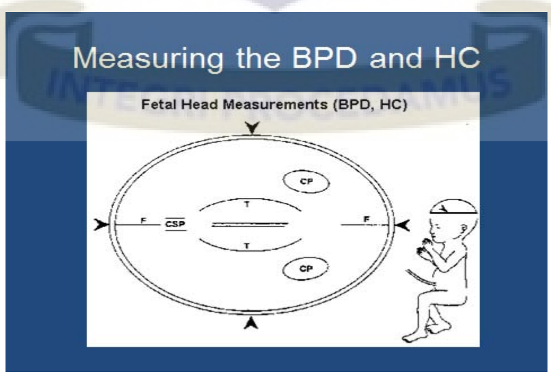

Figure 2.4a Measuring Fetal biparietal diameter (BPD) and head circumference (HC)
Source: Maternity Guide. UTHSCA.edu/images/residency/fetalheadmeasurement.jpg.
Used by permission.

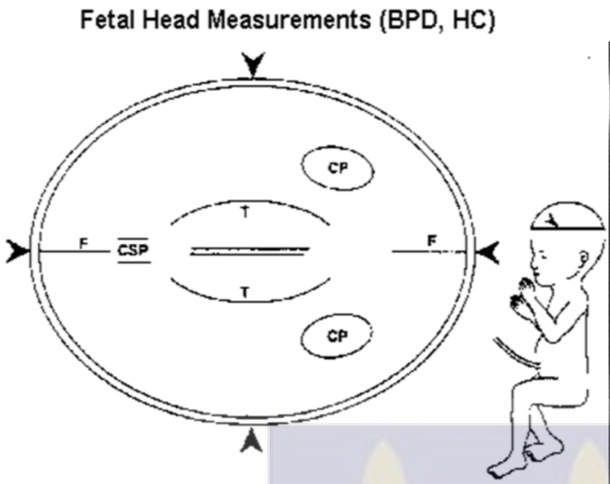

Fig. 2.4b: Fetal head measurement **Fig 2.4c: Ultrasound image of figure 2.4a**

F= falxcerebri CSP = cavumseptipellucudum

T= Thalamus CP= Cerebral peduncles

Source: Maternity Guide. UTHSCA.edu/images/residency/fetalheadmeasurement.jpg
Used by permission.

2.3.3 Abdominal Circumference

This parameter is measured in transverse circular section through the fetal abdomen at the level where the spine, descending aorta, anterior third of the umbilical vein and stomach bubble could be seen in the same plane, as described by Campbell and Wilkin (1975). Though this parameter is very useful its measurement has some limitations. It is more challenging to measure the fetal AC than the other parameters. The abdomen has no bright echoes of bone, it is not always symmetrical, and its size will vary with fetal respiration and central body flexion/extension. Of all the fetal biometric parameters, this measurement has the most variability as it is somewhat dependent on fetal growth factors and body position (Hadlock et al, 1991).

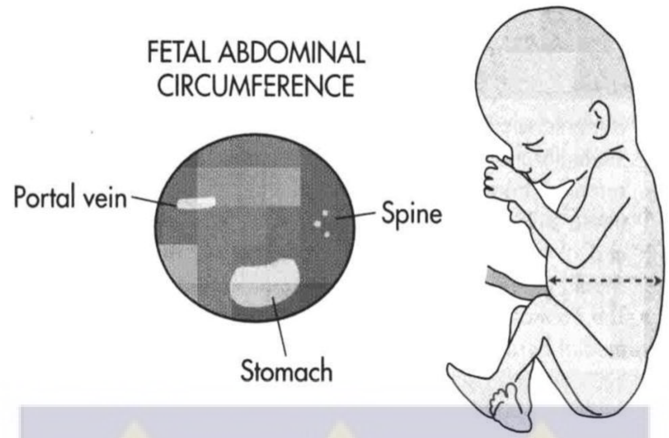

Figure 2.5a Diagram showing level for fetal abdominal circumference (AC) measurement

Source: Maternity Guide. UTHSCA.edu/images/residency/fetalabdomenmeasurement.jpg
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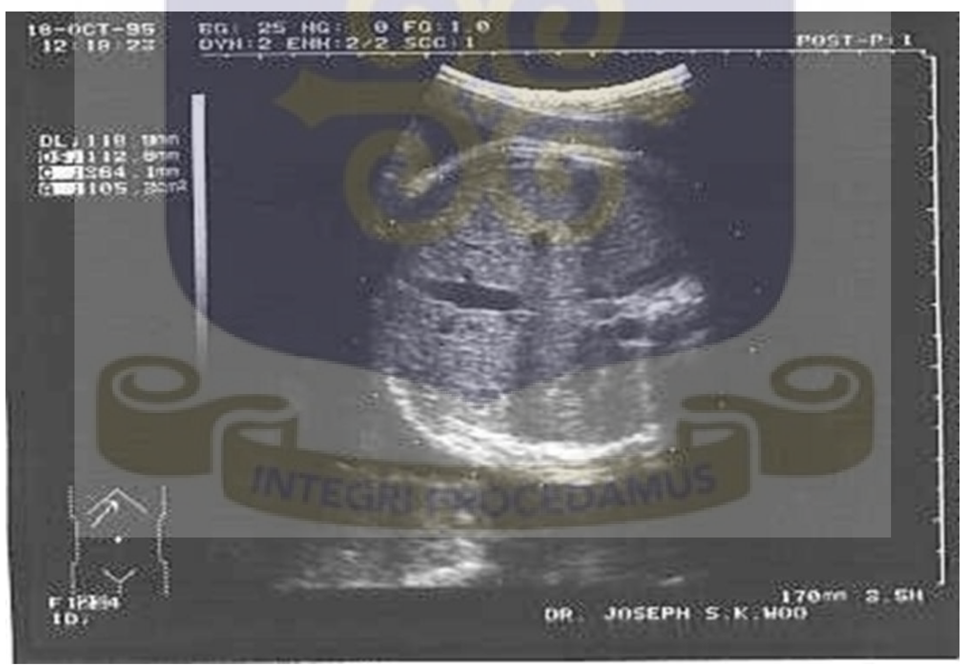

Figure 2.5b Ultrasound image showing fetal abdominal circumference measurement
Source: Field work.

2.3.4 Fetal Femur Length

The femur is measured by rotating the transducer till the full femoral diaphysis is seen in a plane as close as possible to 90° length to the ultrasound beam. A straight measurement from one end of the diaphysis to the other end is made. Care is taken not to include the distal ossification centre (Chitty et al, 1994).

Femur length varies somewhat with ethnicity. Short femurs are commonly a normal variant, however this finding may also indicate fetal growth restriction, aneuploidy, and—when severely shortened—skeletal dysplasias (Weiz et al, 2008; Nyberg et al, 2003; Hadlock et al, 1985). It has been observed that as a single parameter, HC correlates better to gestational age than the other 3 standard parameters in the second trimester.

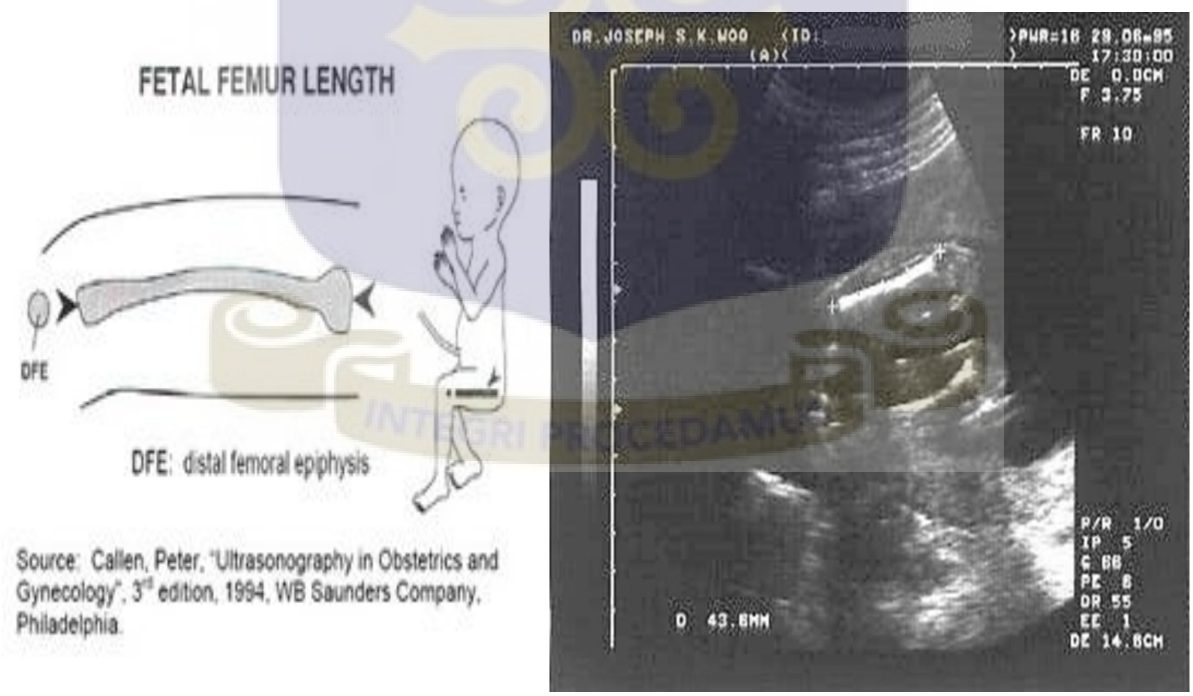

Figure 2.6 Image showing fetal femur length measurement

Source: Maternity Guide. UTHSCA.edu/images/residency/fetalfemurlengthmeasurement.jpg
Used by permission.

2.3.5 Importance of Using Multiple Fetal Parameters Instead of One

Though the use of the above individual parameters is good but as indicated in preceding paragraphs single parameter use has limitations. Variations in skull shape, such as dolichocephaly or brachycephaly limit the stand-alone use of BPD hence some authors feel that BPD is less reliable than HC. Butt et al (2014) therefore recommend that in second or third trimester scan to determine gestational age a combination of multiple biometric parameters (biparietal diameter, head circumference, abdominal circumference, and femur length) should be used to determine gestational age, rather than a single parameter. This recommendation is an echo of an earlier observation made by Degani (2001) that measuring multiple fetal ultrasound parameters is the most effective way for dating pregnancies, evaluation of fetal growth, and detection of altered or abnormal fetal growth.

2.3.6 Ultrasound-based Fetal Parameters versus Last Menstrual Period

The accurate determination of gestational age is required for many aspects of antenatal care. In the past, it was probably felt that a few days of inaccuracy was acceptable; however, emerging data suggests that a few days inaccuracy can affect things, such as the performance of maternal serum screening, the assessment of post-dates pregnancy, and the subsequent induction of labour (Melissa, 2012). Based on the available research, the use of US-derived dates is the best method to determine gestational age for clinical use. It is not, however, intended to be used to determine the exact date of conception because of biological variability in reproduction, fetal size, and development. Clinical history may have value in determining gestational age, and on rare occasions may supersede ultrasound dating; however, in order to achieve the most clinical benefit, the use of ultrasound dating should predominate (Butt et al, 2014).

In common obstetric practice, the adequacy of fetal size is assessed by comparing the observed measurements of fetal anatomical parameters at a given gestational age with reference percentiles of fetal size calculated in populations of fetuses whose growth is assumed to be normal (Salpou, 2008). In the prenatal assessment of the fetus selection of the most useful single biometric parameter depends on the timing and purpose of measurement and is influenced by specific limitations. CRL (crown-rump length) is the best parameter for early dating of pregnancy. Biparietal diameter (BPD) maintains the closest correlation with gestational age in the second trimester. In cases of variation in the shape of the skull, head circumference is an effective alternative. Abdominal circumference is the most useful dimension to evaluate fetal growth, and femur length is the best parameter in the evaluation of skeletal dysplasia. Use of multiple predictors improves the accuracy of estimates. An individual approach to each pregnancy is recommended for fetal growth assessment (Degani, 2001).

2.4 BIOSAFETY OF ULTRASOUND EXAMINATIONS FOR FETAL BIOMETRY AND PRENATAL ASSESSMENT

Ultrasound is acoustic energy whose linear frequency is rated at 20kHz or higher. Ultrasound-based fetal biometry using ultrasound imaging technology therefore employs high-frequency, high energy sound waves which are non-ionizing radiation. It has long been viewed as a safe imaging modality in obstetric examination. In a study by Hellman et al (1970) over 1100 pregnant women at various stages of pregnancy were medically exposed to differing ultrasonic frequencies throughout and it was observed that neither the time in gestation of the first examination nor the number of examinations seemed to increase the risk of fetal abnormality. And up till date, as stated jointly by the Society of Gynecologists Obstetricians of Canada and Canada Association of Radiologists in Policy Statement No. 304 (2014), there is no definitive evidence of fetal abnormalities or harmful biological effects linked to diagnostic ultrasound in human. Bioeffects research has yet to define the effects of exposure to sonography in humans.

