STUDY OF CRANIAL CAPACITY IN RELATION TO INTELLIGENCE AND OTHER ANTHROPOMETRIC PARAMETERS AMONG STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIA

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DEPARTMENT OF HUMAN ANATOMY
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JULY, 2015

DECLARATION

I, GANYU MUJIDAT OLUWATOYIN, declare that the work in the thesis titled ‘‘**STUDY OF CRANIAL CAPACITY IN RELATION TO INTELLIGENCE AND OTHER ANTHROPOMETRIC PARAMETERS AMONG STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIA**was carried out by me under the supervision of Prof. S. S. Adebisi andDr. A.O. Ibegbuin the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria . The information used for my literature review was fully acknowledged in the text and references. No part of this dissertation was previously presented for another degree or diploma at any University.

_____ _____

MUJIDAT OLUWATOYIN GANIYUDATE

CERTIFICATION

The project thesis titled **STUDY OF CRANIAL CAPACITY IN RELATION TO INTELLIGENCE AND OTHER ANTHROPOMETRIC PARAMETERS AMONG STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIAby GANIYU, MujidatOluwatoyin**meets the regulations governing the award of degree of Masters of Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This work is dedicated to my parents, husband and children, for all the sacrifices they made to help me get this far and for always believing in me.

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LIST OF ABBREVIATION

A	=	Age
BMI	=	Body Mass Index
HC	=	Hip circumference
HT	=	Height
WC	=	Waist circumference
WT	=	Weight
NC	=	Neck circumference
Chest C	=	Chest circumference
MUAC	=	mid upper arm circumference
CC	=	cranial capacity
CB	=	cranial breadth
CH	=	cranial height
CL	=	cranial length
BW	=	brain weight
CI	=	cerebral index
IQS	=	intelligence quotient test

ABSTRACT

The capacity of the cranium has in many studies been used to indirectly reflect the volume of the brain, predict mental ability and reflects racial characteristics. The Aim of the present work is to study cranial capacity in relation to other anthropometric parameters and intelligence amongstudents of Ahmadu Bello University, Zaria, Nigeria. Five hundred and fifty one (551) students of ABU students both male and female aged 18 to 30 years old were randomly selected for this study.Data was analyzed using Sigma Stat version. Data on sex, age ethnic background, parental level of education and occupation of participants; cranial dimensions and other anthropometric parameterswere taken and recorded in their respective questionnaires. Craniometric parameters: cranial length (CL), cranial breadth (CB), cranial height (CH) were measured using spreading calliper and cranial capacity (CC), brain weight (BW) and cerebral index computed. Other anthropometric parameters measured include: Height(cm), weight(kg),body circumferences(chest, mid upper arm, waist, and hip), and body mass index(kg/m²) was calculated. Intelligent quotient (IQ) test designed by Department of Psychology, Ahmadu Bello University was used to test individual difference in intelligence. The present study showed that, males were taller and heavier than females (p □ 0.01) The circumferences (neck, mid upper arm and chest) of males were higher than females (p □ 0.01). However, waist and hip circumferences were higher in females than males ($p = 0.96$ and p□ 0.01) respectively. Cranial length, breadth and height were higher in males than females ($p \leq 0.01$). Cranial capacity and brain weight were higher in the males than females ($p \leq 0.01$). However, cerebral index and intelligence quotient test were higher in females than males ($p \leq 0.05$). There was no relationship between Craniometric parameters and test of intelligence

inmales, while in females some relationship was observed. Relationship was observed between anthropometry and test of intelligence.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The evaluation and measurement of human body dimensions are achieved by physical anthropometry (Adebisi, 2008). Craniometric study is an important fraction of anthropometry that can be employed in the determination of the cranial capacity of an individual. It was observed that the racial characteristics are best defined in the skull, cranial capacity being one of the most important parameters for determining the racial difference and sexual dimorphism (Adebisi, 2003). Cranial capacity is a measure of the volume of the interior of the cranium which is sometimes used as a rough indicator of the size of the brain and are affected by environmental, ecological, biological, geographical, racial, gender and age factors (Golalipour and Kamran, 2004;Golalipour*et al*., 2005; Heidari*et al*., 2006). The capacity of the cranium has in many studies been used to indirectly reflect the volume of the brain, predict mental ability (Gault*et al*., 1988; Wolf *et al*., 2003; Mazonakis*et al*., 2004) and reflects racial characteristics and thus has been thought to be one of the commonest items in physical anthropological studies (Hwang *et al*, 1995). Anthropometric studies carried out on the cranium as it relates to gender have shown a lot of variations with males possessing higher values than females in both adults and neonates (Acer *et al*., 2007; Garba*et al*., 2008; Raji*et al*., 2010).

Quantitation of the volume of biological specimens, especially complex biological organs such as the brain, is fraught with technical difficulties. Consequently, different approaches have been implemented to estimate various indices of brain size. Data on the size of head compartments

have been provided by numerous studies using different technology. Autopsy studies have been carried out systematically for more than 100 years. However, inherent technical and logistical problems affectthe measurements such as the type of illness, intervals between deathand brain removal, weighing in the fresh or fixed condition. A few investigations have also been made on living subjects using the linear dimensions of the heads measured by a classic cephalometry. This method is easy and economical to carry out.

Human brain morphometry advanced dramatically by the invention of the modern neuroimaging methods. Magnetic resonance imaging (MRI) techniques make it possible to abstract quantifiable information from the slices taken through different parts of the living body. This image slicing approach is directly comparable to the physical or mechanical slicing which is routine in anatomy and pathology both at macroscopical and microscopical levels. Two such new techniques are available now for the estimation of brain volume using Cavalieri principle which has been employed in physical slices of brain and other organs. Mayhew and Olsen (1991)have tried this application in the human brains. A complete set of parallel slices through a fixed human forebrain was generated by magnetic resonance imaging and the Cavalieri principle, combined with point-counting, was used to estimate brain volume.

Alternative sampling schemes for estimating volumes were then assessed by taking systematic random selection of slices. At present a completely automated longitudinal and cross-sectional measurement method named SIENA (structural image evaluation, using normalization of atrophy) and SIENAX (an adaptation of SIENA for cross-sectional measurement) respectively are available. SIENA performs segmentation of brain from non-brain tissue in the head and

estimates the outer skull surface for both time-points, and uses these results to register the two images, while correcting (normalizing) for imaging geometry changes. Then the registered segmented brain images are used to find local atrophy, measured on the basis of the movement of image edges.

Cotter *et al.* (1999) compared stereological and planimetric methodologies performing MRI in formalin fixed brains. Planimetry involves tracing around a region of interest on a computer screen. The actual volume of the tissue of interest is then calculated from the number of pixels encompassed within the traced regions in each of a series of images. In contrast, the stereological technique of point-counting, based on the Cavalieri principle, estimates the volume of an object by dividing the object into a series of parallel sections of equal thickness and assessing the area of the object in a sample of the sections by point-counting. Mazonakis*et al.* (2004) also compared stereological and planimetric TIV (total intracranial volume) estimations on CT scans concluded the application of the optimized stereological technique on CT scans enables the efficient estimation of TIV. Acer *et al.* (2007) compared stereologic, planimetric, and anthropometric approaches for the estimation of TIV. They stated that there were good agreements between the anthropometric assessments (linear) and three-dimensional methods, i.e. point counting approach. Moreover, there is no need of sophisticated and expensive tools for the application of planimetry method to estimate the TIV.

Several investigators have estimated the cranial capacity in the past to determine sexual dimorphism and ethnic diversity. Most of these studies have been made on dry skulls using linear dimension, packaging methods or occasionally radiological methods while few studies have been

made on living subjects (Manjunath, 2002). Indirect methods of estimating cranial capacity employ a number of formulas that uses external dimension of macerated skulls, living subjects or antero-posterior and lateral direct roentgenograms of the skulls (Lee and Pearson,1901; Williams *et al*., 2000).

The influence of genetic, physiological and anatomical differences between males and females have been well documented in various studies (Moore and Dalley, 1999; Chandrashekar*et al*., 2005; Guyton and Hall, 2006) although, some differences are indistinctive, most are related to body dimensions which are determined by anthropometry (Williams *et al*., 1995; Chamela, 1997). Knowledge of cranial capacity is useful in differentiation of racial and sexual differences either in a dry skull or of a living subject and may be important to the study and comparison of the crania of populations with various fundamental differences like geographic, ethnic, dietry and environment (Manjunath, 2002). This information is useful in correlating cranial capacity with other cranial measurements and in studies of primate phylogeny

Medically, an analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusually large, small or misshaped skull (Haack and Meihoff, 1971). It can also provide useful results in the field of forensic anthropology and pediatrics as an indicator of skull development in both female and male individuals (Pereira*et al*., 2008). Cranial capacity is also a good determinant of normal or abnormal skull; because, living humans have a cranial capacity ranging from about 950 to 1800 cubic centimeter, with an average of about 1400 cubic centimeter (Milner, 1990). Anthropometry is an important tool in the study and understanding of human biological variability, including morphological variation as a universally

applicable, non invasive and inexpensive method (WHO, 1995). Biological relationships and distances between human individuals and groups can be assessed by the use of anthropometric data (Wang, 2003).

Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. Intelligence is not merely book learning, a narrow academic skill, or test-taking smarts, rather, it reflects a broader and deeper capability for comprehending our surroundings – 'catching on,' 'making sense' of things, or 'figuring out' what to do (Gottfredson, 1997). Psychologists' measure intelligence using a range of tests called IQ (Intelligence Quotient) tests. IQ tests come in a variety of forms. Some require an individual to engage in reasoning in order to solve novel problems, which may be presented in verbal, numerical or diagrammatical form.

1.2 Zaria at a glance

1.2.1 Location

The Main Campus of Ahmadu Bello University is located in Samaru, a suburb of Zaria in Kaduna State, Nigeria. Samaru is situated on latitude 112 °12" N and longitude 07° 37" E, at an altitude of 550-700 meters. It is about 13km from Zaria-city on Sokoto road, 8km to Shika and 7km from Bassawa. The Samaru town is the fourth and the most recent addition to the Zaria suburban area made up of Zaria-City, Tudun-Wada, the Government Reservation Area (GRA), and Sabon-Gari. Samaru evolvedfrom a small colonial farming settlement to become a large

community, a melting pot, often referred to as "the University village". It is cosmopolitan in nature, drawing and fusing people of divergent national and international backgrounds.

Zaria itself is a very large, heterogeneous city whose 1.490,000 population comes from different parts of the world. It is second in size only to the State capital, Kaduna. Zaria is flashily accessible from different parts of the country by air via Kaduna, Kano, and Abuja and by rail and road via Kaduna, [Kano and Sokoto. Zaria is located on the high plains of Northern Nigeria, 652.6 Meters above the sea level, some 950km away from the coast. The Zaria region is characterized by gentle rolling plains dotted with groups of rocky residual hills developed on granite bedrock (NEP, 2012).

1.2.2 Weather

Zaria possesses a tropical continental climate with a pronounced dry season, lasting up to seven months (October - May). During the dry season, a cool period is usually experienced between November and February.' This emanates from the influence of the North-easterly winds (the Harmattan) which control the tropical continental air mass coming from the Sahara. This weather prevails over most parts of the country. The NE winds are characterized by hazy to dusty conditions and low temperatures, as low as 10°C at night. In the afternoons, up to 42°C is sometimes recorded. The humidity also drops to less than 15% in December/January.

Zaria experiences a brief period of hot but dry weather in March and April, followed by a progressive incursion of tropical maritime air mass from the Atlantic Ocean which displaces the NE (Harmattan) winds. During this short period, the mean daily maximum temperatures are fairly stable, and they range from 38°C to 42°C. After that, the South Westerly Monsoon winds laden with moisture bring the rain in thunderstorms and squalls with heavy fall of high

intensities. The rainy season lasts from May to September/October with long-term annual rainfall of 1040mm in about 90 rain days (NEP, 2012).

1.2.3 Zaria as a center of learning

It was not by accident that Ahmadu Bello University was located in Zaria, a city that possesses different types of educational and research institutions. In terms of the diversity and size of student population, there is hardly any town in Nigeria which surpasses Zaria. The concentration of the institutions of higher learning has made Zaria famous regionally, nationally, and internationally. Indeed, this fame has its antecedent in the past when *Birnin Zaria* (Zaria-city) was a leading centre of learning in the Central Sudan.

Established in the fifteenth Century, *Birnin Zaria* is one of the oldest towns in Northern Nigeria. Zaria seems to owe its origins to the settlement of refugees who were uprooted by a series of raids launched from the expanding kingdom of Kano, but the status of the settlement was significantly elevated by its conversion into the capital of the emergent kingdom of Zazzau, Zaria's advantageous geographical location and its status as the capital city of a rapidly expanding kingdom ensured its steady growth. By the early part of the 16th century, *Birnin Zaria* had become sufficiently important to attract the attention of Leo Africanus, who described it as "a rich city with an extensive commercial network". This prosperity attracted immigrants from various parts of the Sudan, notably from Borno. By the 17th Century, several colonies of Borno immigrants were located both within and outside Zaria city. Other immigrants from the Western Sudan later joined these. By the 18th Century, the educational and Islamic activities of these immigrants made Zaria one of the leading centers of learning in Hausaland. Students and

scholars from many places therefore frequented it. The location of the Ahmadu Bello University in Zaria thus gives credence to the city's famous epitaph as the city of knowledge (NEP, 2012).

1.3 Statement of the research problem

Anthropometric study in Nigeria has just started to receive attention and more so, comparative data for cranial capacity and anthropometric variables in relation to intelligence. Statistical data on cranial capacity which is useful in the study of racial and sexual differences either on a dry skull or of a living subject and the importance to the study and comparison of the crania of populations with various fundamental differences like geographic, ethnic, dietary and environment are just gain consideration.

1.4 Justification

This study is designed to provide a reference data for anthropometric variables and cranial dimension of the groups to be studied. The sexual differences in cranial dimensions emphasize the significance of applying the anatomical variation data to an individual subject in a given population. Many of the measurements and indexes could be used in genetic studies of different populations or in studies comparing individual families.

1.5 Significance of Study

This study highlights the racial and sexual dimorphism in cranial capacity in students of Ahmadu Bello University, Zaria. It also provides a comparative data in the various ethnic groups as a representative sample of the country and the magnitude of ethnic differences in cranial capacity, anthropometry variables and intelligence. The data serves as a baseline study for determining

cranial capacity and intelligence in Ahmadu Bello University Students. Reference to normative sequential measurements of the skull is essential in diagnostic appraisal of certain neurological disorders such as microcephaly, macrocephaly megaencephaly etc.

1.6 Study Hypotheses

The study is designed with the following hypotheses:

- Craniometric parameters will be different across the groups under study.
- Craniometric parameters will predict sexual dimorphism in the study population.
- There will be a correlation between cranial capacity and all cranial dimensions to be measured.
- There will be correlation between Craniometric parameters and test of intelligence.
- There will be correlation between Craniometric parameters and other anthropometric parameters.

1.7 Aim and Objectives

1.7.1 Aims

The Aim of the present work is to study cranial capacity in relation to other anthropometric parameters and intelligence amongstudents of Ahmadu Bello University, Zaria, Nigeria.

1.7.2 Objectives

This study was designed with the following objectives and to investigate:

- If there exist ethnic differences in craniometric parameters, other anthropometric parameters and intelligence among students of ABU, Zaria.

- Sexual dimorphism in craniometric parameters, other anthropometric parameters and intelligence
- The relationship between craniometric parameters and intelligence and other anthropometric parameters and intelligence.
- The influence of parental socio- economic status on craniometric and other anthropometric parameters.
- The relationship between craniometric and other anthropometric parameters.

1.8 Limitations of study

- The use of just a single measure of intelligence quotient, non-verbal intelligence quotient test.
- The participants refused answering the test of intelligence question.
- Loss of questionnaires

CHAPTER TWO

LITERATURE REVIEW

2.1 The Human Skull

The skull is certainly the most important part of the body for identifying and classifying primates (Conroy, 1990). It is extremely complex and as such has a wealth of features that can be used for taxonomy and as developmental indicators (Aiello and Dean, 1990). Much of the variation among skulls (especially within species, or between closely related species) does not depend on the presence or absence of specific features (non-metric traits) but on the difference in size and shape of the elements. To quantify this difference, a lot of effort has gone into measuring skulls; the most important use of the skull in terms of human evolution is in taxonomy. The other importance of skull anatomy is by linking structure with function in order to reconstruct behaviour as such provides evidence of the size and shape of the soft tissues such as brain, eyes, nose, ears and vocal apparatus. The direct functions of the skull are to provide a bony framework for the teeth and the muscles of mastication, and for support and protection of the soft tissues of the head (Aiello and Dean 1990).

2.2 Genetic variation in the human skull

The human skull is an important source of information for phylogenetic and population-genetic studies (González-José *et al*. 2003; Ackermann and Cheverud, 2004). The complex morphology of the skull is usually compared in a series of craniometric measurements and it has been demonstrated that moderate amounts of genetic heritable variation underlie these traits (Sparks and Jantz, 2002; Carson, 2006). To some extent heritability suggests that skull morphology has substantial potential to evolve and that craniometric characters have the potential to provide

consistent phylogenetic signals. Nevertheless, most studies have disregarded the integrated nature of the skull (McCarthy and Lieberman, 2001; Bookstein*et al*. 2003; Bastir*et al*. 2004). The estimation of the genetic and non-genetic components underlying the phenotypic variation of the human skull has long been a major focus of anthropological research (Kohn*et al*, 1991; Varela and Cocilovo, 1999; Konigsberg, 2000). The first studies addressing this issue date back to the first decades of the 20th century (Dahlberg, 1926) but the interest increased at the end of the century because evolutionary biologists reconsidered the use of skeletal remains to unravel human micro evolutionary paths (Relethford, 1994). This new paradigm was built upon the growing evidence that suggested that human patterns of craniofacial variation reflected the underlying genetic patterns of variation (Buikstra*et al*. 1990). A wide range of studies have estimated the heritability of craniofacial traits (Konigsberg &Ousley, 1995; Nikolova, 1996; Arya*et al*. 2002; Johannsdottir*et al*. 2005). The general conclusion of these studies is that human craniofacial traits have moderate to high degrees of genetic variation. However, the comparison of results from different studies is controversial as they have been computed on very different kinds of samples: living humans or skeletal remains from different geographical regions, accounting for different familiar relationships, twins, nuclear or extended families and using different statistical methods. Moreover, one of the main problems concerning the heritability estimation of cranial measurements in humans is that suitable, large and pedigree-structured skull series are almost non-existent.

The patterns of genetic variation of craniometric traits have thus been analysed previously, but the patterns of genetic correlation among them are nearly unexplored. This issue is of crucial importance because morphological integration is pervasive in the human skull (Lieberman *et al*.

2000; Bastir and Rosas, 2006) and integration between characters can limit the evolvability of traits and determine their evolutionary response (McGuigan, 2006).

2.3 Morphological integration in the human skull

Integration is expressed through covariation between traits and it plays a key role in the evolution of complex morphological structures such as the human skull, as it can enhance or constrain the evolution of its morphology towards certain directions of shape change (Klingenberg, 2004, 2005). Morphological integration assumes that functionally and/or developmentally related traits will be coinherited and will produce coordinate responses to evolution (Cheverud, 1995).

The human skull comprises three regions with different developmental origins and functional requirements (Carlson, 1999): The regions are the cranial base, the cranial vault and the face. The cranial base is formed from endochondral bone that arises from a cartilaginous precursor originated from mesoderm (Mooney *et al*. 2002). The base supports the inferior parts of the brain as well as the pons, the medulla oblongata and the brain stem (Richtsmeier, 2002). The cranial vault is formed from membranous bone of paraxial mesodermal and neural crest origin and it gives room and protects the cerebral hemispheres and the cerebellum. The facial skeleton ossifies intramembranously from neural crest precursors (Sperber, 2002) and it surrounds the pharynx as well as the oral, respiratory and orbital cavities, supporting the functions of feeding, breathing and vision. The cranial base is the most ancient structure and has been highly preserved through phylogeny (Carlson, 1999). Therefore, it is considered that the cranial base is under stronger genetic control than the cranial vault and the face (Schilling and Thorogood, 2000). Moreover, it is assumed that the face is the most sensitive skull region to non-genetic factors because it plays

a key role in foraging and adaptation to environment and because facial growth is more extended into the postnatal period (Siebert and Swindler, 2002).

The level of integration between these skull regions is a matter of current research. Most studies of morphological integration in the skull of mammals (Hallgrímsson*et al*. 2006; Goswami, 2007), non-human primates (Marroig and Cheverud, 2001; Hallgrímsson*et al*. 2004) and humans (McCarthy and Lieberman, 2001) have considered integration at the phenotypic level. However, researchers have not identified yet which phenotypic units reflect morphogenetic units (Lieberman *et al*. 2004) and little is known about genetic integration and constraint in the functional and developmental regions of the skull.

Cheverud (1995) reported studies of cranial integration in primates and evidenced that functionally and developmentally related traits were in fact integrated and findings provided support to the functional matrix hypothesis (Moss and Young, 1960), which predicts that covariation within functional units is stronger than covariation within individual bones or osseous subdivisions with different developmental tissue origins. Afterwards, Hallgrímsson*et al*. (2004) reported that this functional and developmental pattern of craniofacial integration was consistent in rhesus macaques but not in mice. Studies of modularity in mammals (Goswami, 2006, 2007) and primates (Ackermann and Cheverud, 2004) have identified six phenotypic cranial modules, corresponding to four functional regions of the face ,namely the oro-nasal, the molar, the orbital and the zygomatic-pterygoid regions, one neurocranial region (the vault) and one basicranial region (the basicranium). The patterns of covariation within and among regions indicated that the face (the oro-nasal and the molar regions) and the cranial base were the highest integrated structures of the skull, whereas the cranial vault showed differing levels of integration.