To ensure this safety, however, the procedure has to be performed by properly trained individuals in a carefully monitored and medically supervised environment as it involves targeted energy exposure to the fetus. There is a theoretical risk for effects on fetal development as suggested by studies of biological effects of ultrasound reported at or near diagnostic intensities in both human studies and animal models. Hence the concerns raised in recent time in view of lately studies in animal models that report subtle effects on the physiology and development of the fetal brain (Yang et al 2012; Schneider-Kolsky, 2009; Suresh et al, 2008). The American Institute of Ultrasound in Medicine Practice Guideline for Performance of Ultrasound (2014) consequently recommends that the potential benefits and risks of each examination should be considered. The ALARA (as low as reasonably achievable) principle should be observed when adjusting controls that affect the acoustic output and by considering transducer dwell times.

2.5 INFLUENCE OF MATERNAL AND FETAL FACTORS ON FETAL BIOMETRY

It is natural to think that maternal and fetal factors influence fetal biometry. Much research has been undertaken in this area over the years and there is information linking a myriad of factors with foetal growth. Hynes et al (2012) in their book, ‗Parental determinants on neonatal anthropometry' list the following as the most important factors: age, race, parental birth anthropometry, parental height, parental weight, maternal weight gain during pregnancy, maternal activity, diet including calorie, protein and micronutrient intake, parity and interpregnancy interval, socioeconomic status, maternal pathology (hypertension, malaria, anaemia and diabetes) and lastly exposure to toxins (cigarette smoke and alcohol). Among the fetal characteristics that influence the biometry is the gender,

Several studies have shown that the above factors acting individually or jointly or together with other environmental factors influence fetal biometry. A consensus statement of the International Societies of Pediatric Endocrinology and the Growth Hormone Research Society in the work, ―Management of the child born small for gestational age through to adulthood" (Clayton et al, 2007) asserted that ethnicity, genetic, and environmental factors like maternal body mass index (BMI), parity, smoking, and nutrition influence the size of the fetus. Synnove et al (2004) in their study to establish new reference charts for gestational age assessment used concurrently fetal biparietal diameter and head circumference. They sought to determine the effect of maternal and fetal factors on age assessment. They concluded that maternal and especially fetal factors affect gestational age assessment when using biparietal diameter, but less so for the head circumference method which has been suggested as a more robust method.

Drooger et al, (2005) in their work ethnic differences in prenatal growth and the association with maternal and fetal characteristics concluded that there are ethnic differences in fetal growth, which to a large extent are associated with maternal weight, height, age and parity. They further argued that for some ethnic groups, however, additional factors are involved in the explanation of these ethnic differences. They concluded from their study that is important to develop individualized growth curves that take different maternal and fetal characteristics into account.

2.5.1 Influence of Maternal Anthropometry and Parity on Fetal Biometry

From the foregoing studies it can be deduced that there is an association between fetal biometry and the maternal height, weight and body mass index. Lindell et al (2012) in their work ―Impact of maternal characteristics on fetal growth in the third trimester: a population-based study" found out positive the associations between maternal body mass index (BMI), height, pre-existing diabetes mellitus, female fetal gender and fetal growth, whereas maternal smoking had a negative association. They observed in their univariate analyses that primiparity and parity with four or more previous children were significantly associated with reduced fetal growth. However, in the multivariable analysis they found no association between parity and fetal growth. Both univariate and multivariable analyses revealed a significant inverse U-shaped association between maternal age and fetal growth. Although studies in the literature vary considerably regarding design, outcome measures and statistical methods, their results are quite concordant. Most studies reported positive associations of fetal weight, birth weight or fetal biometrics with maternal height, weight or parity, and a negative association with maternal smoking (Lindell et al, 2012; Drooger et al, 2005; Pang et al 2003; Mongelli et al 1995).

There are, however, contra views on the influence of maternal body mass index on fetal biometry. Sarris et al (2010) in their work on the effect of maternal BMI on first trimester fetal growth concluded that there was no influence of maternal body mass index on first trimester fetal growth. This agrees with Bottomley et al (2009) in their work,"Assessing first trimester growth: the influence of maternal ethnicity and age". They reported that factors that influence the embryonic growth are maternal ethnicity and age. The researchers showed that the rate of increase in crown-rump length was greater in fetuses of black versus white women and increased with advancing maternal age. They recommended that since the measured parameter influences further growth assessment consideration should be given to the use of individualized growth charts which take account of maternal factors found to influence first trimester growth.

2.5.2 Influence of Maternal Pathology on Fetal Biometry

Some maternal health concerns are known to influence fetal biometry. Maternal diabetes and hypertension are examples of such conditions. According to Campbell (2014), 5–10% of macrosomic fetuses are associated with maternal diabetes. Macrosomic fetuses are those whose birth weight is >4500 g. It has also been reported recently that the rate of malformations in fetuses is still two to four times higher in type 1 and type 2 diabetic pregnancies than in the general population (Teramo, 2014). These findings are consistent with earlier work carried out by Towner et al (1995) which claimed that maternal diabetes is known to increase the risk of major congenital malformations.

Various maternal illnesses – including hypertensive disorders of pregnancy, diabetes mellitus, autoimmune diseases (such as anti-phospholipid syndrome and systemic lupus erythematosus), chronic maternal illnesses and infections – increase the risk for fetal growth restriction. Chronic hypertension, gestational hypertension and pre-eclampsia are the most common of these maternal conditions and typically increase the risk of fetal growth restriction by three-to four-fold (Mayer et al, 2013). This report is consistent with a recent publication by Shah (2014) which states that a common feature of hypertensive disease in pregnancy, (HDP), irrespective of whether it is chronic or late or early onset preeclampsia or preeclampsia superimposed on chronic hypertension is vascular damage. It continues to say that nearly one third of pregnancies with hypertension disease in pregnancy are affected by growth restrictions as a result of chronic hypoxia. The chronic hypoxia leads to poor fetal reserves and high chances of abnormal fetal growth. The biometric findings of fetuses of such pregnant mothers would consequently give erroneous results. Fetuses of diabetic mothers will be big for gestational age (BGA). Comparing such fetuses with those of normal mothers will give the impression that the former groups are older in gestational ages than the latter. Likewise in the case of fetuses whose mothers suffer chronic conditions like hypertensive disorders the adverse effect of growth restrictions will consequently render the fetuses small for age (SGA), giving the false impression of less gestational age than normal. Thus in any study to compare variations of fetal biometry it will be appropriate to exclude subjects who are known to have any of such medical conditions (Campbell, 2014; Teramo, 2014).

2.5.3 Effect of Exposure to Cigarette Smoking on Fetal Biometry

Pregnant women who smoke are also known to have fetuses with restrictive growth. Smoking influence fetal biometry according to studies carried out by Pringle et al (2005). Smoking was associated with a reduction in fetal femur length and abdominal circumference as well as birth weight, length, and head circumference. A recent research report by Iniguez et al (2013) from a mother and child cohort study on ―Maternal smoking during pregnancy and fetal biometry" observed that there was decreased fetal growth in all growth parameters at 20–34 weeks the reduction being greatest in femur length and least in abdominal circumference. This observation therefore makes it imperative to consider this maternal factor before any comparative study. It is instructive to exclude such mothers from studies where normal fetuses are being compared (Iniguez et al, 2014; Pringle et al, 2005).

2.6 VARIATION OF FETAL BIOMETRY WITH RACE AND ETHNICITY

2.6.1 Inter-Racial Fetal Biometric Variations

Any fetal biometric analysis should strongly consider the factor of maternal and for that matter parental race. It is common knowledge that there are anthropometric differences among the different races. These assertions are supported by various works carried out in ultrasound-based fetal biometry. Studies, both recent and earlier have strongly linked variation in fetal biometry with maternal race (Kwon et al, 2014; Zelopp et al 2003; Kovac et al 2002; Shipp et al 2001; Hadlock et al, 1985). An earlier study had described the possibility of anthropometric differences in fetuses and neonates resulting from maternal race (Hadlock, 1985). Later studies subsequently observed that long bone length varies significantly with maternal race. Zelopp et al (2003) and Shipp et al (2001) in separate works observed that specifically African American populations have a longer long bone length compared with white populations, and Asian populations have shorter long bone length. This observation therefore suggests that the sensitivity and specificity of a short limb length is impacted dramatically by race. Other researchers, however, suggest that population differences in fetal biometry are negligible and that separate studies are not necessary (Borgida, 2003; Ruvolo, 1987). Other studies, however, demonstrate morphometric variation among different populations groups around the world (Kovac, 2002; Shipp 2001).

Informed by the observation of inter-racial differences in fetal biometry many researchers have carried out studies to come out with fetal growth charts which factor in racial or regional characteristics. Kwon et al (2014) reported that in comparison with the North American and United Kingdom populations, Korean fetuses had greater biparietal diameter, head circumference and abdominal circumference in the first half of pregnancy but tended to measure progressively smaller with advancing gestational age. Similar inter-racial variations has been reported in another recent work by Parikh et al (2014) in which the researchers sought to find answers to the possible effect of maternal ethnicity on fetal biometry. In that study involving African-American and Caucasian the researchers conceded that a single fetal growth curve is not applicable across all ethnicities as they observed that African-American fetuses have smaller abdominal circumference than Caucasian fetuses from weeks 17 to 23. It was argued further from that report that because abdominal circumference contributes heavily to estimated fetal weight calculations, physicians may be over estimating growth restriction in fetuses of African-American parents. They therefore recommended that ethnicity-specific fetal growth curves be indicated to limit unnecessary follow up.

Studies carried out in Belgium by Jacquemyn et al (2000) among pregnant autochthonous Belgian women, migrant women from Morocco and from Turkey demonstrated that fetal biometric differences do exist for the head circumference, the abdominal circumference, the femur length and the estimated fetal weight. They therefore recommended the use of adapted charts of fetal size for pregnant women of Turkish or Moroccan origin. Variations between Caucasian and Asian fetuses have also been reported from the work of Ogasawara (2009). Three hundred and five white (305), 370 Asian, 895 part Hawaiian, 76 Pacific Islander, and 311 white Asian fetuses were analyzed. It was observed that at 18 weeks, gestation femur length was significantly shorter in Asian and white Asian. Humerus length was significantly shorter in Asian, part Hawaiian, and white Asian.

African researchers in Egypt have also shown that their fetal biometric measurements are significantly different from those of western populations and have recommended the development of national fetal ultrasound biometric reference charts. Zaki et al (2014) in a pilot data from ultrasound fetal biometry showed a gradual increase in all measurements with gestational age, the maximum increase being in biparietal diameter and head circumference after 22 weeks of gestation, and in femur length between the 14th and the 15th weeks. They reported of abdominal circumference maximum increase between the 15th and the 16th weeks. They showed that difference between their measurements and those of United Kingdom and Italian populations was in femur length.

2.6.2 Intra-Racial or Ethnic Fetal Biometric Variations

Not only has observations of variations been made in the biometry of fetuses whose mothers belong to different races but also of those who belong to same race but different ethnicity. Yeo et al (1994) in their work on ‗Racial differences in fetal morphometry' in Singapore did a systematic collection of fetal morphometric measurements over a seven year period. In a cross-sectional study they compared 2392 Chinese fetuses with 2117 Malay fetuses and 459 Indian fetuses from 18 to 40 weeks. The mean values of the head circumference (HC), abdominal circumference (AC) and femur length (FL) of the 3 ethnic groups were analysed. No statistical significant differences were observed in the head circumference and abdominal circumference of Chinese, Malay and Indian fetuses in Singapore. And though the Chinese and Malay fetal femur length appeared similar yet they were apparently shorter than the Indian femur length. Subsequently nomograms of head circumference, abdominal circumference and femur length were constructed for application to fetuses of all 3 ethnic groups.

The above study was similar to that carried out by Raman et al, (1996) in another intra-racial study among three major ethnic groups in Malaysia, namely Malays, Chinese and Indians. The work sought to determine the growth patterns of the humeral and femur length in that multiethnic population. Significant differences in limb length were found when Indians were compared with the Malays and Chinese and was therefore concluded that there appeared to be definite differences in growth of limbs between the different Malaysian ethnic groups. It was recommended that such difference should be taken into account when growth charts were being designed.

Conversely, Salpou et al (2008), researching on ‗Fetal age assessment based on second trimester ultrasound in Africa and the effect of maternal ethnicity' found no significant impact of ethnicity on fetal size at early gestation (12-22weeks) between two ethnic groups in Cameroun. They, however, admitted that ethnic differences are expressed during fetal development in the latter half of pregnancy and the fact there are established reports on ethnical differences in mid gestation for femur measurements.

Most of the commonly used fetal charts of size by gestation have been obtained from populations of fetuses in the United States of America or Europe and more recently South East Asia. Concern has been raised that such charts might not be appropriate for use in populations of different ethnicity that could show different patterns of fetal growth (Kwon et al, 2014; Zaki et al, 2012; Zhang et al, 2011; Merialdi et al, 2005; Walton, 1981). If valid, the potential for miscalculation of adequate fetal size at a given gestational age should generate concerns regarding diagnostic and management decisions made on the basis of ultrasonographic fetal growth assessments.