2.4 Sex estimation using the skull

Konigsberg and Hens (1998) assessed brow prominence, mastoid size, supraorbital margin sharpness, nuchal crest development, and chin shape in an archaeological sample. Using the logistic regression model, accurate sex estimations were made in 81.16 percent of the combined sex sample, while the cumulative probit model yielded a combined correct classification rate of 83.33 percent. Walker (2008) used the same traits for a study using a sample composed of modern individuals and a sample composed of ancient Native Americans. The mastoid and glabellar areas proved to be the most successful in sex determination, while nuchal crest and supra-orbital margin were the worst. Sex estimations were the most accurate, achieving a rate of 89 percent, when all five traits were used in conjunction. The Native American sample tended toward more robusticity and less sexual dimorphism than the modern sample. In a test of 21 cranial sex indicators, Williams and Rogers (2006) reported correct classification rates between 24 and 96 percent for females and between 60 and 100 percent for males. When six of the indicators were excluded because of high intra observer error rates, overall accuracy was 92 percent, while the use of only the six best performing indicators (size and architecture, supraorbital ridge, nasal aperture, zygomatic extension, mastoid size, and gonial angle) produced an accurate sex estimation rate of 94 percent. Maat*et al.*,1997 tested the 15 morphological criteria of the skull recommended by the Workshop of European Anthropologists (1980) using a medieval churchyard sample of known sex. Each individual was sexed using the pelvic criteria as well as to determine concordance between the regions. Pelvic criteria were concordant with biological sex in nearly all cases. When the complete skull was available, agreement between skull and pelvic determinations was 96.2 percent, and for crania only concordance was 95.7 percent. However, when only the mandible was present, agreement only reached a rate of 69.5

percent. Loth and Henneberg (1996) tested the predictive value of posterior ramus flexure in determining sex. For the sample of 200 African blacks, most males exhibited flexure of the posterior border of the mandibular ramus at the level of the occlusal surface of the molars. In females, posterior borders were more often straight or exhibited flexure at a point closer to the condyle. This method was tested again on a sample of more diverse ancestry. For the African sample, sex was accurately determined in 99 percent of individuals, while for the combined sample of African individuals and the test group, which was comprised of pathological Africans and individuals from the Smithsonian Institution, sex was correctly classification in 94.2 percent of cases (with all groups performing with at least 91% success).

2.5 Cranial capacity

From the early nineteenth century, craniometry—the study of skull measurements—had been touted by racial researchers as one of the most important means of investigating human variety. Cranial measurements were thought essential not only for delimiting racial groups but also in gauging the levels of intellectual attainment achieved by different peoples arguing from the premise that the dimensions of the skull reflected the contours of the brain, the physical seat of the mind. Man's brain is relatively larger than other animals, it is natural for man to conclude that the brain is the hallmark of man and the measurement of it must be the key to the understanding of his unique intellectual capacity (Douglas, 1990). Measuring of man's potential intellectual capacity from sources other than direct observations and testing is derived from direct, indirect and inferential data. The direct data is obtained from measuring cranial capacity and examining casts which 'expose' the interior of the skull. The indirect evidence comes from the study of comparative brain sizes, which is based on the assumption that there is a correlation

between brain size and configuration and behavioral studies. Other indirect evidence comes from the study of fossil remains of non cranial parts which infer manual dexterity and visual acuity (Douglas, 1990).

The renowned French neurologist Paul Broca (1824–1880) measured external and internal skull dimensions and weighed wet brains at autopsy and observed that mature adults averaged a larger brain than either children or the very elderly, skilled workers averaged a larger brain than the unskilled, and eminent individuals averaged a larger brain than the less eminent. Brain size and cranial capacity are receiving much contemporary attention because of new technologies available to scan the brain and because a small robust relation has been established between intelligence test scores and brain size. The correlation between test scores and brain size estimated from magnetic resonance imaging (MRI) ranges from .35 to .47 with an average of about .40 (Raz*et al*., 1993; Wickett, *et a*l, 1994). Ankney (1992) analyzed sex differences from autopsied brain weights of adults and showed that at any given surface area or height, brains of White men are about 100 gm heavier than those of White women, and brains of Black men are heavier than those of Black women.

Rushton (1992) calculated cranial capacities for a stratified random sample of U.S. military personnel measured in 1988 for the fitting of helmets and confirmed Ankney's results with men averaging 110 cm^3 larger cranial capacities than women after correcting for the effects of stature and weight. Also, Rushton (1994) calculated cranial capacities from data based on tens of thousands of people from around the world collated by the International Labour Office in Geneva in 1990. After adjustments for the effects of body size, race, and sex, men averaged 160

cm³ more than women and Asians about 70 cm³ more than Africans, with Europeans intermediate.

2.6 Intelligence

Studies on intelligence started with an investigation conducted by Galton (1888) in United Kingdom, quantifying the relation between brain size and General Mental Ability (GMA) in living people. He reported that men who obtained high honours degrees had a brain size 2%–5% greater than those who did not. Following World War II (1939–1945) craniometry became associated with extreme forms of racial prejudice. Research on brain size and intelligence virtually ceased, and the literature underwent vigorous critiques (Tobias 1970; Kamin 1974). However, other studies later followed as modern studies confirm many of the earliest observations. Anthropologist Van Valen (1974) rekindled discussion of brain size/General Mental Ability relations in *Homo sapiens* by reviewing a handful of studies using external head size, he pointed out that correlations between IQ and overall brain size would be modest. Research into the causes of state differences in IQ can be informed by knowledge of the reasons or correlates of the individual differences in IQ. At the level of individuals, IQ is clearly a function of both genetics and environment (Bouchard, 2004). Although the specific genetic and environmental mechanisms that cause IQ are relatively unknown. Lynn and Vanhanen (2002) estimated the IQ of countries using data from the average of various measures of intelligence. Researchers have documented correlations between IQ and other variables when examined at the level of the individual. For example, IQ is a predictor of productivity at the individual level (Schmidt and Hunter, 1998), Likewise, IQ predicts health for individuals (Batty and Deary, 2005; Hart *et al*, 2005), IQ also predicts who is likely to engage in crime (Farrington, 2005),

Intelligent individuals tend to evaluate cognitively complex information more efficiently and accurately, thus making more informed decisions (Hunt, 1995;Gottfredson, 2004).

2.7 Differences in cognitive ability/intelligent quotient

Throughout the history of psychology, no question has been as persistent to resolution as that of the relative roles of nature and nurture in causing individual and group differences in cognitive ability (Loehlin*et al*, 1975; Degler, 1991). The scientific debate goes back to the mid-19th century, starting with the widespread use of standardized mental tests in World War I, average ethnic and racial group differences were found. Jensen(1969) concluded in his article that (a) IQ tests measure socially relevant general ability; (b) individual differences in IQ have a high heritability, at least for the White populations of the United States and Europe; (c) compensatory educational programs have proved generally ineffective in raising the IQs or school achievement of individuals or groups; (d) because social mobility is linked to ability, social class differences in IQ probably have an appreciable genetic component; and tentatively, but most controversially, (e) the mean Black–White group difference in IQ probably has some genetic component.

Herrnstein and Murray (1994) presented an update of the evidence for the hereditarian position along with several policy recommendations and an original analysis of the 12-year National Longitudinal Survey of Youth. The study show that most 17-year-olds with high scores on the Armed Forces Qualification Test, regardless of ethnic background, went on to occupational success by their late 20s and early 30s, whereas those with low scores were more inclined to welfare dependency. The study also found that the average IQ for African Americans was lower than those for Latino, White, Asian, and Jewish Americans. A meta-analytic review by Switzer and Tyler (2001) showed IQ differences also hold for college and university application tests

such as the Scholastic Aptitude Test and the Graduate Record Examination as well as for tests for job applicants in corporate settings and in the military. According to Schmidt & Hunter (1998), test scores are the best predictor of economic success in Western society; these group differences have important societal outcomes (Gordon, 1997).

2.8 Intelligent quotient and race

The IQ debate became worldwide in scope when it was shown that East Asians scored higher on IQ tests than did Whites, both within the United States and in Asia, even though IQ tests were developed for use in the Euro American culture (Lynn, 1978). Around the world, the average IQ for East Asians centers around 106; that for Whites, about 100; and that for Blacks, about 85 in the United States and 70 in sub-Saharan Africa. Most of the early research was conducted in the United States, but some was also performed in Canada and the Caribbean (Eysenck,1984; Osborne and McGurk, 1982; Flynn, 1980; Lewontin*et al*,1984).Study on the Black and the White 3-year-old children in the standardization sample of the Stanford–Binet IV show a 1 standard deviation mean difference after being matched on gender, birth order, and maternal education (Peoples *et al*,1995).Similarly ,the Black and the White 2½- to 6-year-old children in the U.S. standardization sample of the Differential Aptitude Scale have a 1 standard deviation mean difference. However on the Differential Aptitude Battery, by age 6, there was significant different in the average IQ of East Asian children, compared with White children and Black children (Lynn, 1996).

2.9 IQ differences among sub-Sahara Africans

A study conducted in Nigeria by Fahrmeier (1975) on the effects of schooling on cognitive development on children ages 6 to 13 years reported the children's mean score on the Colored Progressive Matrices was 12 out of 36, which is at the 4th percentile for 9½-year-olds on U.S. norms, an IQ equivalent of about 75. In Ghana, Glewwe and Jacoby (1992) reported a World Bank study that tested a representative sample of individuals ranging in age from 11 to 20 years old from the entire country. All had completed primary school; half were attending middle school. Their mean score on the Colored Progressive Matrices was 19 out of 36, which is below the 1st percentile for 15½-year-olds on U.S. norms, an IQ equivalent of less than 70. In Kenya, (Sternberg *et al*. 2001) administered the Colored Progressive Matrices to children ages 12 to 15 years old who scored 23.5 out of 36, which is about the 2nd percentile for 13½-year-olds, an IQ equivalent of 70. In Zimbabwe, Zindi (1994) reported mean IQs for 20 African 12- to 14-year-olds of 67 on the Wechsler Intelligence Scale for Children—Revised (WISC–R) and of 72 on the Standard Progressive Matrices. In South Africa, Owen (1992) found that African 12- to 14-year-old high school students solved 28 out of 60 problems on the Standard Progressive Matrices, which is around the 10th percentile, or an IQ equivalent of about 80. Again in South Africa, (Skuy*et al*,2001) found mean scores 1 to 2 standard deviations below U.S. norms on a wide variety of individually administered tests given to 154 African high school students under optimized conditions. Also, in a study at the University of Venda in South Africa's Northern Province by Grieve and Viljoen (2000), reported that students in 4th-year law and commerce averaged a score of 37 out of60 on the Standard Progressive Matrices, equivalent to an IQ of 78 on U.S. norms. A study at South Africa's University of the North by (Zaaiman*et al* ,2001) found the highest scoring sample of first-year mathematics and science students who scored 52 out of

60 on the Standard Progressive Matrices, which is equivalent to an IQ of 100. This higher score may reflect the fact that they were mathematics and science students, specially selected for admission to the university from a pool of 700 applicants on the basis of a math-science selection test. Rushton and Skuy (2000) conducted a study of Raven's Progressive Matrices in four separate studies at the University of the Witwatersrand in Johannesburg, South Africa; found African 1st-year psychology students averaged an IQ equivalent of 84. (Skuy*et al*., 2002) tested another 70 psychology students who averaged an IQ equivalent of 83. After receiving training on how to solve Matrices-type items, their mean score rose to an IQ equivalent of 96. Rushton *et al* (2003) gave nearly 200 African 1st-years engineering students both the Standard and the advanced version of the Raven's test and found they averaged an IQ of 97 on the Standard and 103 on Advanced.

2.10 Gene, environment and intelligent quotient

Dozens of twin, adoption, and family studies have confirmed the high heritability of intellectual and behavioral traits within a race (Bouchard, 1996; Deary, 2000; Bouchard and Loehlin, 2001). Most of these estimates have been calculated on White samples. A study conducted in United States by Osborne (1980) compared Black and White pairs of 12- to 18-year-old twins drawn from schools in Georgia, Kentucky, and Indiana, reported heritabilities of about 50% for both Blacks and Whites, all significantly different. Similarly, study of pairs of identical and pairs of non identical 12-year-old Japanese twins in Japan reported substantial high heritability of IQ (Lynn and Hattori, 1990). (McGue*et al*., 1993) reported that the average correlation of IQ between full siblings reared together reaches .49 in adulthood. The correlation in IQ for siblings reared apart as children is .24, which increases to .49 in adulthood. This shows that siblings grow

more similar to each other as they age. In genetically unrelated people reared together, such as adopted children, the correlation for IQ is .25 in childhood but decreases to .01 in adulthood. This shows, conversely, that unrelated people reared together grow less similar over time. Between childhood and adulthood the influence of the shared home environment on IQ decreases, whereas the effect of genetic similarity increases. (Plomin*et al*., 2001) then explained that the diminishing or even vanishing effect of differences due to the shared home environment can best be understood in terms of three components of gene– environment correlation and the change in their relative importance during development. The passivecomponent of the gene–environment correlation reflects all those things that happen to the phenotype, independent of its own characteristics. For example, children of academically oriented parents may inherit genes for academic ability and also be exposed (through no effort of their own) to stimulating intellectual environments. The reactivecomponent of gene– environment correlation results from the reaction of others to the expression of genetically based abilities, as when children with an unusual curiosity about science are given chemistry sets. The activecomponent of the gene–environment correlation results from children actively seeking experiences compatible with their genotypes, for example, going to science fairs rather than sports events or music concerts. From early childhood to late adolescence the predominant component of the gene– environment covariance gradually shifts from passive to reactive to active. The child's enlarging world is like a cafeteria in which choices become increasingly biased by genetic factors (Scarr and McCartney, 1983; Scarr, 1996). As individuals mature they seek out and even create their own experiential environment.

2.11 Brain size and intelligence

Studies on some participants show that individuals with larger brain volumes have higher IQ scores. Also some group of researchers have shown that using magnetic resonance imaging (MRI) to measure the volume of the human brain have found an overall correlation with IQ of greater than .40 (Vernon *et al*, 2000). Also in Rushton and Ankney (1996) research using simple head size measures with IQ score, found .20 correlations. The most likely reason why larger brains are, on average, more intelligent than smaller brains is that they contain more neurons and synapses, which make them more efficient. (Haier *et al*. 1995) tested the brain efficiency hypothesis by using MRI to measure brain volume and glucose metabolic rate to measure glucose uptake (an indicator of energy use). They found a correlation of –.58 between glucose metabolic rate and IQ, suggesting that more intelligent individuals have more efficient brains because they use less energy in performing a given cognitive task. In any individual, however, energy use increases with the increasing complexity of the cognitive task. Studies have also shown that correlations between brain size and IQ also hold true within families as well as betweenfamilies (Jensen & Johnson, 1994; Gignac*et al*., 2003), which also implies shared genetic effects. This also shows that families with larger brains overall tend to have higher IQs and, within a family, the siblings with the larger brains tend to have higher IQ scores. The within-family finding shows controls for most of the sources of variance that distinguish families, such as social class, styles of child rearing, and general nutrition, that differ between families. However, one study that examined only sisters failed to find the within-family relation (Schoenemann*et al*., 2000).

2.12 Socio-economic status and intelligence

Socio-economic status is a very important and basic parameter to study any characteristic prevailing in the society because this is what determines and influences one's place in social set up. The socio-economic status influences not only the physical setting where the home and neighbourhood are located but also the intelligence process. Thus, the intelligence behaviour could be the product of the socio-economic status to which the individual belongs (Vijayalakshimi, 1996). Children from favourable environment homes are found to be warm-hearted, outgoing and socially more intelligent than children from unfavourable homes (Rani, 1998). Nineteenth- and early twentieth-century data from researchers suggested that people in higher status occupations averaged a larger brain or head size than those in lower ones.A review on Galton's data analyzed by Johnson *et al* (1985), found that professional and semiprofessional groups averaged significantly larger head sizes in both length and width than unskilled occupational groups. The relationship between head size and occupational status has also been found after correcting for body size. Jensen and Sinha (1993) analyzed the head circumference data from the National Collaborative Perinatal Project (Broman *et al*., 1975) found a small but significant correlation of (0.10) with social class of origin within both the White and Black populations.

Jensen and Sinha (1993) also reanalyzed autopsy data reported by Passingham (1979) on 734 men and 305 women and found an overall correlation between brain mass and achieved occupational level of about 0.25, independent of body size. Studies using brain imaging techniques have also reported significant main effects of brain size on occupational status and education level; higher-status subjects had, on average, a larger brain than lower-status subjects (Andreasen*et al*., 1990). Intelligent Quotient test scores are significantly correlated with the

socioeconomic hierarchies of modern Europe, North America, and Japan (Herrnstein & Murray, 1994; Jensen, 1998). A study of children born between 1950 and 1956 replicated the relationship with measures made of father's SEP at the time of the child's birth and the child's General Mental Ability at ages 7, 9, and 11 years after adjustment for maternal characteristics and perinatal factors, father's SEP accounted for 6% of the variation in child's GMA at age 11 (Lawlor*et al*., 2005).

2.13 Body height

Body height is a classic example of a polygenic inherited trait, which is also substantially influenced by environmental factors during fetal life, childhood, and adolescence (Sinclair, 1989). Recently, interest in body height as an indicator of childhood living conditions has increased remarkably in the field of epidemiology. Body height has also been used as a societal level indicator of the standard of living. The important focus here is on the dramatic increase in body height throughout the world during the 20th century.

The increase in body height has been uniform with the possible exceptions of the two world wars, and it seems to be a universal process occurring worldwide in both affluent societies and in the developing world (Silventoinen, 2003). In Europe, mean body height has increased about 1 cm per decade during the 20th century (Cavelaars *et al.,* 2000). This increase is similar across European countries, and the differences in mean body height have generally remained stable over birth cohorts. Earlier research reported that the Dutch people are the tallest people in Europe (Cavelaars *et al.,* 2000). Reasons for this geographic pattern are not fully understood, and both environmental and genetic differences between the populations offer potential explanations. However, since the increasing trends in body height during the last century have generally been

very similar in European populations, it is probable that genetic factors are most important when explaining these geographic differences in height. Variation in the heritability estimates of body height was larger between the study populations in women compared to men. Previous report have suggested that women are more resistant to environmental stress than that in men (Stini, 1969), in addition, heritability of body height is lower among women than in men and there is also greater geographic variation in the heritability estimates among women. This is probably due to unidentified environmental factors specific to women only, which may vary more in time and between populations (Silventoinen*et al.*, 2003).

2.14 Waist hip ratio

In most Western cultures, females with low Waist Hip Ratio are rated as more sexually attractive (Henss, 1995; Furnham*et al.*, 1997). This preference has ecologic validity because higher ratios (eg> 0.80) are associated with various adverse factors. Female waist-hip ratio begins to decline during childhood from 1.03 at 4 months of age to 0.78 at the time of menarche (Fredriks*et al.*, 2005), and there is a steep increase in hip circumference just before menarche (Forbes, 1992). Young German women in higher quartiles for self-reported hip, thigh and leg circumferences had higher odds of menarche in cross-sectional bivariate analyses (Merzenich*et al.*, 1993).

2.15 Body mass index

An index that expresses adult weight in relationto height, it is calculated as weight in kilograms divided by height in meter square.Body Mass Index was calculated as the weight (kg) divided by height squared (m^2). It was categorized according to the WHO BMI levels as the following: low weight (BMI < 18.5), appropriate weight (18.5<BMI< 25), over weight (25.1< BMI< 29.9), and obese (BMI_30) (WHO, 1998). 30.00 -34.99 kg/m2 as obese class I, BMI 35.00-39.00 kg/m2 as obese class II "severe obesity," and BMI > 40 kg/m2 as obese class III "morbid obesity.". In the surgical literature, people with a BMI > 50 kg/m2 are classified as "super obese" (Almogy*et al*., 2004) and BMI > 60 kg/m2 are classified as "super-super obese" (Regan *et al*., 2003). Once obese, the higher the BMI, the more health threatening it is, such as cardiovascular diseases, high blood pressure, sleep apnea, and gallstone/cholecystectomy (NIH, 1998).

World Health Organisation (1998) defined obesity as the presence of excessive body fat, which is associated with a number of adverse health condition (Allision*et al*., 2002). BMI is the most common and convenient method used to measure obesity, it is readily available in most survey.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Participants

Participants were randomly selected from healthy students of Ahmadu Bello University, Zaria with ages ranging from 18 to 30 years.

3.2 Study location

The study was conducted in Ahmadu Bello University, Samaru, Zaria.

3.3 Sample size determination

The sample size for this study was calculated using the formula:

$n=z^2pq/d^2$ **(**Naing*et al*, 2006).

Where:

n= the desired sample size

Z = the standard normal deviation, usually set at 1.96(approx 2.0)

P = the proportion in the target population having the particular trait (when no estimate 50% is used; i.e. 0.50)

q= 1.0-*p*

d= degree of accuracy desired, usually set at 0.05

Thus

$n= (1.96)^2(0.5)\ (0.5)/\ (0.05)^2$

= **384**

Thus, a minimum of 384 subjects would have been used in this study in order to draw valid conclusions from it. However, a total of five hundred and fifty one (551) subjects were used for the study, made up of 300 females and 251 males.

3.4 Ethical approval

Ethical approval was obtained from the Ahmadu Bello University Research Ethics Committee and the Ahmadu Bello University Teaching Hospital Research Ethics

3.5Biodata

Data on sex, age, ethnic background, parental socioeconomic status, and parental level of education of participants were obtained through questionnaire.

3.6 Materials

- Caliper
- Inelastic measuring tape
- Stadiometer
- Pencil
- Sheet of paper.

3.7 Methods

This is a prospective study and data was collected through questionnaire. Out of six hundred and fifty questionnaires distributed, six hundred were retrieved and the information contained in each questionnaire was analysed and presented in a table.A total of forty nine questionnaires were

returned uncompleted. These questionnaires were distributed randomly among students of Ahmadu Bello University.

The following was included in the questionnaire: sex, age, ethnic background, parental level of education and parental occupation of participants; cranial dimensions and other anthropometric parameterswere taken and recorded in their respective questionnaires using standard techniques as required by WHO and intelligence quotient test.