2.7 CUSTOMIZED VERSUS NON-CUSTOMIZED GROWTH CHARTS

From the foregoing numerous studies and reports on the significant influence of maternal factors, especially maternal ethnicity on the outcome of fetal biometry, there are strong contention that there should be customized growth charts for individual ethnic group. Such fetal charts will take into consideration the peculiar characteristics of the population. Many of the discussions of fetal biometry charts have highlighted that charts in different groups should be based on standards produced from that population. A population reference is often established on the basis of a large sample size, ideally representing the underlying population, with a study population that includes both low-risk and high-risk pregnancies and both normal and abnormal perinatal outcomes. On the other hand, a standard usually is based on low-risk pregnancies with a normal outcome. When the ―population reference” and the ―standard” are applied to an individual fetus or infant, interpretation of the findings differs. The use of a population reference will yield a relative fetal size in relation to the total population; a standard will assess a fetal size in comparison to normally grown fetuses. Thus, a standard may have more clinical utility than a population reference to detect deviation from normal (Zhang, 2011).

A large group of researchers recommend the use of customized growth charts (Zaki et al, 2014; Mongelli et al 2014; Bottomley et al, 2009; Gardosi et al, 2009; Sarris et al 2008; Clayton et al, 2007; Drooger et al, 2005; Kovac et al 2002; Zelopp et al, 2001). As indicated by Figueras et al (2011) the idea of customizing fetal growth standards has intuitive appeal. They argue that if small women tend to have smaller babies then incorporating maternal height, weight and ethnicity/race into the equation will help in the identification of babies who are small because of fetal growth restriction and not because of constitutional reasons.

But many are the other researchers who argue against the use of customized growth charts. In their works they found no significant difference between the effect of ethnic groups on the outcome of fetal biometrics (Hucheon et al, 2011). Earlier studies that suggested that population differences in fetal biometry are negligible and that separate studies are not necessary include the work of Ruvolo, (1987) and Borgida (2003). Recently Hucheon et al in the ‗Case against customized birthweight standards' (2011) have criticized the use of customized fetal growth charts arguing that their improved performance appears to be a consequence of an artifact and not because of a real improvement in predictive ability. The contemporary stand in the literature therefore is clearly divided one on the merits of customized fetal growth standards (Zhang et al, 2011; Gardosi et al, 2009; Hutcheon et al 2008).

In an apparent attempt to tow a neutral line or better still, to satisfy both sides of the argument the World Health Organization (2006), in recent developments in pediatrics have led to the creation of a new weight-for-age standard based on normal infants and children followed longitudinally, with subjects recruited from several different countries including Brazil, Ghana, India, Norway, Oman and the United States

2.8 ETHNIC VARIATIONS IN GHANA

The Ghanaian population is ethnically heterogeneous. According to the Statistical Services Department (SSD) of Ghana the national population is divided into some 75 ethnic groups. In the 2010 Housing and Population Census it was estimated that there are 25 million people in Ghana with 51% being females and 49% being males with an overall population density of 78 persons per sq km. The most densely populated parts of the country are the coastal areas, the Ashanti region, and the two principal cities, Accra and Kumasi. About 70 percent of the total population lives in the southern half of the country. The most numerous peoples are the coastal Fanti, and the Ashanti, who live in central Ghana, both of whom belong to the Akan family. The Accra plains are inhabited by the Ga-Adangbe. Most of the inhabitants in the northern region belong to the Moshi-Dagomba or to the Gonja group. The ethnic groups by percentage of the national population in 2010 are illustrated in Table 2.1.

Table 2.1: Ethnicity distribution of Ghana

Ethnic Group	Percentage of National Population
Akan	47.5
Mole-Dagbon	16.6
Ewe	13.9
Ga-Adangbe	7.4
Gurma	5.7
Guan	3.7
Grusi	2.5
Mande-Busanga	1.1
Other	1.6

Source: 2010 National Population and Housing Census, Statistical Service Department, Ghana.

Despite its rich ethnic diversity, easy geographical and social mobility have scattered people from various ethnic groups throughout the country without destroying or weakening their ethnic bonds. Thus, in cosmopolitan settlements like Accra, even though the original inhabitants were of the Ga-Adangbe ethnic group the city has become more heterogeneous in nature due to its assumption of a cosmopolitan character (Demanya, 2006).

In view of the abundant findings in literature on the influence of race or ethnicity on fetal biometry; in view of the delicate role played by fetal biometry in modern obstetric care; in view of the decision taken based on the outcome of fetal biometry and in view of the fact the Ghanaian population is multiethnic it was considered worthwhile to investigate the operation of this phenomenon in a typical multiethnic Ghanaian community.

The literature shows there are many factors that influence fetal biometry. Some of these like maternal ethnicity, parity, height, or paternal factors cannot be modified in pregnancy, while others like smoking can be modified during pregnancy. These maternal factors are used in some jurisdictions to customise fetal growth centile charts as well as to allocate birthweight centile for the neonate.

The facilities selected for the study are located and patronized by multiethnic communities in Accra. This study was to investigate whether these ethnic groups do show variations in ultrasound measured fetal biometry.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

The previous Chapter showed how the subject of fetal biometry and its variation with ethnicity has been investigated over the years, in different jurisdictions among different racial and ethnic study populations. It also revealed how the related subject areas have been appraised by previous works: the approaches, the research methods, the results obtained and the conclusions drawn by these researchers. The current Chapter describes the methodology adopted in carrying out this scientific study. In particular, key details or aspects such as research design, sample population and size, sampling techniques, procedure for data collection, data analysis and ethical considerations are presented. The Chapter also explains why the various steps were taken to achieve the aim of this work.

3.2 STUDY DESIGN

A prospective cross-sectional study involving 700 second trimester pregnant women with uncomplicated singleton pregnancies, certain date of the last menstrual period and presenting between 19weeks and 28weeks of completed gestation was adopted. A prospective design was adopted because existing data on the study population was not sufficiently. The reason for choosing a cross-section design was because the aim of this work was to verify the variation of fetal biometry with maternal ethnicity among the selected populations at a given point in time. This design allowed for the collection of the data within the given short time frame, ensured that the selected variables were assessed and analysed under the same set of conditions. The aim was not to manipulate the ultrasound equipment settings or interfere with the target population who in this case were pregnant women. An experimental study would have been unethical (Howe, 2014). A longitudinal design requires a longer time frame to carry out several observations on the same subjects over a period of time. (Institute for Health and Work, 2009; Aday, 2006). However, the aim and time available for this work made it difficult as there was always the possibility that the participants might decide to change their centre for the antenatal scans during the study period. Monitoring and therefore longitudinal study would have been difficult under such conditions. A longitudinal study would have been more appropriate if the objective of the study was to detect development or change like ‗growth' in the character of the fetuses. That would have extended beyond a single moment in time lasting months or even years. (Institute for Work and Health, 2009).

3.3 STUDY SITES

The study was conducted in two health facilities in the Accra Metropolis. These were the Lighthouse Mission Hospital and the Shukurah Community Hospital. These facilities cater for both low and high risk obstetric populations and have high client turnouts who report for antennal ultrasound scans. Both sites are located in parts of the city with high proportion of communities made up of the selected ethnic groups. The city of Accra was selected because of its cosmopolitan characteristics. It is known to have communities with good mix of high proportions of almost all the ethnic groups in Ghana.

3.4 STUDY POPULATION

A population of mid-term pregnant women comprising 300 Akans, 180 Mole-Dagbons, 120 Ewes and 100 Ga-Adangbe residing in Accra and attending routine antenatal clinic were initially selected for this research study. The participants were selected by stratified proportional quota sampling based on the proportionate ethnic distribution in Ghana as presented in the year 2010 Housing and Population Census report (Ghana Statistical Service, 2010). This population size was selected considering the time available for the study and the proportion of second-trimester pregnant women to the population.

3.5 INCLUSION AND EXCLUSION CRITERIA

3.5.1 Inclusion Criteria

The inclusion criteria for selection of participants for this study were:

i) uncomplicated singleton pregnancies,

ii) certain date of the last menstrual period

iii) regular menstrual cycle

iv) pregnancies presented between 19 weeks and 28 weeks of gestation.

v) both parents of the foetus were of the same ethnic stock i.e. Akan, Mole-Dagbon, Ewe or Ga-Adangbe.

3.5.2 Exclusion Criteria

The exclusion criteria were:

i) known maternal medical diseases like diabetes, hypertension, or renal disease

ii) uncertain or irregular last menstrual period

iii) smoking pregnant mothers

3.6 PROCEDURE FOR DATA COLLECTION

3.6.1 Sampling Technique

Ethnicity of participants was self-reported. Participants were selected from the Akan, Mole-Dagbon, Ewe and Ga-Adangbe ethnic groups because a review of the literature showed that these were the four main ethnic groups in Ghana. The choice was therefore to offer high frequency of the targeted sample population and a greater chance to observe the phenomenon of variation of fetal biometry with ethnicity in a typical multi-ethnic Ghanaian community.

The reason why both parents of the foetus were supposed to be of the same ethnic stock was to have fetuses which truly belonged to the selected ethnic groups. It was to exclude fetuses which had mixed identity which would not have given a true reflection of the phenomenon under study. In particular, second trimester pregnant women with gestational ages between 19weeks and 28weeks were selected because fetal biometric scans are conducted in routine antennal clinics during this period as published in the literature (Mayer et al, 2013; Mellisa et al, 2012). The gestational ages of the fetuses was based on the last menstrual period as reported by the participant. The regularity of the LMP was self-reported by participants. Participants with irregular menstrual cycle as were excluded from the study because the gestational age calculation from LMP based on Nagale‘s Rule assumes that the average human pregnancy was 266 days from conception, or 280 days (40 weeks) from the start of the last menstrual period. This ―rule" doesn‘t consider the fact that, not all women have 28 day cycles, and not all women ovulate on day 14 of their cycle.

Complicated pregnancies were also excluded. Fetuses known to have congenital conditions either from the pre-study clinical history of the gestation or as accidental finding during the study were excluded. Foetuses which were observed to be small for gestational age (SGA) or large for gestational age (LGA) were excluded to eliminate biasing of results. According to literature fetuses of multiple pregnancies have different biometric measurements and different growth charts as evidenced in the work of Araujo et al (2014) which established that biometric parameters between twins in monochorionic and dichorionic pregnancies were statistically different.

The pregnant women who responded positively to known diabetes were excluded from the study because reviewed literature suggested that 5-10% of macrosomia are associated with the condition and also that the rate of malformations is two to four times higher in diabetes than in the normal population (Teramo, 2014). Participants who presented with hypertensive disorder were excluded by the reason that nearly one third of pregnancies with this condition are affected by growth restrictions as a result of chronic hypoxia (Shah, 2014). Per the indications of Mayer et al (2013), hypertensive disease in pregnancy typically increases the risk of fetal growth restriction by three- to four-fold. The chronic hypoxia leads to poor fetal reserves and high chances of abnormal fetal growth (Shah et al, 2014; Mayer et al, 2013; Insunza et al, 2010).

Smoking is also known to influence fetal biometry according to studies carried out by Pringle et al (2005). Smoking was associated with a reduction in fetal femur length and abdominal circumference as well as birth weight, length, and head circumference. For these reasons, smoking pregnant women were excluded from the study.

3.6.2 Data Collection

A consent form designed to explain the purpose of the study and the right of the participant was self-administered to each participant. It was also explained in participants' local dialect for easy communication. A simple 2-sectioned questionnaire consisting of demographic data and medical history was administered. The demographic section required participant information such as of age, last menstrual period, menstrual cycle, parity, nationality, ethnicity and the ethnicity of the father of the fetus. The medical history section was structured to solicit information on participant's medical history. Participants who met the inclusion criteria were considered for the study. For each, the height was measured to the nearest centimeter with a _SECA' combined height and weight scale (Seca Gmbh and Co, Germany Model 755 102 1994). The heights were recorded in a predesigned form. Real time trans-abdominal ultrasound was performed using Mindray Digital Ultrasound DP 9900 Plus machine equipped with a 3.5 MHz curvilinear trans-abdominal probe. (Shenzhen Mindray Bio-Medical Electronics Company Limited China). Both the ultrasound equipment and the height scale had been proved to yield the required results. The results from the ultrasound scanner had been validated by the resident consultant obstetricians of the facilities. The height measurements were validated by comparing its results with other height scales.

Obstetric ultrasound examination focusing on fetal biometry was performed on each of the participants. For the purpose of the study each participant was scanned once.

3.6.3 Scan Procedure

The scan procedure was explained to the participant before commencement. With the help of a nurse/chaperon, participants were helped onto the couch for partial lower abdominal exposures. A coupling gel was copiously applied to the exposed abdomen and scans in sagittal, coronal and oblique planes performed. All ultrasound examinations were performed by only the researcher and were in agreement with standardized procedures. Furthermore, the first ten measurements were reviewed by the resident obstetrician to check for consistency with the protocol. The following sonographic measurements were performed according to Hadlock's criteria (Hadlock et al, 1982): biparietal diameter, head circumference and the femur length.

Measurements of BPD were obtained in a horizontal section at the level where the continuous midline echo is broken by the cavum septi pellucidi in the anterior third and both thalami are seen symmetrically. Care was taken to ensure that the calvarium appeared smooth and symmetrical bilaterally. Measurement of BPD was obtained by placing the calipers at the leading edge of the echo from the proximal fetal parietal bone on one side and at the leading edge on the distal parietal bone, BPDouter-inner, (BPDoi).

The occipital-frontal diameter (OFD) will be measured between the outer borders of the frontal bone and the occiput. Head circumference was measured by placing elliptical calipers over the BPDoo and the OFD. The femur was measured by rotating the transducer till the full femoral diaphysis was seen in a plane as close as possible to 90^{o} length to the ultrasound beam. A straight measurement from one end of the diaphysis to the other end was made. Care was taken not to include the distal ossification centre. Abdominal circumference was not considered for this study although it is widely studied (Parikh et al, 2014; Zaki et al, 2014; Jacquemyn et al 2008). However, since the emphasis of the research was not on fetal weight this parameter was not studied. The other reason was the challenges encountered in fetal abdominal measurement. The abdomen has no bright echoes of bone, it is not always symmetrical, and its size varies with fetal respiration and central body flexion/extension. It is known to be the parameter with most variability as it is somewhat dependent on fetal growth factors and body position (Hadlock, et al 1991).

For each parameter three fetal biometric measurements were made and the mean calculated. Gestational age was calculated from the last menstrual period, that is the first day of the last menstruation and corrected for cycle length. Corresponding number of days was added or subtracted according to menstrual cycle length shorter or longer than 28 days respectively, in accordance with Nagele's Rule. All fetal biometric measurements was recorded also recorded on the form.

3.7 DATA ANALYSIS

Statistical analysis was done using SPSS software version 17. (SPSS Incorporated, Chicago, Illinois, USA). *Chi-square tests* were used to analyze the maternal parameters. Kruskal Wallis test was used to compare the fetal biometric parameters among the four ethnic groups. The 95% confidential level was used as cut-off. The significance level was set to $P \leq 0.05$. The mean fetal measurements of BPD, HC and FL at each of the ten gestational ages (19-28weeks) for each of the four ethnic groups were compared, for possible variations. Maternal characteristics, namely, age, height and parity were compared and analysed for any significant variations and possible association with the observed fetal biometry. Maternal ages were classified as ≤20years, 21-25years, 26-30years, 31-35years, 36-40years and >40years. Further data analysis was conducted in the fetal parameters that showed significant variations. The mean of the measured fetal parameter at each gestational age for each ethnic group was compared to the mean of each of the remaining three groups. This was to verify which specific ethnic group showed much variation with respect to the others. This was achieved by carrying out multiple comparisons using *Bonferroni's test*.

3.8 DATA MANAGEMENT PLAN

All data collected was handled anonymously and confidentially. Questionnaires, sonographic fetal biometry data sheets and all other data were filled and completed and signed by the researcher only. They were stored in bound folders while in use, and then secured in locked cabinet until data entry. Data were doubly entered and checked for entry and range errors. During data entry and validation, database files were secured and password protected. The findings from this work will be made available to the Department of Radiography, School of Allied Health Sciences of the College of Health Sciences, University of Ghana. It will be presented and adopted for Research and Development purposes and for publication in scientific journals.

3.9 ETHICS

3.9.1 Approval

Approval was received from the Ethical and Protocol Review Committee of the School of Allied Health Sciences, University of Ghana and also from the managements of the facilities where the patients were scanned, namely, the Lighthouse Mission Hospital and Shukurah Community Hospital. Voluntary written informed consent was also sought from the pregnant women and their husbands or fathers of the fetuses before inclusion in the study. The study was carried out in an environment devoid of coercion but rather one where participant could be sufficiently informed of the purpose, nature, procedures and risks if any.

Prior to commencement of data collection visits were made to the study facilities discuss the objectives and methods of the study to the management, obstetrician gynecologists, the nurses and other staff involved in the antenatal clinics. Their individual consents were sought after they had indicated understanding of the procedure and willingness to participate

3.9.2 Participants' Confidentiality

Due to the sensitive nature of the study, all forms of data collected were regarded as sensitive therefore handled anonymously and confidentially. Questionnaires, sonographic fetal biometry data sheets and all other collected data were completed and signed by only the researcher. They were stored in bound folders while in use. During data entry and validation, database files were secured and password protected.

3.9.3 Safety Precaution

Though there is no definitive evidence of fetal abnormalities or harmful biological effects linked to diagnostic ultrasound in human yet as it involves targeted energy exposure to the fetus there is a theoretical risk for effects on fetal development. This is suggested by studies of biological effects of ultrasound reported at or near diagnostic intensities in both human studies and animal models (Yang et al, 2012). Per the recommendations contained in the American Institute of Ultrasound in Medicine (AIUM) Practice Guideline for Performance of Ultrasound (2014) the ALARA (as low as reasonably achievable) principle was observed during the scan procedure in the selection of controls and adjusting of controls that affected the acoustic output. Transducer dwell times per scan procedure were also considered as the duration was proportional to ultrasound energy exposure to the foetus.

CHAPTER 4

RESULTS

4.1. INTRODUCTION

The previous Chapter showed the research design and the method employed to obtain the data for quantitative description and analysis. In this Chapter the results of the study are presented. The details include participants' demographics and other maternal characteristics. This Chapter also shows results from the biometric measurements of the second-trimester fetuses from the four ethnic groups. It goes on to show the results of the comparisons of the maternal factors and the comparisons of the fetal biometrics among the ethnic groups. It ends with analysis of the comparisons. How the maternal factors considered in the study influenced the measurements and the degree of variations in the measured parameters, highlighting which ethnic group showed much variation from the others are also presented.

4.2 DEMOGRAPHICS

4.2.1. Response Rate

A total of 700 pregnant women were initially interviewed purposefully for this study. However, in respect of the conditions listed in the inclusion criteria, only 448 pregnant women qualified to participate in the study as shown in Table 4.1.

Table 4.1: Distribution of participating and non-participating pregnant women

Category of participants	Number of participants	Percent, %
Included participants	448	64
Excluded participants	252	36
Total	700	100

A response rate of 64% was therefore achieved for the study.

4.2.2 Ethnicity of Participants

Per the aim of the study and the requirements contained in the inclusion criteria, a statistical survey of the ethnicity of the participants was made. The results of the distribution are shown in Table 4.2.

Table 4.2: Ethnic distribution of participants

Ethnic groups	Number of participants	Percent, %
Akans	148	33..04
Mole-Dagbon	119	26.56
Ewe	96	21.43
Ga-Adangbe	85	18.97
Total ∑	448	100

Comparatively, the majority or most dominant ethnic group of the population consisted of Akans (*n*=148, 33.04%). The least represented was the Ga-Adangbe ethnic group which accounted for almost 19% (*n*=85).

4.2.3 Age Demographics

The ages of the participants ranged between 17-43 years. The results of the statistical distribution of the ages of the participants are presented in Table 4.3. In classifying the participants according to age groups, it was observed that 17 (4%) were 20 years and below 94 (21%) were aged 21 – 25 years. The least group of participants were aged over 40 years (*n*=2, 0.45%) while the 26-30 years group was the most populous of which the Akan ethnic group constituted the majority (*n*=60, 35.93%). Pregnant women of the Mole–Dagbon ethnic group formed the majority of participants aged less than 20 years (*n*=9, 52.94%).

Tab 4.3: Statistical distribution of participants age

Age (yrs)	Ethnic groups									
	Akan		**Mole-Dagbon**		**Ewe**		**Ga-Adangbe**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
≤ 20	2	0.45	9	2.01	5	1.12	1	0.22	17	3.79
21-25	31	6.92	26	5.80	19	4.24	17	3.79	94	20.98
26-30	60	13.39	43	9.60	29	6.47	34	7.59	167	37.28
31-35	44	9.82	24	5.36	24	5.36	25	5.58	119	26.56
36-40	11	2.46	16	3.57	15	3.35	8	1.79	49	10.94
> 40	0	0.00	1	0.22	1	0.22	0	0.00	2	0.45
Total	148	33.04	119	26.56	96	21.43	85	18.97	488	100.00
	Estimated means									
Mean age (yrs)	Mean ± s.d		Mean ± s.d		Mean ± s.d.		Mean ± s.d		Mean ± s.d	
	29.04 ± 0.36		28.52 ± 0.50		29.34 ± 0.56		29.31 ± 0.49		29.02±0.94	

The computed mean ages for the pregnant women per ethnic group were Akan: 29.04 ± 0.36 years; Mole-Dagbon: 28.52 ± 0.50 years (youngest); Ewe: 29.34 ± 0.56 years (oldest) and Ga-Adangbe: 29.31 ± 0.46 years for the participants. The estimated mean of the entire participant population was 29.02±0.94, showing that the participants from the Mole-Dagbon ethnic group had a mean age lower than that of the entire population. Comparatively and averagely, the Ewe and Ga-Adangbe women were marginally the older than the Akans and Mole-Dagbons.

4.2.4 Height Demographics

The heights of the participants were measured during the study. The results are presented in Table 4.4.

Table 4.4: Demographics and anthropometrics of participants

Demographic variables	**Ethnic group**				***p*-value**
	Akan	**Mole-Dagbon**	**Ewe**	**Ga-Adangbe**	
	Height: Mean ± s.d (cm)				
	163.21 ± 0.40	164.51 ± 0.49	163.58 ± 0.51	163.11 ± 0.64	

With respect to height, the distribution of the computed average values per ethnic group of the second trimester pregnant women attending routine ante-natal clinic was Akans: (163.21±0.40) cm; Mole-Dagbon (164.51±0.49) cm (tallest); Ewe: (163.58±0.51) cm; and Ga-Adangbe: (163.11 ± 0.64) cm (shortest).

4.2.5 Parity

The parity of the participants was between 0 and 4 births. None presented with more than 4 births. The most prevalent type among the participant was nulliparous (*n*=127, 28%), followed by 2 births (*n*=121, 27%) as shown in Fig.4.1. A comparison of the parity distribution among the study groups shown is presented in Table 4.5.

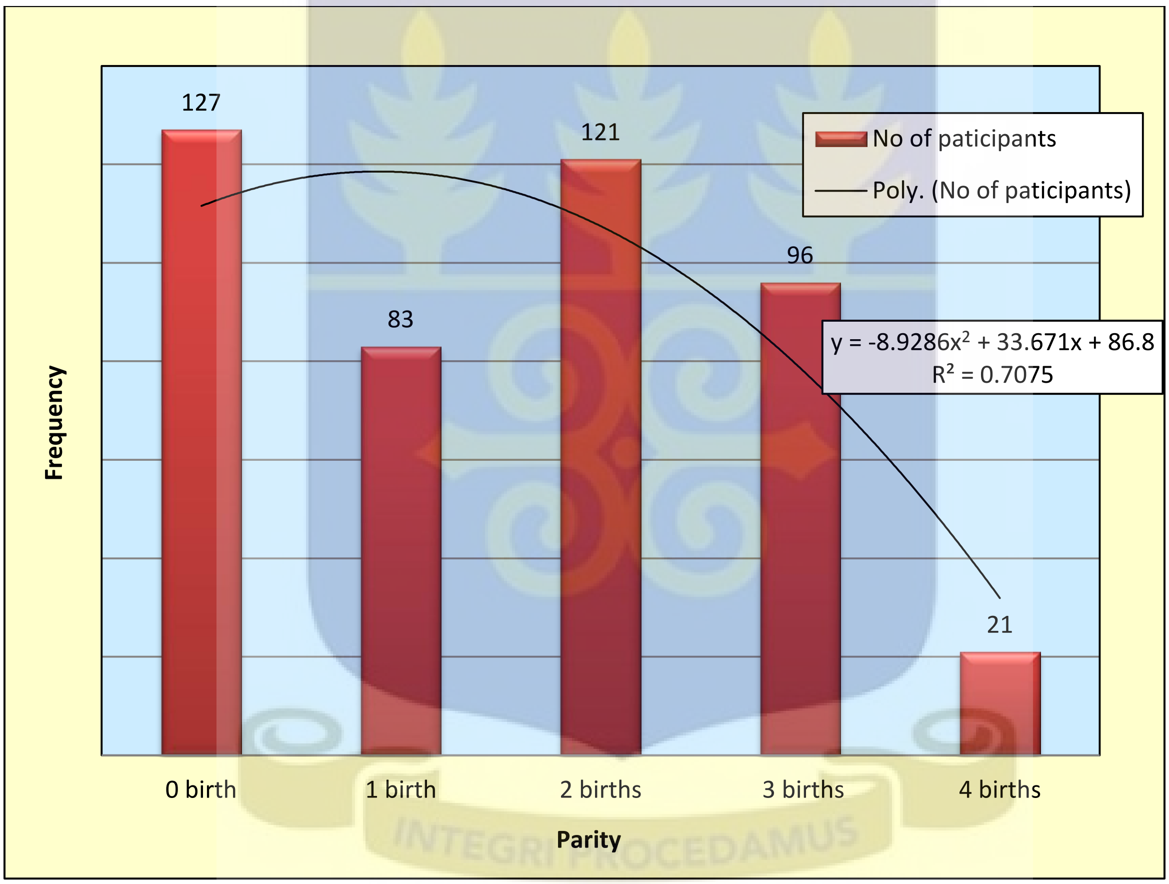

Fig. 4.1: Parity of participants

Table 4.5: Parity per ethnic group

	Parity					
Ethnic group	**0**	**1**	**2**	**3**	**4**	**Total**
Akan	42	26	45	25	10	148
Mole-Dagbon	37	17	30	29	6	119
Ewe	25	19	28	23	1	96
Ga-Adangbe	23	21	18	19	4	85
Total	127	83	121	96	21	448

The least prevalent was of the participants were mothers with previous births (*n*=21, 5%). The relationship between parity and number of participants was described by a polynomial distribution with a regression of $R^2 = 0.707$ was established among the participants.