In the first session, participants completed intelligent quotient test (IQ test) to assess individual differences in intelligence. This is a non-verbal, timed, group administered, multiple choice, pencil-and-paper sub test (AH4 Part II Non – verbal Reasoning Test) designed in Department of Psychology, Ahmadu Bello University, Zaria. This test is intended to measure intelligence in such a way that the influence of verbal fluency, culture, and educational level has the least effect possible. It focuses on the ability to perceive patterns and relationships between things.

Grading of test of intelligence score

The test of intelligence questions, which comprises of thirty questions were marked scored and graded as followed:

Intelligence quotient range	**Intelligence quotient classification**
0 – 10	Low
11 – 15	Average
16 – 20	Good
21	Very good

In the second session, participants body anthropometric parameters andlinear dimensions of the head measurements was taken.

The dimensions measured are as follows:

- **Body weights**: measured using weighing scale with an accuracy of 1 kg.
- **Heights**: standing height was measured taking the maximum distance from the floor to the highest point on the head, when subjects were standing in anatomical position. Shoes were put off, feet together, and arms by the sides. Heels, buttocks and upper back should also be in contact with the wall when the measurement is made. This measurement was carried out using a stadiometerwith an accuracy of 1 cm.
- **Neck circumference:** measured using inelastic measuring tape with head erect and eyes facing forward, horizontally at the upper margin of the laryngeal prominence (Adam's apple)
- **Mid upper arm circumference**:measured using an inelastic measuring tape, at the point halfway between the acromion and the olecranon process of the ulna with the right arm flexed at 90°
- **Chest circumference (cm)**: Tape was wrapped around the chest at the level of the middle of the sternum (breast-bone), with the tape passing under the arms. The arms were relaxed by the side, and the measurement taken at the end of a normal expiration
- **Waist circumference**: measured using inelastic measuring tape at the level midway between the lower rib margin and the iliac crest.
- **Hip circumference**: measured using inelastic measuring tape at the largest posterior extension of the buttocks.

- **Maximum anterio-posterior cranial length (*L*)**: measured between glabella and the inion. It is also named as head length.
- **Maximum cranial breadth (*B*)**: biparietal diameter; measured between two parietal eminences). It is also called head width.
- **Auricular height (*H*)**: basi-bregmatic height, measured between the external acoustic meatus to the highest point of the vertex, i.e. the bregma.

Cranial length, cranial breadth and cranial height were carried out with the aid of the spreading calliper considered for calculations with an accuracy of 1mm. Using the following formulae derived by Lee–Pearson, the cranial capacity (mm^3) was computed as follows:

Males: $0.000337 (L - 11) (B - 11) (H - 11) + 406.01\ mm^3$

Females: $0.000400 (L - 11) (B - 11) (H - 11) + 206.60\ mm^3$ (Williams *et al*., 2000).

Brain weight in grams and cerebral index (CI) were determined by the following formulae:

Brain weight = cranial capacity × 1.035

Where 1.035 is the mass density of the brain

Cerebral index = brain weight/body weight.

3.8 Statistical analysis

Data was expressed as mean $\pm$ standard deviation. Student's t-test was used to test the level of difference in the mean of the variables, one way analysis of Variance (ANOVA) was used to investigate ethnic variationin cranial dimension, IQ score and other anthropometric parameters. Pearson correlation wasused to test relationship between each of the measured cranial dimensions, IQ score and anthropometric parameters.

3.9 Inclusion criteria

- Healthy Nigeria citizen
- Three generation of indigenization of being a Nigerian: Grandfather's, father's and mother's ethnic background.
- Aged 18-30 years.

3.10 Exclusion criteria

- Subjects with some form of deformity that could hinder accurate measurement.
- Subjects outside the chosen age range
- Non students of Ahmadu Bello University

CHAPTER FOUR

RESULT

4.1 Descriptive statistics of study population

Five hundred and fifty one (551) students of Ahmadu Bello University students both male and female aged 18 to 30 years old were considered for this study. The mean age and the mean of the different anthropometric parameters in the general study population are as shown in Table 4.1.

The study population was made up of two hundred and fifty one (251) males (mean age 22.83 ± 2.39) and three hundred (300) females (mean age 21.28 ± 2.40).The mean age of the males was greater than that of the females though the difference in their age mean was not statistically significant as shown in Table 4.2 ($p = 0.82$).

The present study showed that, males were significantly taller than females ($p \square 0.01$), significantly heavier than females ($p \square 0.01$) but the body mass index (BMI) of the females were higher than that of males but there was no significant difference between them ($p = 0.140$).

The circumference (neck, mid upper arm, chest, waist and hip) of subjects studied were compared and showed that neck, mid upper arm and chest circumferences of males were higher than females and statistically significant ($p \square 0.01$). However, waist and hip circumferences were higher in females than males in the present study ($p = 0.96$ and $p \square 0.01$) respectively.

Table 4.3 showed the descriptive statistics of Craniometric parameters between the sexes in the study population. From Figure 4.1, it was observed that cranial length, cranial breadth and cranial height were higher in males than females ($p \leq 0.01$).

Cranial capacity and brain weight were significantly higher in the males than the females ($p \leq 0.01$), Figure 4.2. However, cerebral index and intelligence quotient test were significantly higher in females than males ($p \leq 0.05$) as shown in Figure 4.3.

The population size was categorized according to father's ethnic group into four groups: Hausa, Igbo, Yoruba and Others. Then according to parents level of education into four levels as (1) Tertiary (2) secondary (3) primary (4) no formal education. In addition, the population was further categorized according to parental occupation into three groups: working, business and others.

Table 4.1: Descriptive statistics showing mean and standard deviation of studied parameters

Parameters	Minimum	Maximum	Mean ±SD
Age(Yrs)	18.00	30.00	22.09 ± 3.06
Height(cm)	140.00	200.00	165.74 ± 9.25
Weight(kg)	39.00	95.00	59.66 ± 9.82
Body Mass Index(kg/m^2)	14.00	42.00	21.48 ± 3.43
Neck Circumference(cm)	22.50	41.00	33.82 ± 2.63
Mid upper arm circumference(cm)	15.00	37.50	27.44 ± 3.28
Chest Circumference(cm)	42.00	102.50	69.09 ± 16.78
Waist Circumference(cm)	57.50	105.00	75.38 ± 7.27
Hip circumference(cm)	55.00	122.50	92.28 ± 7.24
Cranial Length(mm)	170.00	222.00	189.49 ± 8.25
Cranial Breadth(mm)	64.00	164.00	148.30 ± 8.34
Cranial Height(mm)	101.00	152.00	129.03 ± 9.30
Cranial Capacity(mm^3)	537.40	1787.33	1370.39 ± 140.82
Brain Weight(g)	556.21	1849.89	1418.36 ± 145.74
Cerebral Index	3.36	11.15	8.28 ±.81
Intelligence test score	4.00	22.00	16.18 ± 3.82

Table 4.2: Descriptive statistics of anthropometric variables in the study population

Variables	Males (n=251) Mean ± SD	Min.	Max.	Females (n=300) Mean ± SD	Min	Max.	t value	p value
Age(years)	22.83 ± 2.39	18.00	30.00	21.28 ± 2.40	18.00	30.00	0.02	0.820
Wt(kg)	63.65 ± 7.61	47.00	95.00	56.31 ± 10.01	39.00	95.00	-9.60	0.000
Ht(cm)	173.15 ± 6.87	150.00	200.00	159.23 ± 5.76	140.00	177.00	-24.89	0.000
BMI(kg/m²)	21.25 ± 2.55	16.00	32.11	21.67 ± 4.01	14.00	42.00	1.48	0.140
NC(cm)	35.38 ± 2.47	22.50	41.00	32.52 ± 1.98	25.00	37.50	15.08	0.000
MUAC(cm)	28.37 ± 2.62	22.60	35.00	26.66 ± 3.57	15.00	37.50	6.29	0.000
Chest C(cm)	83.46 ± 5.44	58.00	101.50	57.06 ± 13.20	42.00	102.50	29.65	0.000
WC(cm)	75.36 ± 5.87	62.00	97.50	75.39 ± 8.28	57.50	105.00	-0.05	0.960
HC(cm)	90.57 ± 5.82	55.00	110.00	93.71 ± 7.97	56.25	122.50	-5.19	0.000

Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. $P \leq 0.05; 0.001$

Table 4.3: Descriptive statistics of studied Craniometric parameters for males and females

Variables	Males (n=251) Mean±SD	Min.	Max.	Females (n=300) Mean±SD	Min	Max.	t value	p value
CL(mm)	190.65 ± 8.11	174.00	222.00	188.52 ± 8.25	170.00	220.00	-3.04	0.002
CB(mm)	150.41 ± 6.69	133.00	164.00	146.49 ± 9.17	64.00	164.00	-5.80	0.001
CH(mm)	131.28 ± 8.72	104.00	152.00	127.15 ± 9.37	101.00	149.00	-5.36	0.001
CC(mm^3)	1422.50 ± 113.60	1148.50	1787.30	1326.80 ± 146.60	537.40	1761.10	-8.63	0.001
BW(g)	1472.30 ± 117.50	1188.70	1849.90	1372.20 ± 152.10	556.20	1822.70	-8.71	0.001
CI	23.45 ± 3.25	15.19	34.23	24.97 ± 4.44	6.39	39.57	4.61	0.001
IQS	15.61 ± 4.07	4.00	22.00	16.65 ± 3.53	4.00	22.00	3.17	0.002

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index. $p \leq 0.05$.

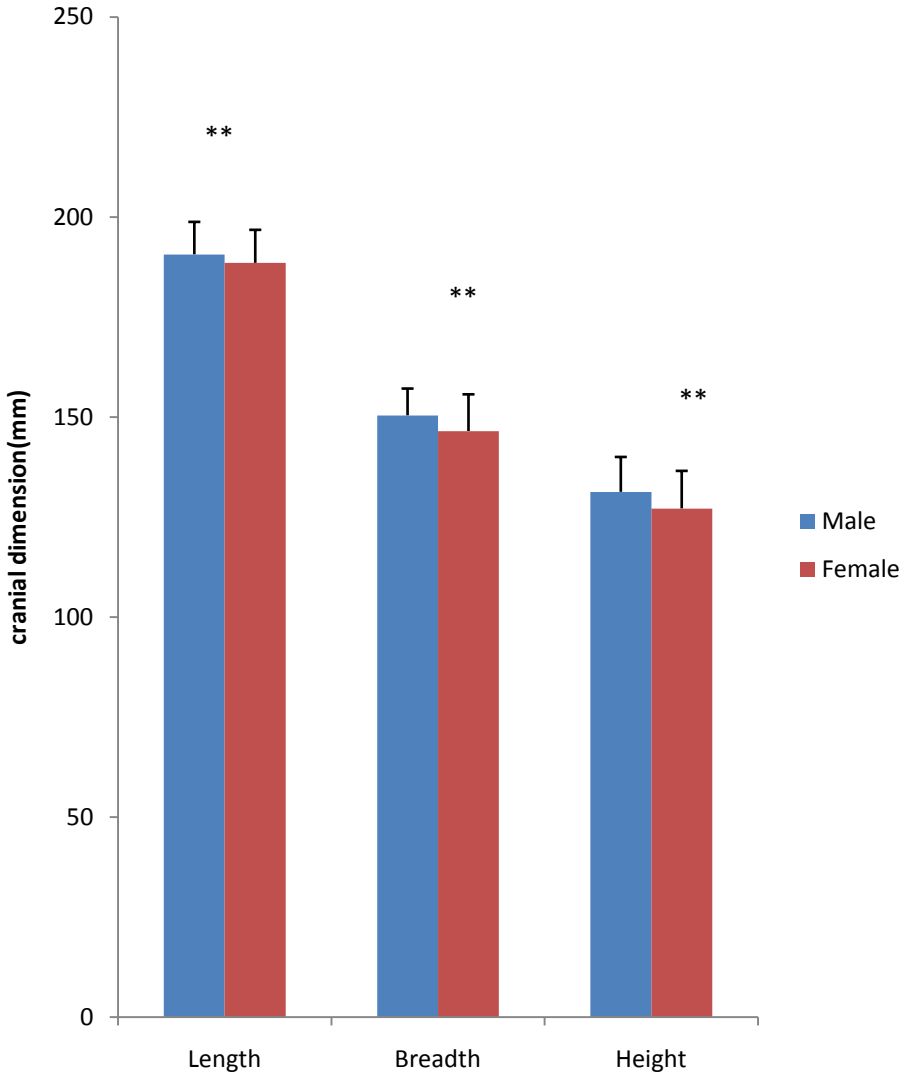


Fig 4.1: comparison of male and female cranial length, breadth and height. Male (n=251), female (n=300); Independent sample *t*- test:**p □ 0.001.