4.3 FETAL CHARACTERISTICS

4.3.1 Gestational Age of Fetuses

A total of 448 fetuses were successfully scanned ultrasonographically. The gestational ages of the fetuses determined from the ultrasonographic imaging are presented in Fig. 4.2.

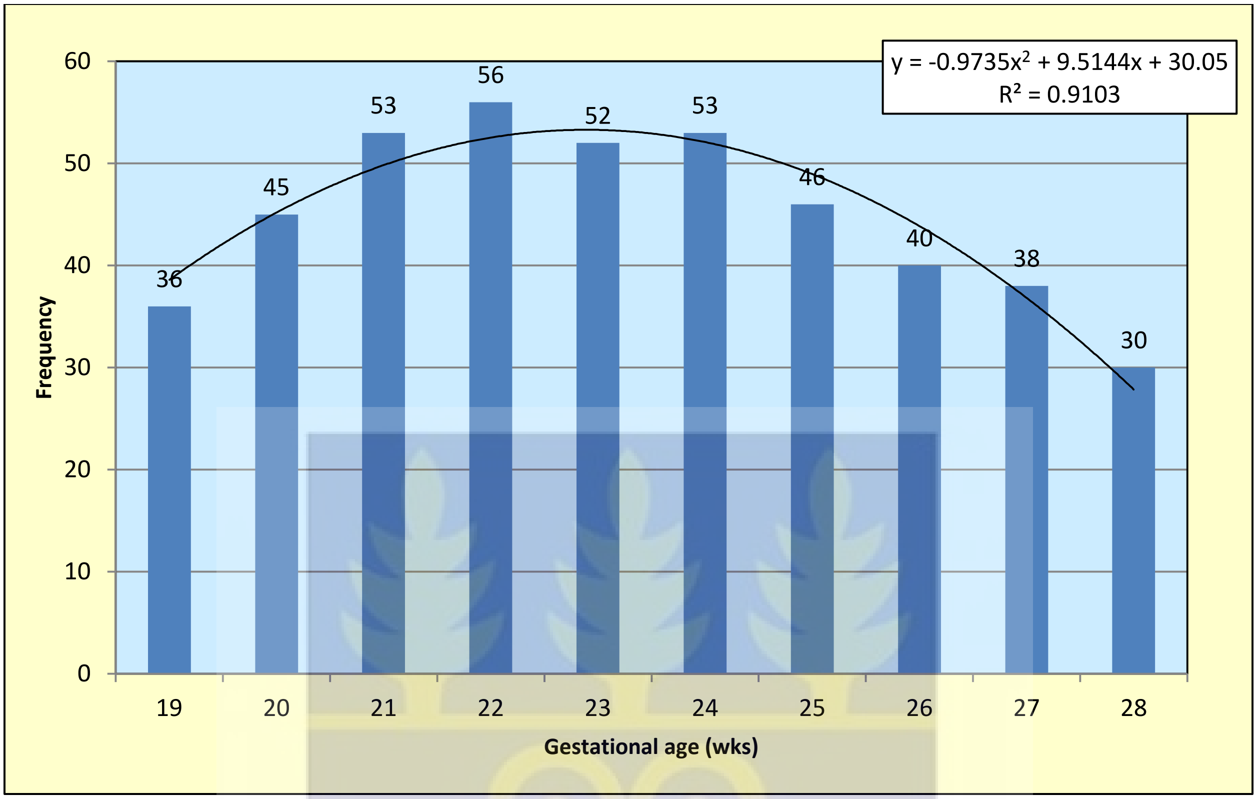

Fig. 4.2: Number of fetuses per gestational age

The number of fetuses higher than 50 were recorded between the gestational ages of 22- 24 weeks, representing 47.55% (*n*= 213) of the population. The lowest frequencies were fetuses that had completed 28 weeks (*n*=30, 6.70%) and 19 weeks (*n*=36, 8.04%) of gestation respectively. The average gestational age was estimated 22.5 ± 5weeks with a corresponding frequency of 1.99 ± 8 fetuses per week.

4.4 FETAL BIOMETRIC ANALYSIS

4.4.1 Analysis of the Mean Fetal Biparietal Diameters

The mean BPD of fetuses of each of the 10 gestational ages (19weeks - 28weeks) was calculated. This was done for each ethnic group and the results analyzed by using Kruskal Wallis test. The analysed results and variation of the fetal BPD with gestational age from the 4 ethnic groups are shown in Table 4.6 and Fig. 4.3 respectively.

Table 4.6: Mean BPD values among second trimester fetuses

Gestational age /weeks		Ethnic groups				
		Akan	**Mole-Dagbon**	**Ewe**	**Ga-Adangbe**	***p- value***
	n	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	
19	36	44.08 ± 1.12	44.10 ± 1.37	44.43 ± 1.27	43.83 ± 2.32	0.916
20	45	45.93 ± 1.16	45.75 ± 0.87	46.40 ±1.43	46.38 ± 1.69	0.619
21	53	53.39 ±.0.87	53.21 ± 0.80	54.00 ± 1.79	51.83 ± 1.85	0.028*
22	56	55.53 ± 1.14	55.47 ± 1.13	55.98 ± 1.19	55.64 ± 1.12	0.335
23	51	56.72 ± 1.09	57.38 ± 0.87	56.45 ±1.44	56.91 ±1.38	0.270
24	53	59.26 ± 0.99	59.43 ± 1.09	59.05 ± 1.25	59.30 ± 1.49	0.808
25	46	62.81 ± 1.47	62.58 ±1.00	61.79 ± 1.84	62.30 ± 2.00	0.590
26	40	65.07 ± 1.54	65.00 ± 1.33	64.25 ± 2.12	64.63 ± 1.92	0.855
27	38	66.38± 1.89	66.50 ± 1.43	66.22 ± 2.39	66.67 ± 1.63	0.995
28	30	70.60 ± 1.65	70.44 ± 1.33	70.00 ± 1.41	70.00 ± 1.58	0.833

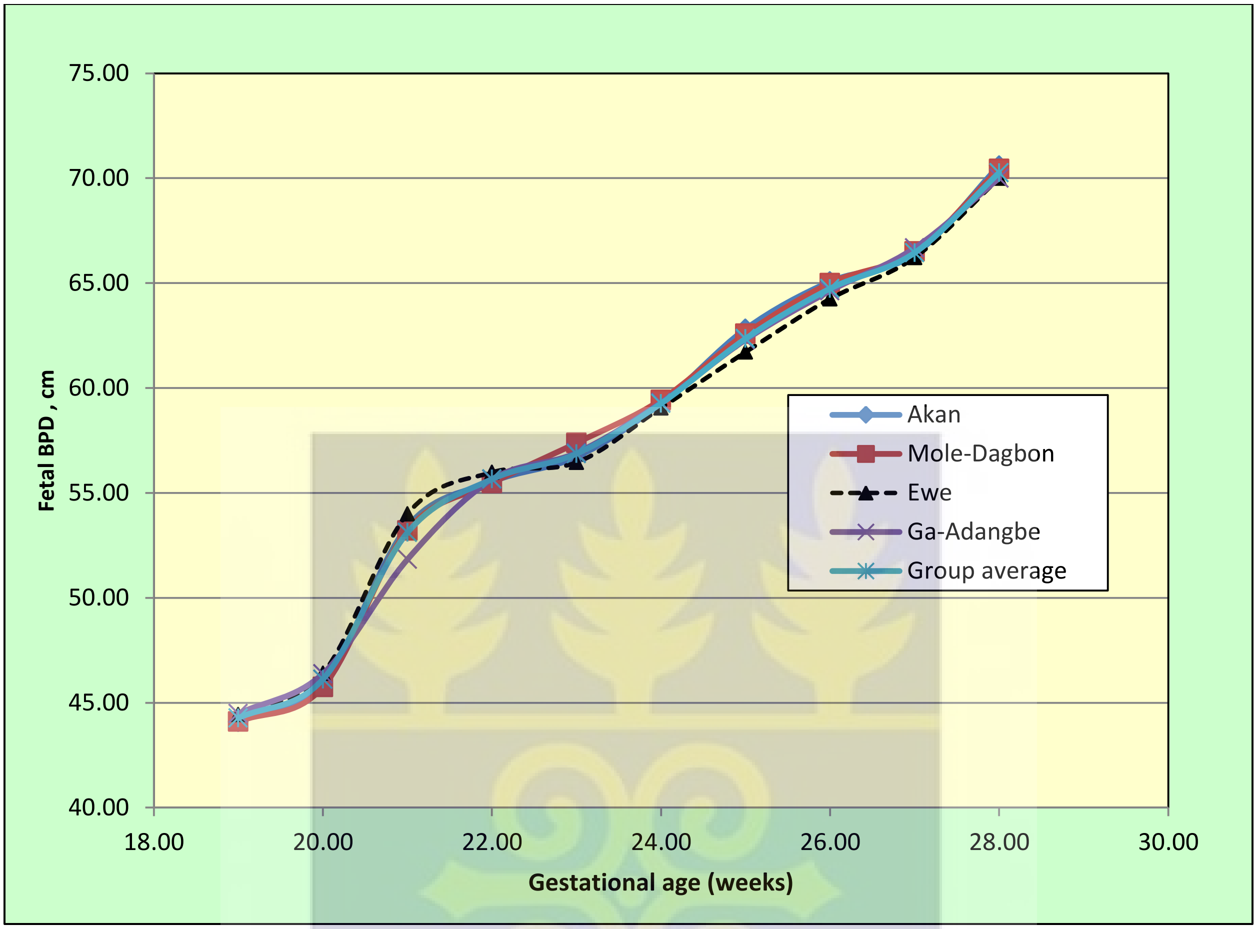

Fig. 4.3: Variation of fetal BPD with gestational age of different ethnicities

The *p*-value for each of the 10 gestational ages analysed generally was $p > 0.05$. This shows that there is no statistically significant difference in the BPD measured in the gestational ages 19-28weeks except in gestational age 21weeks which showed a significant difference ($p=0.028$) in the measured parameter among the four groups. The ethnic group average BPDs for the 10 gestational ages were Akan: 57.98cm; Mole-Dagbon: 57.99 cm; Ewe: 57.85 cm;, and Ga-Adangbe: 57.81 cm. The overall average fetal BPD for all the ethnic groups was 57.91 cm. From Fig. 4.3, the results of the study showed an increasing BPD with gestational age for all the ethnic groups. From the statistics, a linear regression coefficient R^2 =0.976 was established between the BPD and gestational age.

4.4.2 Analysis of Mean Fetal Head Circumference

Fetal head circumference is one of the fetal biometric measurements determined in this research study. The results and statistical of the mean fetal HC estimated for the second trimester fetuses of the ethnic groups at the study sites are shown in Table 4.7. A variation of the fetal HC with gestational age for the 4 ethnic groups is presented in Fig. 4.4.

Table 4.7: Head circumference values among second trimester fetuses

Gestational age /weeks	Ethnic groups					
	No.	**Akan**	**Mole-Dagbon**	**Ewe**	**Ga-Adangbe**	*p-value*
		Mean ± sd	Mean ± sd	Mean ± sd	Mean ± sd	
19	36	164.85± 2.38	164.80± 2.62	164.00± 3.00	163.83± 3.43	0.869
20	45	182.33± 3.75	182.50± 4.78	181.30±3.95	182.88± 4.05	0.857
21	53	192.00±.2.68	193.36± 2.62	192.82± 3.34	192.67± 3.23	0.621
22	56	203.53 ±2.92	205.47± 2.10	204.42± 3.34	203.82± 3.09	0.330
23	51	214.50± 3.48	215.92± 2.66	216.18±3.46	216.45±3.64	0.417
24	53	223.12± 3.43	224.93± 2.95	223.23± 2.92	223.22± 2.77	0.362
25	46	234.25±3.99	236.33 ±2.84	236.67± 2.06	236.78± 2.64	0.390
26	40	244.64±2.95	244.50± 2.84	243.88± 3.23	244.63± 2.72	0.980
27	38	252.15± 2.27	253.10± 3.03	251.78± 3.63	251.67± 3.27	0.704
28	30	262.70± 3.92	265.11± 2.32	264.50± 2.66	263.40± 3.36	0.430