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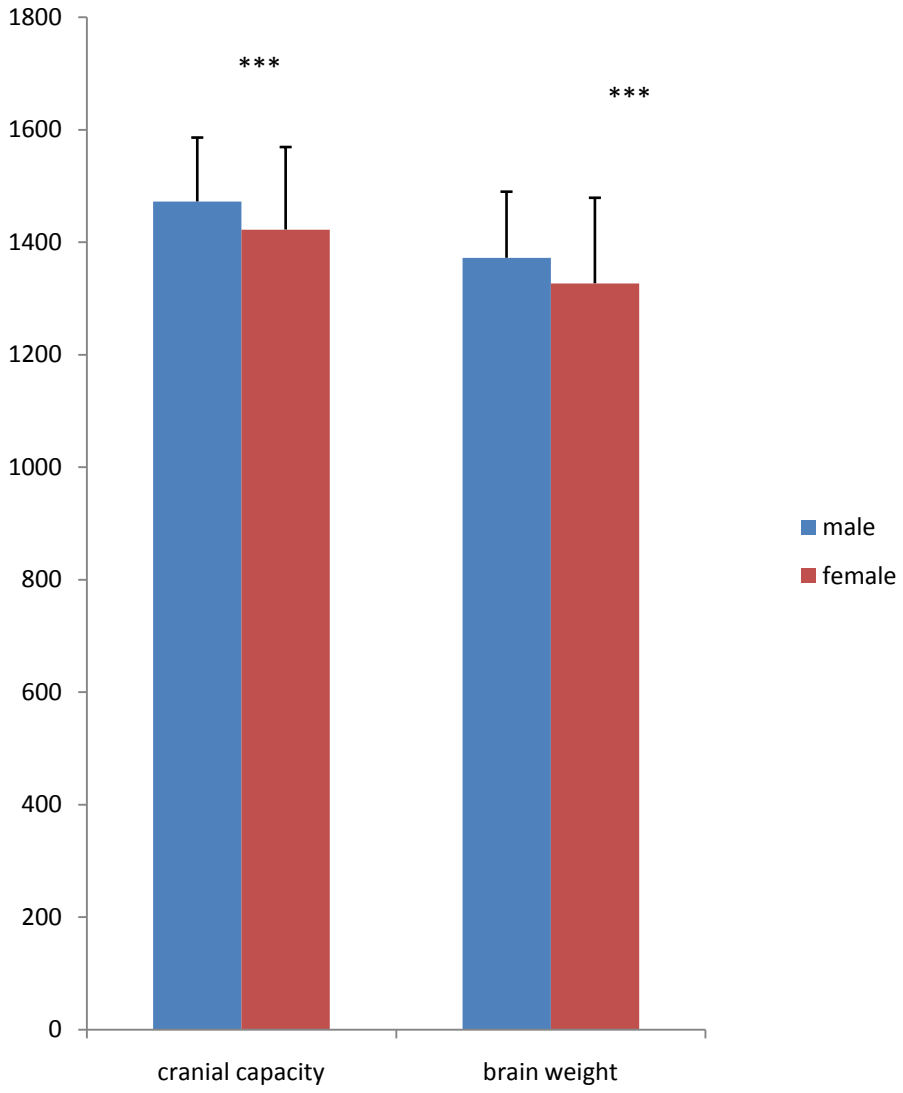


Fig 4.2: comparison of male and female cranial capacity and brain weight. Male (n=251), female (n=300); Independent sample *t*- test:***p □ 0.000.

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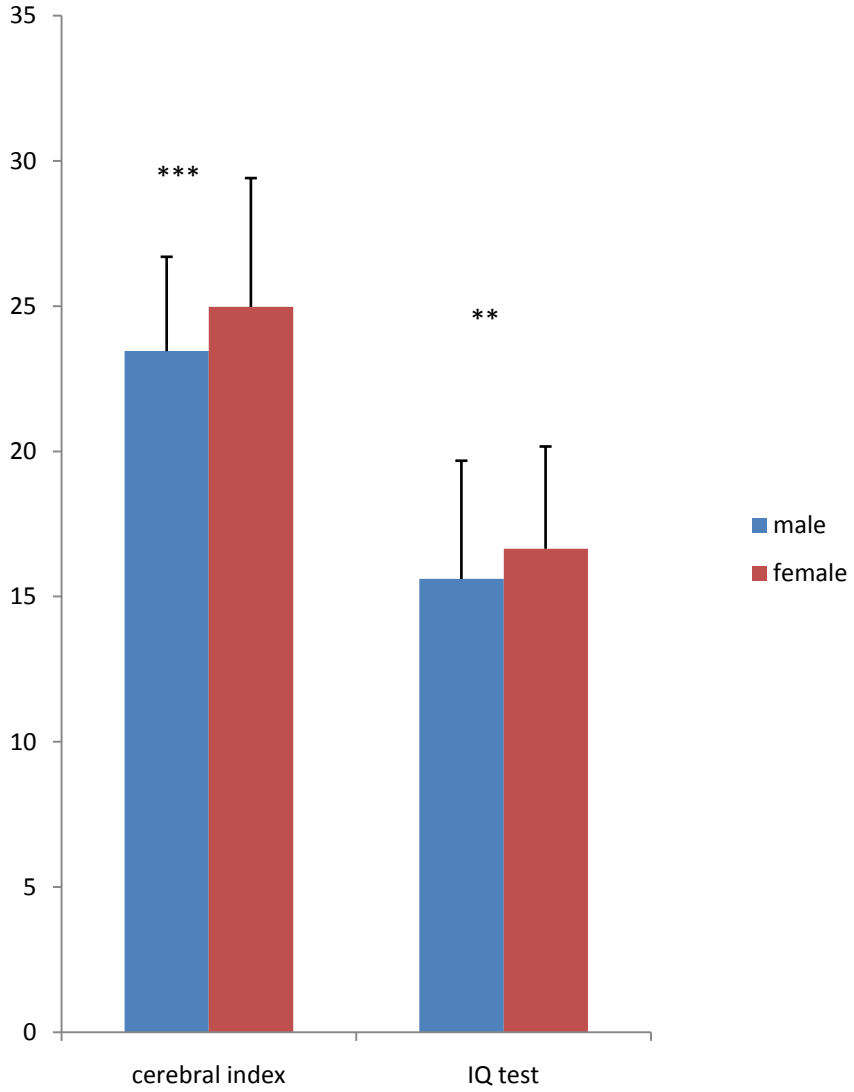


Fig 4.3: comparison of male and female cerebral index and intelligence quotient test. Male (n=251), female (n=300); Independent sample *t*- test: **p □ 0.001; ***p □ 0.000.

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4.2 Association between studied variables and parental level of education.

4.2.1 Studied variables and father's level of education.

Parental level of education was grouped into four categories; tertiary, secondary, primary and none. The present study showed that majority of subject in the studied population their parent attained tertiary education (73.87%), followed by secondary (19.24%), primary (4.3%), and none (2.54%). The result showed that the father's level of education was significantly associated with cranial breadth, cranial capacity and brain weight ($p \leq 0.05$). Father's level of education was significantly associated with age, weight, neck circumference, chest circumference, and height ($p \leq 0.05$). However, there was no association between cranial length, cranial height,Intelligence quotient test, cerebral index, mid upper arm circumference, waist circumference, hip circumference and body mass index (Table 4.4).

4.2.2 Studied parameter and mother's level of education.

Table 4.5 showed that 9.62%, 7.26%, 26.68% and 56.44% in the order of none, primary, secondary and tertiary education respectively, this implied that majority of our participant's parent have attained tertiary level of education.

Height and weight showed association with mother's level of education and statistically significant ($p \leq 0.05$). Age, body mass index, cranial length, cranial breadth, intelligence quotient test, cerebral index, waist circumference and hip circumference showed no association with mother's level of education. Cranial height, cranial capacity and brain weight also showed no association with mother's level of education. Neck circumference also showed significant association with mother's level of education ($p \leq 0.01$). Also, chest circumference showed association with mother's level of education significantly.

Table 4.4: Parameters according to father's level of education.

Variables	Tertiary Mean ±SD (n=407)	Secondary Mean ±SD (n=106)	Primary Mean ±SD (n=24)	None Mean ±SD (n=14)	p value
CL(mm)	189.13 ± 8.36	190.73±8.08	189.17±7.570	191.14±6.94	0.291
CB(mm)	147.54 ± 8.64□	150.22±6.81[a]□	150.04±7.64[a]	152.00±8.69[a]□	0.005
CH(mm)	128.42±9.07	130.72±9.97	130.17±8.08	132.07±11.20	0.069
CC(mm^3)	1356.40±138.00[a]	1408.50±143.40[a]□	1393.00±132.20[a]	1448.20±148.80□□	0.001
IQ S	16.08±3.92	16.72±3.11	15.67±3.78	15.86±5.55	0.408
BW(g)	1403.10±143.20[a]	1457.80±148.40[a]□	1441.80±136.80[a]	1498.90±154.00□□	0.001
CI	24.13±3.89	25.11±4.39	23.92±4.00	22.81±3.82	0.067
AGE(YRS)	21.85±3.21	22.61±2.44	22.92±2.24	23.71±3.02	0.010
WT(kg)	59.34±9.62□	59.55±10.58□	61.42±8.73[a]□	66.86±9.36[a]	0.032
NC(cm)	33.71±2.65□□	34.10±2.56□	33.32±2.43□	35.77±2.34[a]	0.015
MUAC(cm)	27.28±3.32	27.74±3.10	27.59±3.45	29.48±2.61	0.061
CHESTC(cm)	68.56±16.79	69.78±16.01 □	67.22±19.66□	82.56±11.55[a]	0.019
WC(cm)	75.07±7.01	75.83±7.66	76.55±9.49	78.75±7.11	0.191
HC(cm)	92.18±6.98	92.72±8.16	91.41±7.53	93.45±6.97	0.760
BMI(kg/m^2)	21.45±3.39	21.30±3.76	22.32±2.56	22.33±3.24	0.452
HT(cm)	165.38±9.46□	166.43±8.65□	164.54±6.99□□	173.07±8.02[a]	0.015

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index, Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. n=551; one way ANOVA; Post Hoc test: 'a and b', 'c and d' represents were significance level lies. Means with similar superscripts are significantly different (p□ 0.05)

Table 4.5: Parameters according to mother's level of education.