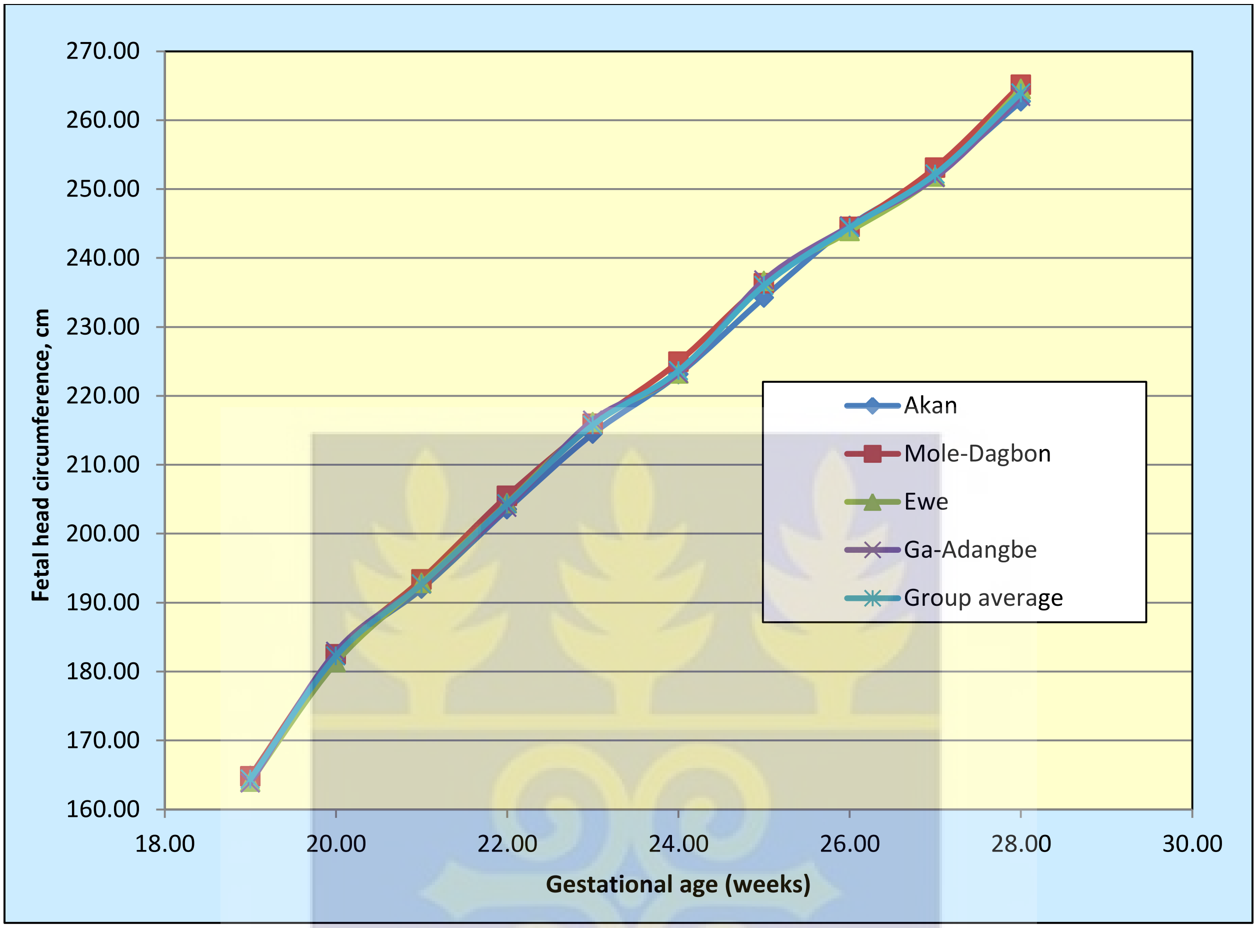

Fig. 4.4: Variation of fetal head circumference with gestational age of different ethnicities

All estimated *p-values* for each group measure exceeded the theoretical value of 0.005. Hence, the results established no significant difference among the four ethnic groups in respect of their HCs. The computed ethnic group average of the fetal head circumferences for the 10 gestational ages were Akan: 217.41cm; Mole-Dagbon: 218.60 cm; Ewe: 217.88 cm; and Ga-Adangbe: 217.94 cm, while the overall average fetal HC for all the ethnic groups was 217.96 cm. The results illustrated in Fig. 4.4 showed a more linear increasing variation between the fetal HC and gestational age for all the ethnic groups. Compared to the BPDs, the statistics established a stronger linear regression coefficient R^2 =0.992 between the HC and gestational age.

4.4.3 Analysis of the Mean of the Measured Fetal Femur Length

Fetal femur lengths were also measured during the study. The statistical results of these measurements and corresponding variation of the fetal femur lengths with gestational age are presented in Table 4.8 and Fig. 4.5 respectively.

Table 4.8: Mean fetal femur length values among second trimester fetuses

Gestational Age/weeks		Ethnic group				
		Akan	Mole-Dagbon	Ewe	Ga-Adangbe	*p-value*
	No.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	Mean ± s.d.	
19	36	31.02±0.65	31.51±0.59	30.40±0.53	30.78±0.53	0.038*
20	45	33.86±1.16	34.35±0.79	33.76±0.51	34.31±0.51	0.331
21	53	36.30±0.41	36.89±0.47	36.23±0.42	36.21±0.42	0.004*
22	56	37.93±1.03	38.95±0.76	37.71±0.65	37.74±0.65	0.001*
23	51	40.10±0.97	40.95±1.05	39.58±0.47	39.74±0.47	0.010*
24	53	43.59±0.60	44.48±0.65	43.75±0.70	44.14±0.70	0.005*
25	46	45.51±0.80	45.98±0.59	45.47±0.71	45.56±0.71	0.485
26	40	47.04±0.83	48.03±0.85	46.91±0.67	46.78±0.67	0.016*
27	38	49.90±1.09	50.94±0.62	49.79±0.75	50.27±0.75	0.054
28	30	52.25±0.84	54.19±0.84	53.02±0.27	53.86±0.27	0.001*

The analysis of the data on femur lengths generally established statistically significant differences among the four ethnic groups (p <0.05) although the femur lengths measured from fetuses at gestational ages 20 weeks ($p=0.331$), 25 weeks ($p=0.485$) and 27 weeks ($p=0.054$) showed no significant differences. The computed ethnic group averages were Akan: 41.75cm; Mole –Dagbon: 42.63 cm, Ewe, 42.63 cm; Ga-Adangbe: 41.46 cm. The overall ethnic group average femur length was estimated at 41.91 cm. The shortest fetal femur length (average) was recorded in favour of the Ga-Adangbe ethnic group.

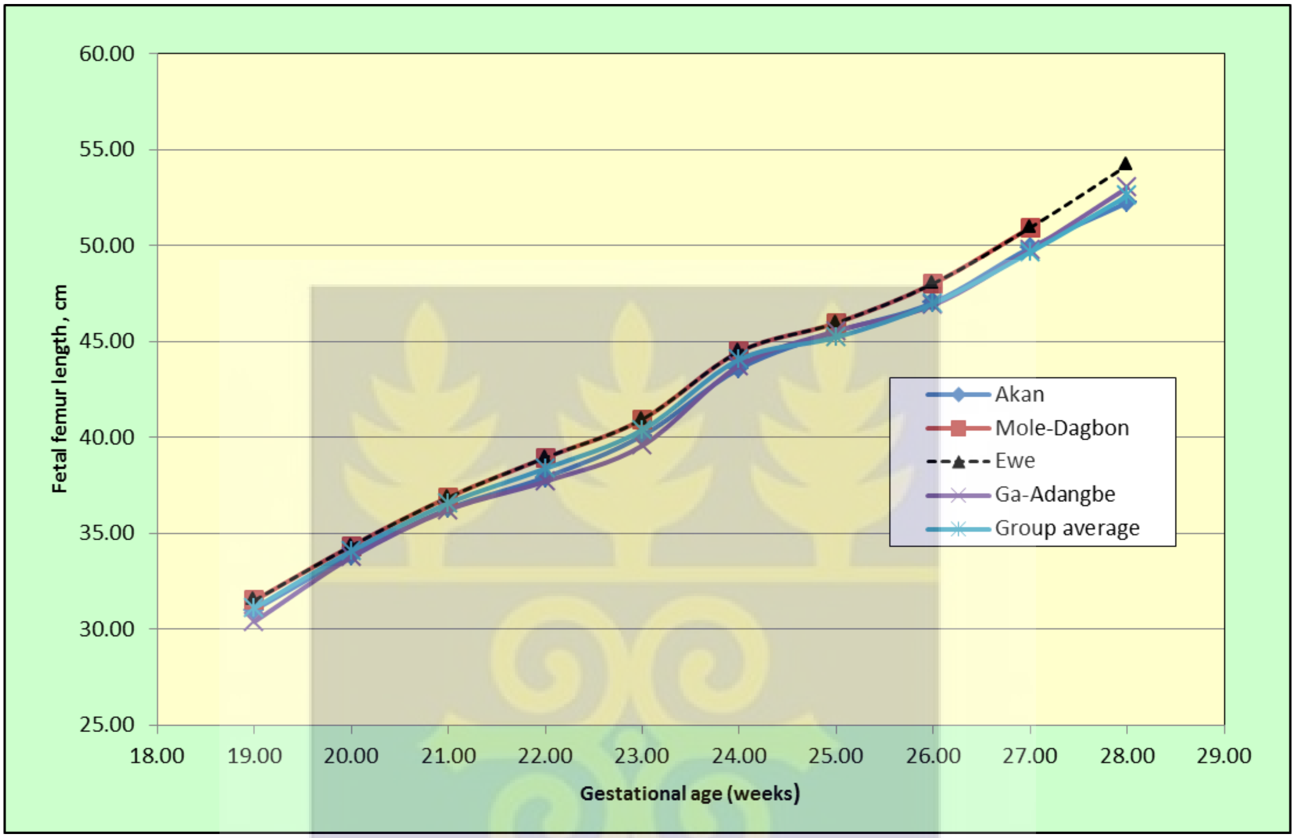

Fig. 4.5: Variation of fetal length with gestational age

As observed for the BPD and head circumference, the results illustrated in Fig. 4.5 showed an increasing linear variation of the femur length with gestational age for all the ethnic groups. A linear regression coefficient R^2 =0.994 between the femur length was estimated.

4.4.4 Analysis of mean fetal femur lengths between ethnic groups

The variations observed in the mean fetal femur lengths among the four ethnic groups were further analysed to ascertain which specific ethnic group showed much deviation from the rest as shown in Table 4.9. This was achieved by conducting multiple comparisons using Bonferroni's test. The mean value of femur length was compared across ethnic groups and gestational ages.

Table 4.9 (Bonferroni) Inter-ethnic comparisons of fetal femur lengths

		Akan	Mole-Dagbon	Ewe	Ga-Adangbe
19w	Akan	-	0.589	0.398	1.000
	Mole-Dagbon	0.589	-	0.016*	0.299
	Ewe	0.398	0.016*	-	1.000
	Ga-Adangbe	1.000	0.299	1.000	-
20w	Akan	-	1.000	1.000	1.000
	Mole-Dagbon	1.000	-	0.840	1.000
	Ewe	1.000	0.840	-	1.000
	Ga-Adangbe	1.000	1.000	1.000	-
21w	Akan	-	0.032*	1.000	1.000
	Mole-Dagbon	0.032*	-	0.027*	0.017*
	Ewe	1.000	0.027*	-	1.000
	Ga-Adangbe	1.000	0.017*	1.000	-
22w	Akan	-	0.010*	1.000	1.000
	Mole-Dagbon	.010*	-	0.004*	0.006*
	Ewe	1.000	0.004*	-	1.000
	Ga-Adangbe	1.000	0.006*	1.000	-
23w	Akan	-	0.070	0.762	1.000
	Mole-Dagbon	0.070	-	0.002*	0.007*
	Ewe	0.762	0.002*	-	1.000
	Ga-Adangbe	1.000	0.007*	1.000	-
24w	Akan	-	0.003*	1.000	0.268
	Mole-Dagbon	0.003*	-	0.036*	1.000
	Ewe	1.000	0.036*	-	1.000
	Ga-Adangbe	0.268	1.000	1.000	-
25w	Akan	-	1.000	1.000	1.000
	Mole-Dagbon	1.000	-	1.000	1.000
	Ewe	1.000	1.000	-	1.000
	Ga-Adangbe	1.000	1.000	1.000	1.000
26w	Akan	-	0.024*	1.000	1.000
	Mole-Dagbon	0.024*	-	0.028*	0.010*
	Ewe	1.000	0.028*	-	1.000
	Ga-Adangbe	1.000	0.010*	1.000	-
27w	Akan	-	0.083	1.000	1.000
	Mole-Dagbon	0.083	-	0.060	0.982
	Ewe	1.000	0.060	-	1.000
	Ga-Adangbe	1.000	.982	1.000	-
28w	Akan	-	0.0001*	0.407	0.005*
	Mole-Dagbon	0.0001*	-	0.050*	1.000
	Ewe	0.407	0.050*	-	0.513
	Ga-Adangbe	0.005*	1.000	0.513	-

*The mean difference is significant at the 0.05 level

Significant variations were seen in 7 out of the 10 (70%) gestational ages compared under this research. Sixty individual comparisons were made. The mean femur length measurement of fetuses of a particular ethnic group at a given gestational age was compared with of each of the three other ethnic groups at the same gestational age. (Table 4.9). Seventeen out of 60 (28.3%) showed significant differences in the femur lengths. The least instances of variations was 1.67% (*n*=1) and was recorded in gestational age 19weeks. The highest frequency of comparisons with significant variations was recorded at gestational ages 21, 22, 26 and 28weeks. Fetuses at the ages, 23 and 24weeks of gestation showed 2 instances of significant variations in the comparison. A summary of these is presented in Table 4.10.

Table 4.10 Summary I of Inter-ethnic variations

Gestational age/ weeks	Inter-Ethnic groups	frequency	Significance of variation (*p-value*)
19	Mole-Dagbon vrs Ewe	1	0.016
21	Mole-Dagbon vrs Akan	3	0.032
	Mole-Dagbon vrs Ewe		0.027
	Mole Dagbon vrs Ga-Adangbe		0.017
22	Akan vrs Mole-Dagbon	3	0.010
	Ewe vrs Mole-Dagbon		0.004
	Ga-Adangbe vrs Mole Dagbon		0.006
23	Ewe vrs Mole Dagbon	2	0.002
	G-Adangbe vrs Mole-Dagbon		0.007
24	Akan vrs Mole-Dagbon	2	0.003
	Ewe vrs Mole-Dagbon		0.036
26	Mole-Dagbon vrs Akan	3	0.024
	Ewe vrs Mole-Dagbon		0.028
	Ga-Adangbe vrs Mole-Dagbon		0.010
28	Mole-Dagbo vrs Akan	3	0.0001
	Ewe vrs Mole-Dagbon		0.050
	Ga-Adangbe vrs Akan		0.005

Table 4.11: Cross-tab of Table 4.10

	Akan	Mole-Dagbon	Ewe	Ga-Adangbe
Akan	-	5	0	1
Mole-Dagbon	5	-	7	4
Ewe	0	7	-	0
Ga-Adangbe	1	4	0	-

From Tables 4.10 and 4.11 above 17 instances of inter-ethnic comparisons of measured fetal femur lengths showed statistically significant variations. Seven out of 17 (41.18%) of the comparisons with significant variations were between fetuses of Mole-Dagbon mothers and those of Ewes mothers. Five (29.41%) of such significant observations were between fetuses Mole-Dagbon mothers and those of Akan mothers. This distribution of significant inter-ethnic variations are shown in Table 4.12

Table 4.12 Summary II of Inter-ethnic comparisons

Inter-ethnic comparison			Frequency of Significant variations	%	Total no. of comparisons (Gestational weeks compared)	Percentage occurrence of significant variations
Mole-Dagbon	vrs	Ewe	7	41.18	10	70
Mole-Dagbon	yrs	Akan	5	29.41	10	50
Mole-Dagbon	vrs	Ga-Adangbe	4	23.53	10	40
Akan	vrs	Ga-Adangbe	1	5.88	10	10
Akan	vrs	Ewe	0	0.00	10	0
Ewe	vrs	Ga-Adangbe	0	0.00	10	0
Total			**17**	**100**		

From Table 4.12, out of the total 17 inter-ethnic comparisons which showed significant variations 16 (94.12%) were between fetuses of Mole-Dagbon mothers and fetuses of the other ethnic groups. One instance (5.88%) of significant variation was recorded between fetuses of Akan mothers and Ga-Adangbe mothers. The above table also shows that a total of 10 mean femur length comparisons were made between fetuses of Mole-Dagbon mothers and those of Ewe mothers. Seven (70%) of the comparisons showed significant differences between them. Again femur lengths of Mole-Dagbon fetuses varied from that of Akan and Ga-Adangbe in 5(50%) and 4(40%) respectively. Comparisons of femur lengths made between Ewe and Ga-Adangbe, and Akan and Ewe showed significant variations in fetuses at none of the 10 gestational ages compared.

4.5 ANALYSIS OF MATERNAL DEMOGRAPHICS AND ANTHRPOMETRIC PARAMETERS

Maternal demographics (age), anthropometric parameter (height) and parity were measured and analysed with chi-square. They are shown in Tables 4.13 and 4.14.

Table 4.13: Comparison of Maternal factors: Age and Height

Demographics	**Ethnic groups**				
	Akan	Mole-Dagbon	Ewe	Ga-Adangbe	p-value
Age	29.04 ± 0.36	28.52 ± 0.50	29.34 ± 0.56	29.31 ± 0.49	0.542
Height	163.21 ± 0.40	164.51 ± 0.49	163.58 ± 0.51	163.11 ± 0.64	0.208

Table 4.14: Analysis of parity among ethnic groups

Statistical indices	Value	*df*	Asymp. Sig. (2-sided)
Pearson chi-square	11.949	12	0.450
Likelihood ratio	13.123	12	0.360
Linear/bi-linear association	0.51	1	0.821
Number of valid cases	448.000		

The results revealed no significant difference among the participants with respect to ages (p=0.542) and height (p=0.208). In subjecting these results to Chi-square analysis it was realized that there was no statistically significant difference in parity among the ethnic groups (p=0.51).

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

The preceding Chapter has shown the results and their analysis in relation to the aim of this work. In this Chapter, a discussion of the major findings of this research work is presented. A comparison with literature and findings of other studies, as well as the clinical relevance of these findings are made.

5.2 GENERAL OVERVIEW

Current fetal biometry with the help of ultrasound imaging is based on growth charts which are preset in the ultrasound equipment. These charts do not factor in the possibility of ethnic variations among the subjects assessed with this equipment. In particular, for pregnant women undergoing obstetric scans the fetal and maternal characteristics are not considered in the formulation of equations for computing the expected fetal measurements. Non-recognition of such determinants can lead to wrong assessment or dating of the foetus. The result of this situation is the difficulty in distinguishing a constitutionally small fetal parameter from one suffering from growth restriction. But factors which can significantly impact on the outcome of fetal biometric findings must be considered in the final analysis of fetal calculations. The city of Accra is cosmopolitan with multiethnic communities. Pregnant women from these communities attending routine antenatal clinics will standardly have a minimum of three ultrasound scans, during which fetal biometry is carried out. The current practice assumes that the populations from the different ethnic backgrounds have similar characteristics or the variations they might present are not statistically significant. However, the reviewed published works show that ethnicity and for that matter maternal and fetal characteristics determine the outcome of fetal biometry

5.3 SAMPLE CHARACTERISTICS

This research was conducted to verify if there were ultrasound-based fetal biometric variations among second trimester (19-28weeks) fetuses whose mothers belonged to the Akan, Mole-Dagbon, Ewe or Ga-Adangbe ethnic groups in cosmopolitan Accra. The data were collected prospectively for this study rather than being obtained from an available clinical dataset. Data for the study were obtained from only one ultrasound examination from each pregnant woman. After recruitment,participant who did not meet the inclusion criteria were exempted from the study. The response rate was 64% giving a final sample size of 448 which was not as large as that used in other works (Ogasawara, 2009; Yeo et al, 1994). This was, however, similar to that used by Jacquemyn et al (2000) and larger than that used by Salpou et al (2008) and Raman et al (1996).

A larger sample size than the current although might have given a more precise outcome of the investigation. The sample size was limited by the fact that many of the women interviewed either did not know or were not sure of their last menstrual period which was considered in this work as the reference for computing the gestational age of the foetus. This observation of uncertain LMP was also made by other studies (Salpou et al, 2008; Campbell et al, 1985). The latter demonstrated that 45% of pregnant women are uncertain of menstrual dates as a result of poor recall, irregular cycles, bleeding in early pregnancy, or oral contraceptive use within 2 months of conception. The gestational age range (19-28weeks) was chosen because ethnic influence and maternal anthropometric characteristics are significantly associated with ultrasound measurements in second to third trimester and not in the early gestation according to Albouy-Llaty et al (2011) and Salpou et al (2008).

5.4 INFLUENCE OF MATERNAL FACTORS

Maternal factors compared among the participants in this study were age, height and parity. These were compared among the participants and also analyzed for their possible influence on the outcome of the fetal biometrics. From the inferential analysis made on the results these factors did not vary significantly among the participants and therefore could not have any statistically significant influence on the outcome of fetal measurements made. Although the mean age of the participants from the Mole-Dagbon ethnic group in this study was younger 28.52±0.50 years as compared to 29.04±0.36 years, 29.34±0.56 years and 29.31±0.49 years for Akan, Ewe and Ga-Adangbe participants respectively this difference was not significant enough (p=0.542) to have any association with the fetal biometry in this study.

In the same vein, maternal heights showed no association with the observed fetal biometry. The mean height (164.51±0.49cm) of the participants from Mole-Dagbonethnic was greater than that (163.21±0.40cm) of participants from Akan ethnic by almost 1.30cm, Ewe participants (163.58±0.51) by about 0.93cm and Ga-Adangbe participants (163.11±0.64cm) by about 1.40cm. These differences however, showed no significant association with the observed fetal biometry (p=0.208) and could not have influenced the variation observed in any of the fetal measurements. The comparison of the number of parity of the participants from the four ethnic groups showed no significant variations (p=0.51) as shown in Table 4.10.

Contrary to the considerations of the studies (Lindell et al, 2012; Albouy-Llaty et al, 2011; Sarris et al, 2010; Salpou et al, 2008), maternal demographics such as weight and body-mass index (BMI) were not considered in this study. This was because the weight and BMI factors specifically influence fetal corpulence measures such as abdominal circumference and estimated fetal weight (Lindell et al, 2012; Drooger, 2005). However, fetal weight was not assessed in this study due the high level of imprecision generated in the measurements of fetal abdominal circumference, which is the most difficult measurement to obtain reproducibly due to the absence of clear limits for positioning of the ellipse (Butt, 2014; Albouy-Llaty, 2011).Maternal nutrition, socioeconomic status and level of education were other maternal factors that were not measured although they could influence fetal biometry. However, the study was focused on ‗constitutional' rather than ‗environmental' factors; therefore variables selected were on the basis of their being constitutional characteristics. Paternal height was not considered in this work because Albouy-Llaty (2011) had reported that maternal height had a greater impact on ultrasound measurements than paternal height. This assertion is contrary to an earlier work by Griffiths et al (2007) which established that both paternal and maternal heights had similar effects on birth weight.

5.5 FETAL BIOMETRY FINDINGS

Fetal biparietal diameter, head circumference and femur length were the parameters compared among the fetuses of the participants. Among the fetal parameters not analysedwere abdominal circumference, estimated fetal weight, the gender, and genetic screening for congenital anomalies.

5.5.1 Fetal Biparietal Diameter

This study showed that generally there were no significant variations in the BPD measured for the 19-28weeks fetuses of the four ethnic groups. BPD increased with gestational age for all the ethnic groups. The variation of BPD with gestational age showed a very good correlation (R^2= 0.9761). The similarity in BPD measurements observed in this study could be explained by the fact that there is possibly no significant difference among the ethnic groups to translate into difference in in the measured BPD. It could also be attributed to the fact there were no significant differences among the mothers with respect to their measured characteristics. Thus the resultsobtained here are a reflection of the influence of the maternal factors on the BPD measurements. In particular, the BPD findings agree with many previous studies (Sarris et al, 2010; Bottomley et al, 2009; Drooger et al, 2005; Johnsen et al, 2004). However, in the work by Salpou et al (2008) which demonstrated significant maternal differences there were no corresponding differences in the BPD measurements. The present observation also showed interpreted as no significant difference in the ethnic groups studied with respect to BPD. This is similar to the observation made by Jacquemyn et al (2000).

Contrary to the general trend, comparison of the BPD measurements at gestational age 21weeks showed a significant variation (p=0.028) among the four ethnic groups. This isolated variation, however, was not consistently translated from the preceding weeks into the subsequent weeks. This might be as a result of sample size (n=53). A larger study population would have cancelled out the few individual variations. This variation could also be attributed to possible variations in skull shape, such as dolichocephaly or brachycephaly; hence some authors feel that BPD is less reliable than HC. (Nyberg et al, 2003; Hadlock et al 1991,1982, 1981).

5.5.2 Fetal Head Circumference

The trend of observations made for the head circumference measurements were similar to that seen in the BPD. There were no significant variations when the HCs of the four ethnic groups were compared. There was a linear increasing variation between the fetal HCs and gestational ages for all the ethnic groups. Compared to the BPDs, the statistics established a stronger linear regression coefficient $R^2 = 0.992$ between the HC and gestational age which in all four ethnic groups.

The reasons assigned to the findings in the fetal BPD measurements hold good for the observations made in respect of the HC. In particular, there appears to be similarities among the ethnic groups; no significant differences or variations among the pregnant women in this study with respect to the measured determinants These observations are in agreement with independently reported findings by Zaki et al (2012) and Salpou et al (2008). The former group observed that HC appeared to show no significant variations even across races, and further reported that HC measurements conducted in Egyptian populations were similar to those from Italian and United Kingdom populations. The latter studies on the other hand showed that ethnic variations were not associated with HC measurements. The findings in this work, however, are contrary to the report of Jacquemyn et al (2000) which indicated significant HC variations among different ethnic groups.

The stronger linear variation between the HC and gestaional observed in this workagrees with those reported by Nyberg (2003), Hadlock et al, (1991, 1982, and 1981). This finding may result from the fact that fetal HC measurement is more robust and reliable than BPD because the former is not affected by variation in skull shape like dolichocephaly and brachycephaly. It may also be due to the fact HC correlates better to gestational age than the other standard parameters like BPD and LMP in the second trimester (Butt, 2014).