Variables	Tertiary Mean ± SD (n=311)	Secondary Mean ± SD (n=147)	Primary Mean ± SD (n=40)	None Mean ± SD (n=53)	p value
AGE(yrs)	21.859±3.287	22.31±2.60	22.95±3.27	22.23±2.51	0.122
HT(cm)	164.65±8.81□	166.91±9.97□ □	165.57±9.53□ □	169.08±8.45[a]	0.003
WT(kg)	58.56±9.733□	60.49±9.343	62.45±11.55	61.68±9.56[a]	0.015
BMI (kg/m²)	21.335±3.469	21.52±3.289	22.56±4.28	21.40±2.70	0.205
CL(mm)	189.38±8.55	189.63±7.89	188.68±8.14	190.42±7.59	0.764
CB(mm)	147.49±7.96	149.01±9.72	149.40±6.38	149.96±7.51	0.080
CH(mm)	128.50±9.20□	128.71±9.51□ □	129.82±8.71□ □	132.43±9.24[a]	0.035
CC(mm^3)	1356.80±138.10□	1375.60±148.30	1383.20±129.30	1425.90±131.10[a]	0.008
IQS	16.325±3.75	15.89±3.79	16.80±4.27	15.64±3.96	0.340
BW(g)	1404.1±143.2□	1421.90±154.40	1431.70±133.90	1475.80±135.70[a]	0.009
CI	24.478±3.93	23.97±4.06	23.55±4.06	24.48±4.29	0.379
NC(cm)	33.32±2.69□	34.37±2.46	33.87±2.21□	35.22±2.29[a]	0.000
MUAC(cm)	27.16±3.43	27.53±2.97	28.46±3.74	28.01±2.65	0.051
CHESTC(cm)	66.81±16.90□	70.68±16.24	69.92±17.29 □	77.43±14.11[a]	0.000
WC(cm)	75.31±7.61	75.34±6.65	76.44±8.42	75.06±6.03	0.804
HC(cm)	92.53±7.61	91.80±7.01	93.16±7.196	91.47±5.49	0.520

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index, Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. n=551; one way ANOVA; Post Hoc test: 'a and b', 'c and d' represents were significance level lies. Means with similar superscripts are significantly different (p□ 0.05)

4.3 Association between studied variables and parental occupation.

Parental occupation was grouped into: working, business and others.

4.3.1 Studied variables and father's occupation.

The result showed that 65.34% of fathers were working, 29.22% were on business while 5.44% were grouped under order. It was observed from this study that weight, body mass index, hip circumference, chest circumference and cerebral index were significantly associated with father's occupation (p □ 0.05), (Table 4.6)

4.3.2 Studied variables and mother's occupation.

It was observed that all studied parameters showed no association with mother's occupation except hip circumference (Table 4.7)

Table 4.6: Parameters according to father's occupation in subjects

Variables	Working Mean ± SD (n=360)	Business Mean ± SD (n=161)	Other Mean ± SD (n=30)	p value
CL(mm)	189.63±8.59	189.64±7.38	187.03±8.36	0.245
CB(mm)	148.17±8.18	148.40±7.38	148.83±8.23	0.896
CH(mm)	128.74±9.28	129.34±9.35	130.83±9.36	0.441
CC(mm^3)	1367.0±144.3	1377.2±133.3	1375.0±140.8	0.735
IQS	16.289±3.401	15.832±4.454	16.733±4.770	0.324
HT(cm)	165.11±9.55	167.12±8.59	165.97±8.37	0.070
Age(yrs)	21.91±3.24	22.39±2.61	22.73±2.91	0.129
WT(kg)	59.004±9.806□	60.28±9.67[a]□	64.167±9.756[a]	0.014
BMI(kg/m^2)	21.403±3.627□	21.35±2.91[a]□	23.083±3.198[a]	0.030
BW(g)	1414.9±149.4	1423.5±139.0	1421.2±147.6	0.817
CI	24.516±4.086[a]	24.075±3.922[a]□	22.467±2.974□	0.020
NC(cm)	33.608±2.634	34.191±2.610	34.447±2.498	0.027
MUAC(cm)	27.378±3.352	27.319±2.947	28.773±3.949	0.071
CHESTC(cm)	67.290±16.70□	72.235±16.591[a]□	73.777±15.703[a]	0.002
WC(cm)	75.531±7.460□	74.487±6.270	78.263±9.188[a]	0.026
HC(cm)	92.726±7.787□	90.995±5.668□□	93.873±7.158[a]	0.019

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index, Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. n=551; one way ANOVA; Post Hoc test: 'a and b', 'c and d' represents were significance level lies. Means with similar superscripts are significantly different (p□ 0.05)

Table 4.7: Parameters according to mother's occupation in subjects

Variables	Working Mean ±SD (n=246)	Business Mean ±SD (n=179)	Others Mean ±SD (n=126)	P value
CL(mm)	189.63±9.00	188.90±7.97	147.25±9.99	0.448
CB(mm)	148.62±7.68	145.53±7.97	147.25±9.99	0.289
CH(mm)	129.64±9.53	128.98±9.29	127.91±8.82	0.238
CC(mm^3)	1378.4±143.7	1367.3±138.7	1359.2±138.2	0.431
IQS	16.163±3.724	16.190±4.180	16.198±3.478	0.995
Age(yrs)	21.17±3.60	22.12±2.59	21.91±2.47	0.740
HT(cm)	165.83±9.26	165.71±10.07	165.60±7.97	0.968
WT(kg)	59.936±9.679	59.587±9.973	59.214±9.948	0.794
BMI(kg/m^2)	21.579±3.531	21.422±3.357	21.370±3.337	0.825
BW(g)	1426.9±148.8	1413.8±144.0	1405.7±143.9	0.379
CI	24.294±3.951	24.201±3.918	24.345±4.296	0.949
NC(cm)	33.817±2.825	33.554±2.233	34.221±2.736	0.092
MUAC(cm)	27.513±3.304	27.046±3.382	27.841±3.062	0.101
HC(cm)	93.161±7.396□□	91.673±6.570□	91.434±7.682[a]	0.036
WC(cm)	75.938±7.503	75.020±6.664	74.781±7.622	0.254
CHESTC(cm)	69.162±16.745	67.912±17.007	70.614±16.506	0.382

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index, Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. n=551; one way ANOVA; Post Hoc test: 'a and b', 'c and d' represents were significance level lies. Means with similar superscripts are significantly different (p□ 0.05)

4.4 Influence of ethnicity on studied variables

Table 4.8 showed the association of ethnicity with the studied variables. Ethnicity was grouped into Hausa, Igbo, Yoruba and Others (Idoma, Tiv, Itsekirietc). All studied variables were associated significantly with ethnicity except age, body mass index and cranial height.

The result of the present study showed that the Igbos were taller and heavier than the rest of ethnic group. The mean cranial dimensions of the ethnic group of studied population were significantly different with Igbos higher than the rest of the group. However, the intelligence quotient test showed Others scoring more than the rest of ethnic group followed by Hausa, then Yoruba and lastly Igbos. This implied that Others group were more intelligent than the rest of ethnic group. This study also showed that body circumferences (neck, mid upper arm, chest, waist and hip) significantly higher in Igbos than the rest of the group.

Table 4.8: Parameters according to ethnicity in male and female

Variables	Hausa Mean ±SD (n=230)	Igbo Mean ±SD (n=23)	Yoruba Mean ±SD (n=93)	Other Mean ±SD (n=205)	p value
Age(yrs)	22.078±2.482	23.348±3.575	22.355±2.195	21.849±3.800	0.118
HT(cm)	168.82±9.21 [a]	173.13±5.60[a]	165.52±9.62	161.56±7.46	0.000
WT(kg)	60.593±9.810[a]	65.261±12.388[a]	59.731±8.045[a]	57.946±9.946	0.001
BMI(kg/m²)	21.098±3.202	21.669±3.886	21.679±3.099	21.797±3.728	0.172
CL(mm)	188.04±7.37	193.65±8.22[a]	191.46±8.73[a]	189.76±8.63[a]	0.000
CB(mm)	147.44±8.22	154.09±5.97[a]	149.85±6.060[a]	147.85±9.28	0.001
CH(mm)	129.35±8.96	131.13±9.11	129.14±9.70	128.39±9.52	0.490
CC(mm³)	1360.0±120.6	1462.3±132.8[a]	1393.4±141.4[a]	1360.0±157.3	0.001
IQS	16.443±3.909[a]	13.652±3.676	15.462±4.218[a]	16.493±3.398[a]	0.001
BW(g)	1407.2±125.2	1513.5±137.4[a]	1445.3±146.1[a]	1406.4±163.3	0.001
CI	23.694±3.541	23.881±4.372[a]	24.536±3.547[a]	24.854±4.555[a]	0.021
CHESTC(cm)	72.23±15.64	84.04±12.50	69.90±16.13	63.15±16.79	0.000
NC(cm)	34.113±2.765	35.496±2.423	34.202±2.639	33.141±2.320	0.000
MUAC(cm)	27.197±3.014	30.013±3.069	27.612±2.623	27.337±3.732	0.001
WC(cm)	74.765±7.033	78.804±7.204	75.505±6.426	75.616±7.848	0.072
HC(cm)	90.941±7.196	93.957±6.315	90.834±6.143	94.257±7.386	0.000

CL =cranial length, CB= cranial breadth, CH= cranial height, cc= cranial capacity, IQS= intelligence quotient test, BW= brain weight, CI = cerebral index, Wt = weight, ht = height, BMI = body mass index, NC= neck circumference, MUAC = mid upper arm circumference, ChestC = chest circumference, WC = waist circumference, HC = hip circumference. n=551; one way ANOVA; Post Hoc test: ‘a and b’, ‘c and d’ represents were significance level lies. Means with similar superscripts are significantly different (p 0.05)

4.5 Association between Craniometric variables and Intelligence Quotient test

4.5.1 Craniometric variables and test of intelligence in studied population.

Test of intelligence was classified as low, average, good and very good

Table 4.9 showed the baseline of study participants classified as good (n=296), average (n = 162), very good (n = 50) and low (n =43). This implied that majority of study participants fell under good category while those that fell under very good category were few. It was observed from this study that cranial length of very good category were higher than the rest and much more lower when compared to average category but not significant. Cranial breadth of average category was higher when compared to other categories while the cranial height of very good category was higher than others but not statistically significant. However, cranial capacity of good category was higher compared to other categories but the brain weight and cerebral index of very good category were higher than the rest of the categories but then again not statistically significant (Table 4.9)

4.5.2 Craniometric variables and test of intelligence in females

Table 4.10 showed the following breakdown: low (n=18), average (n=82), good (n=173) and very good (n=27). This showed that majority of the female subjects were good.