5.5.3 Fetal Femur Length

The study showed that there was a consistent increase in fetal femur length with gestational age for all the four ethnic groups. A linear regression coefficient of $R^2 = 0.994$ was also measured. The comparison of the femur lengths showed general significant variations among the ethnic groups. These variations were measured in 7 out of the 10 (70%) gestational ages from which fetal femur lengths were compared. Comparison of femur lengths among the groups at gestational ages 20, 25 and 27weeks showed a p value >0.05. Though this may agree with the reported findings in the work of Salpou et al (2008) it is contrary to the general trend of significant variations among the ethnic groups.It could therefore be interpreted as being the result of small sample size.

5.6 FETAL FEMUR LENGTH VARIATIONS

5.6.1 Inter-ethnic Comparisons: Variations from Gestational Ages

Comparisons of femur lengths measurements between each ethnic group and the other three groups individually showed that in 17 (28%) of the 60 instances of inter-ethnic comparisons of the variations were significant and were most frequent among fetuses of gestational ages 21, 22, 26 and 28weeks. These recorded 3 (17.6%) instances each and a collective total of 12 instances (70.6%). The least frequency was a single (5.9%) instance and was registered among fetuses of 19 weeks gestational age. A possible explanation for this observation could be that maternal ethnicity is strongly associated with fetal biometry during this mid pregnancy period. The non-expression of this observation in all the 19-28 weeks gestational ages could be explained by the fact that the sample size of each of the weeks studied was too small. A larger population size would be required to confirm thisobservation.

5.6.2 Inter-ethnic Comparison: Variations Between Ethnic Groups

The summary of the inter-ethnic comparisons (Table 4. 12) indicates that among the significantly varied femur lengths measurements, 16(94.12%) out of the total 17 comparisons were between fetuses of Mole-Dagbon mothers and fetuses of the other ethnic groups.Seven (41.18%) out of this total significant variations were recorded when the mean femur length of Mole-Dagbon fetuses were compared to those of Ewe fetuses. This implies that the mean femur length of Mole-Dagbon fetuses varied from that of Ewe fetuses in 7(70%) out of the 10 gestational weeks in which the fetal parameters were compared. Five (29.41%) and 4(23.53%) of the significant femur variations were measured between Mole-Dagbon fetuses and Akan and Ga-Adangbe fetuses respectively. Mole-Dagbon fetal femur lengths varied from those of Akan fetuses in 5(50%) and Ga-Adangbe in 4(40%) of the times the mean femur lengths were compared.

No significant variations were measured between either Akan and Ewe or Ewe and Ga-Adangbe fetal femur lengths. This means that the femur lengths of the second trimester fetuses whose mothers belonged to the Mole-Dagbon ethnic group varied significantly most of the times (94.12%) from the femur lengths of the fetuses of the other three ethnic groups. There was a single isolated variation at gestational age 28weeks between Akan and Ga-Adangbe fetal femur measurements. There were, however, no significant variations were measured when the femur lengths for Akan and Ewe fetuses or Ewe and Ga-Adangbe fetuses were compared.

5.6.3 Explanations for femur lengths variations between the ethnic groups

The variations in fetal femur lengths between the ethnic groups cannot be attributed to maternal age, height, or parity as these factors showed no significant variations among the participants considered in this study. Other maternal characteristics like nutrition, socioeconomic status and education were not considered in this research. Likewise, fetal gender, screening for genetic anomalies and paternal characteristics like height were also not considered. However, the variations of femur length of fetuses of Mole-Dagbon mothers from those of fetuses whose mothers belonged to the Akan, Ewe and Ga-Adangbe ethnic groups were consistent. The only obvious difference among these groups was ethnicity as the differences among them in all the other variables measured in this work were statistically not significant. Ethnicity therefore might have been the main factor influencing these variations.

5.6.4 Importance of Findings

This work established that femur length of Mole-Dagbon fetuses appear to vary significantly from that of Akan, Ewe and Ga-Adangbe fetuses. This finding will be very important information for the obstetric sonographer and the obstetrician attending to pregnant women from these ethnic backgrounds. It also sets the tone for further research with a larger study sample to verify if this is consistent nationally. Obstetricians will depend on this to make informed and reliable decision in fetal and maternal management during antepartum, peripartum and postpartum care.It will be beneficial in evaluating fetal growth, estimating gestational age, calculating the estimated fetal weight, predicting fetal maturity and intra uterine growth retardation in high risk cases. It will help avoid underestimation or overestimation of femur length and help make accurate assessment of fetal growth. This would help eliminate the potential dangers posed by misinterpretation of findings which do not account for this variation .

5.7 INFLUENCE OF ETHNICITY ON FEMUR LENGTHS VARIATIONS

The observation in this research is consistent with many others reported in the literature. It is in agreement with the findings in the work of Butt et al (2014) which reported that fetal femur length is known to vary somewhat with ethnicity.It is also in agreement with the study by Raman et al (1996) which reported that the femur length values of Malaysian population resulted as significant difference with the common reference femur length values from United States of America, United Kingdom and also with selected Asian populations like India, China, Korea and Japan. Zaki et al, (2014) also reported of similar findings.

These studies reported that the main difference between fetal biometric results in Egyptian population and those of the United Kingdom and Italian populations was in the femur length measurements. Jacquemyn et al, (2000) had earlier confirmed that differences do exist for femur lengths among autochthonous Belgian and migrants from Morocco and Turkey.

The findings in this work, however, are not consistent with the findings from Salpou et al (2008), which reported of no significant difference in the femur lengths measured among fetuses from Fulani, and Kidir in Cameroun. In that study, however, the sample size was smaller compared to this current study and others in which fetal femur lengths were observed to have varied with ethnicity.

5.7.1 Other Possible Interpretations of Fetal Femur Length Variations Among Ethnic Groups

Other factors have been attributed to variations in fetal femur lengths among different ethnic groups. As indicated by Drooger et al (2005), although variations in fetal femur lengths might be observed between ethnic groups additional factors other than ethnicity might be involved in the explanation of these ethnic differences.

a. Influence of Maternal Nutritional Status

Maternal nutrition has been cited as another influencing factor on femur length. Chang et al (2003) had reported that fetal femur length was influenced by maternal dairy intake in pregnant African American adolescents. The study suggested that consumption of less than 2 servings of dairy products per day by pregnant adolescents might negatively affect fetal bone development by limiting the amount of calcium provided to the fetus. This has been confirmed by the findings in the work of Young et al (2012) which reported that maternal vitamin D status and calcium intake interact to affect fetal skeletal growth in utero in pregnant adolescents. The work revealed that fetal femur and humerus *z* scores and neonatal birth length were significantly greater ($p < 0.03$) in adolescents consuming ≥1050 mg than in those consuming <1050 mg calcium per day. It was further asserted that maternal 25-hydroxyvitamin D [25(OH)D] concentration of more than 50 nmol per litre was significantly positively associated with fetal femur and humerus z scores ($P < 0.01$). This reason has been recently affirmed by Garza-Gisholt et al (2012) that maternal diet and vitamin D intake during pregnancy are associated with bone health during childhood. According to Bonjour et al (2009), bone mass is determined by genetics 60-80% of the time; however, diet has to be considered an important modifiable factor to promote bone accretion.

The current research, however, did not consider maternal nutritional status though a very influencing factor. The emphasis here was to investigate the variation according to constitutional determinants. A further research where maternal nutritional status is controlled is recommended.

b. Other factors

This work could not exhaust all the factors that could contribute to influencing variations in femur lengths of fetuses. In addition to ethnicity and maternal nutritional status, other factors might have contributed to the variations measured in this work. Hynes et al (2012) have indicated that the ways in which parents influence the anthropometry of their offspring stem from a myriad of factors including age, race, parental birth anthropometry, parental height, parental weight, maternal weight gain during pregnancy, maternal activity, diet including calorie, protein and micronutrient intake. Others include parity and interpregnancy interval, socioeconomic status, maternal pathology (hypertension, malaria, anaemia and diabetes) and lastly exposure to toxins (cigarette smoke and alcohol). This is reflected by the findings of Albouy-Llaty (2011) which suggested that paternal characteristics and parental height were more strongly associated with femur length. The report specifically suggested that maternal and paternal anthropometric characteristics are significantly associated with ultrasound measurements in mid to late pregnancy and provide support for the use of these characteristics in ultrasound fetal size reference charts.

In the current study some of these factors such as maternal pathology and exposure to cigarette smoke were excluded and therefore controlled. Others including ethnicity, age, parity and maternal height were analysed.

Other possible interpretations that could be assigned to the variations in the measured femur lengths in fetuses are errors in scanning methods. Variations have been observed in the measurement of fetal femoral diaphysis length by ultrasound in which the effect of depth, the angle of the bone relative to the axis of the sound beam, the machine, and the observer on the precision of measurement have been identified as determinants. Using analysis of variance techniques, Leesoway et al (1990) demonstrated that depth, angle, and machines have significant effects. The variations due to changes in angle were highly significant ($p<0.001$) and may be controlled by obtaining the measurement with the femur perpendicular to the sound beam. It was again demonstrated that errors due to variation between machines were also highly significant ($p<0.001$).

In the case of the current study, however, the error from the effect of the angle of bone relative to the axis of the beam was eliminated by obtaining the measurements with the femur perpendicular to the sound beam. This has been described in the paragraph on Scan procedure in the Methodology. Again, the effect of machine as another source of error was eliminated by scanning with the same ultrasound machine throughout the study in the two study sites. The error from observer precision on measurements was eliminated by ensuring that only the researcher performed the entire scan and did all the measurements. As stated in the Methodology, the first ten measurements were reviewed by the resident obstetrician to check for consistency with the protocol.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

A study on the Variation of fetal biometry with maternal ethnicity has been performed. This has been a cross-sectional study involving second trimester fetuses belonging to four principal ethnic groups. Fetal parameters have been measured and compared among these ethnic groups. The findings and their interpretations have been enumerated in the previous chapter. In this closing Chapter, conclusions, the recommendations and some of the limitations encountered in the research are presented.

6.2 CONCLUSIONS

There has been a growing interest in adjusting fetal size charts for genetic influence. This has resulted in a renewed body of publications regarding race-adjusted and/or customized fetal size charts. It is well known that ethnicity has a significant influence on fetal biometry. The findings from this study agree with the general assertion and also suggest that maternal ethnicity appear to have influence over femur length of second trimester fetuses. They also suggest that maternal ethnicity appear not to have influence over biparietal diameter and head circumference of second trimester fetuses. Maternal demographics and parity appear not to influence fetal biometry. In conclusion this research has firmly established that ultrasound-measured fetal biometry varies according to maternal ethnicity. It was able to prove that the variations in the fetal biometric measurements were statistically significant. It, however, failed to establish that the fetal biometric variations were due to maternal anthropometrics. Further research with a larger and a more representative sample size is required to validate the findings in this work and also to determine the necessity for ethnic-specific fetal biometry chart.

6.3 RECOMMENDATIONS

In view of the findings from this work the following recommendation are being made:

- Obstetric sonographers and obstetricians-gynaecologists should consider soliciting ethnic background of their clients as part of the clinical history. Obstetric examination request forms should be designed to solicit such information as ethnicity of parents and grandparents of fetuses.

- Since the study showed significant variation in the fetal femur lengths a validation study in a large independent data set should be considered as the current study could not employ a large sample size due to time and financial constraints
- The current study sampled only second trimester pregnant women living in only Accra therefore a more representative sample size taken across the nation for a national perspective as same ethnic group living under different environmental conditions may show corresponding different characteristics.
- Due to the fact that most of the interviewees could not remember their last menstrual period (LMP) it will be prudent to calculate the fetal gestational age with reference to the biparietal diameter which is also more reliable that the certain last menstrual period.

- Further studies should consider screening for fetus genetic disorder and congenital abnormalities like Down‘s syndrome the presence of which can negatively influence the biometry outcome.
- A similar study should take into consideration other maternal factors like maternal nutrition, body mass index (BMI) and paternal height.

6.4 LIMITATIONS

The current study encountered the following limitations:

- **Sample size**. The sample size was small compared to many other studies carried out earlier by other researchers. This might have influenced the results recorded. The result may therefore not reflect the phenomenon of fetal variations with maternal ethnicity in cosmopolitan Accra.
- **Ethnicity**. Though ethnicity of the participants and that of the fathers of the fetuses were self-reported there could have been instances of mixed ethnicity as there are many inter-ethnic marriages in communities in Accra. The questionnaire used in this work did not ask for the ethnicity of the parents of fetuses down to the grandparents.
- **Gestational age**. Using the last menstrual period as the reference for calculating the gestational age of the fetus has its limitations. Though LMP and menstrual cycles were self-reported they might have been influenced by some inaccuracies as the mothers might not have reported them exactly.
- **Other Determinants**. This research did not factor in other parental characteristics which could have also contributed to the variations measured in the femur lengths. Principal among the factors were maternal nutrition and paternal height.

- **Genetic screening**. Fetuses were not screened for possible genetic anomalies like Down's syndrome which could have contributed to the current findings.
- **Time Constraints**. This study was conducted within a time period of six months. A longer time schedule could have enabled the researcher increase the sample size and also include other factors.
- **Financial Constraints**. A larger financial input and sponsorship could have enabled the involvement of more facilities and expanded the study population size.

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