This study revealed a perfect linear increase in cranial length, cranial breadth, cranial height, cranial capacity, brain weight and cerebral index increasing as the score of test of intelligence were increasing i.e low to very good but not significant except cerebral index (Table 4.10). This implied that the higher the cranial dimensions, the higher the brain weight and the higher the intelligence.

4.5.3 Craniometric variables and test of intelligence in males.

Table 4.11 showed the following breakdown: low (n=25), average (n=80), good (n=123) and very good (n=23). This showed that majority of the male subjects were good. It was observed in this study that cranial capacity, cranial height and brain weight were higher in very good category but cranial breadth, cranial length and cerebral index were higher in low category when compared to other categories, all not statistically significant. This showed that some cranial dimensions increased with brain weight. From table 4.10 and 4.11, the cranial capacity of males were higher than females, however the females were more intelligent than males.

Table 4.9: Craniometric parameters and test of intelligence in subjects

Variable	Test of intelligence classification				F value	p value
	Low (n=43) mean ± SD	Average (n=162) mean ± SD	Good (n=296) mean ± SD	Very good (n=50) mean ± SD		
CL(mm)	189.07±7.55	188.91±8.61	189.73±8.24	190.300±7.74	0.550	0.65
CB(mm)	149.36±8.96	150.85±6.14	150.46±6.67	149.82±6.07	0.378	0.769
CH(mm)	132.08±10.06	129.83±8.86	131.57±8.60	133.96±6.75	1.590	0.192
CC(mm^3)	1426.44±152.09	1411.63±114.63	1426.72±109.90	1399.89±123.49	0.374	0.772
BW(g)	1413.46±166.30	1408.70±149.55	1419.20±143.29	1448.88±127.81	0.374	0.772
CI	23.57±4.34	24.30±3.90	24.30±3.90	24.95±4.81	1.614	0.187

n =551, one way ANOVA; CL= cranial length, CB= cranial breadth, CH= cranial height, CC= cranial capacity,BW= brain weight , CI= cerebral index.

Table 4.10: Craniometric parameters and test of intelligence in female

Variables	Test of intelligence				F value	p value
	Low (n=18) Mean ± SD	Average (n=82) Mean ± SD	Good (n=173) Mean ± SD	Very good (n=27) Mean ± SD		
CL(mm)	186.33 ± 7.44	187.57 ± 9.12	188.82 ± 7.75	190.93 ± 8.77	1.64	0.18
CB(mm)	143.00±16.60	146.07±11.31	146.95±6.66	147.67±8.75	1.23	0.29
CH(mm)	127.56±8.27	126.49±8.94	127.09±9.93	129.19±7.57	0.57	0.63
CC(mm^3)	1281.24±134.72	1311.67±153.89	1331.73±143.31	1371.51±146.65	1.79	0.15
BW(g)	1326.09±139.44	1357.58±159.28	1378.34±148.32	1419.52±151.42	1.79	0.15
CI	22.54±5.18	25.32±4.39	24.79±4.20	27.12±5.05	4.27	0.006

n =300, $p \leq 0.05$, one way ANOVA; CL= cranial length, CB= cranial breadth, CH= cranial height, CC= cranial capacity, BW= brain weight , CI= cerebral index.

Table 4.11: Craniometric parameters and intelligence in male

variable	Test of intelligence classification				F value	p value
	Low (n=25) mean ±SD	Average (n= 80) mean ±SD	Good (n=123) mean ±SD	Very Good (n=23) mean ±SD		
CL(mm)	191.04±7.14	190.29±7.87	191.01±8.76	189.57±6.43	0.29	0.83
CB(mm)	149.36±8.96	150.85±6.14	150.46±6.67	149.83±6.08	0.38	0.77
CH(mm)	132.08±10.06	129.83±8.86	131.57±8.60	133.96±6.75	1.59	1.19
CC(mm^3)	1426.44±152.09	1411.68±114.63	1426.72±109.90	1433.20±80.75	0.37	0.77
BW(g)	1476.37±157.41	1461.09±118.64	1476.66±113.74	1483.36±83.58	0.37	0.77
CI	24.32±3.55	23.25±3.01	23.60±3.35	22.39±2.99	1.61	0.19

n =251, one way ANOVA; CL= cranial length, CB= cranial breadth, CH= cranial height, CC= cranial capacity, BW= brain weight, CI= cerebral index.

4.6 Correlation between variables studied

4.6.1 Variables studied in males

Table 4.12 shows that age correlated positively and significantly with cranial length, cranial breadth, cranial capacity and brain weight. Height did not show significant correlation with craniometry except cerebral index. Weight and neck circumference showed no significant correlation with craniometric parameter except with cerebral index. BMI showed significant negative correlation with only cerebral index. Mid upper arm circumference correlated significantly with cranial length and cerebral index. Chest circumference correlated significantly with cerebral index, intelligence test score. Waist and hip circumference correlated significantly with cerebral index, cranial length.

Intelligence test score correlated significantly and positively with waist and chest circumference, implying that males with large chest and waist circumference will likely have high IQ. Test of intelligence showed no correlation with Craniometric parameters.

Cranial length correlated significantly with all other Craniometric parameters except cranial height, test of intelligence. Cranial breadth, brain weight, cerebral index and cranial capacity correlated positively with Craniometric parameters except test of intelligence. Cranial height correlated significantly with cranial length and test of intelligence score.

4.6.2 Variables studied in females

Table 4.13: Age shows no correlation with Craniometric parameters and intelligence quotient score except cerebral index which correlated negatively and significantly at $p<0.05$. Height show significant correlation with Craniometric parameters except Cerebral Index and intelligence quotient score. Weight showed no significant correlation with Craniometric parameter except with Cranial height positively and cerebral index. BMI showed significant negative correlation with only intelligence quotient score. Neck circumference showed significant parameters with all Craniometric parameters except intelligence quotient score. Mid upper arm circumference showed significant positive correlation with Craniometric parameters except cranial length and intelligence quotient score. Chest circumference showed significant negative correlation with cranial length, while positively correlated with cranial height. Waist and hip circumference correlated significantly with all Craniometric parameters except cranial length and test of intelligence score.

Test of intelligence score correlated significantly and positively with Craniometric parameters except cranial breadth and cranial height.

Cranial length correlated significantly with all other Craniometric parameters except cranial height. Cranial breadth and height correlated positively with Craniometric parameters except test of intelligence score. Cranial capacity, brain weight and cerebral index correlated significantly with Craniometric parameters.

Table 4.12: Correlation matrix of anthropometric and craniometric variables in males

	A	HT	WT	BMI	NC	MUAC	C.CIR	WC	HC	CL	CB	CH	CC	BW	CI	IQS
A		-0.04	0.26***	0.29***	-0.03	0.26***	0.24***	0.30***	0.08	0.14**	0.16**	0.07	0.18**	0.18**	-0.09	0.03
HT			0.37***	-0.27	0.08	-0.01	0.101	0.03	0.19**	-0.11	0.09	0.07	0.03	0.03	-0.31***	0.12
WT				0.79***	0.54***	0.52***	0.69***	0.57***	0.66***	-0.02	0.07	0.08	0.07	0.07	-0.80***	0.09
BMI					0.51***	0.53***	0.63***	0.57***	0.56***	0.05	0.02	0.04	0.05	0.05	-0.62***	0.01
NC						0.39***	0.52***	0.38***	0.48***	0.05	0.01	0.01	0.03	0.03	-0.46***	0.06
MUAC							0.54***	0.53***	0.44***	0.14*	0.09	-0.08	0.04	0.04	-0.41***	0.06
C.CIR								0.52***	0.58***	0.09	0.00	0.03	0.06	0.06	-0.54***	-0.13*
WC									0.62***	0.08	0.04	0.08	0.10	0.10	-0.42	-0.15*
HC										0.03	0.06	0.12	0.11	0.11	-0.48***	-0.01
CL											0.20***	0.02	0.52***	0.52***	0.32***	-0.03
CB												0.21**	0.66***	0.66***	0.32***	0.00
CH													0.75***	0.75***	0.37***	0.08
CC														1.00***	0.52***	0.04
BW															0.52***	0.04
CI																-0.05

*p □ 0.05; **p □ 0.001; ***p □ 0.000.

A = age, HT = height , WT = weight, BMI= body mass index, NC= neck circumference , MUAC = mid upper arm circumference, C.CIR= chest circumference, WC= waist circumference, HC= hip circumference, CL= cranial length, CB= cranial breadth, CH= cranial height, CC= cranial capacity, BW = brain weight, CI= cerebral index, IQS= intelligence quotient test

Table 4.13: Correlation matrix of anthropometric and craniometric variables in females

	A	HT	WT	BMI	NC	MUAC	C.CIR	WC	HC	CL	CB	CH	CC	BW	CI	IQS
A	1	0.02	0.15**	0.137*	0.07	0.27***	0.23***	0.24***	0.30***	-0.08	-0.08	0.05	-0.04	-0.04	0.05	-0.08
HT		1	0.17**	-0.25***	0.23***	0.07	0.06	0.22***	0.19***	0.23***	0.12*	0.26***	0.31***	0.31***	-0.03	0.10
WT			1	0.91***	0.23***	0.46***	0.31***	0.42***	0.45***	0.00	-0.01	0.16**	0.10	0.10	-0.05	-0.06
BMI				1	0.13*	0.42***	0.27***	0.31***	0.35***	-0.09	-0.06	0.05	-0.02	-0.02	0.06	-0.11*
NC					1	0.43***	0.34***	0.47***	0.45***	0.16**	0.19***	0.18**	0.28***	0.28***	0.21***	-0.07
MUAC						1	0.67***	0.77***	0.75***	-0.04	0.12*	0.24***	0.19***	0.19***	0.18**	-0.05
C.CIR							1	0.45***	0.55***	-0.13*	0.02	0.18***	0.07	0.07	0.06	-0.06
WC								1	0.77***	0.08	0.15**	0.17**	0.22***	0.22***	0.15**	0.00
HC									1	0.02	0.13*	0.16**	0.18**	0.18**	0.12*	0.00
CL										1	0.23***	0.07	0.52***	0.52***	0.47***	0.16**
CB											1	0.20***	0.70***	0.70***	0.69***	0.09
CH												1	0.74***	0.74***	0.68***	0.07
CC													1	1.00***	0.94***	0.15**
BW														1	0.94***	0.15**
CI															1	0.12*
IQS																1

*p□ 0.05; **p□ 0.001; ***p□ 0.000.

A = age, HT = height , WT = weight, BMI= body mass index, NC= neck circumference , MUAC = mid upper arm circumference, C.CIR= chest circumference, WC= waist circumference, HC= hip circumference, CL= cranial length, CB= cranial breadth, CH= cranial height, CC= cranial capacity, BW = brain weight, CI= cerebral index, IQS= intelligence quotient test

4.7 Relationship between variables and intelligence.

4.7.1 Sex and test of intelligence.

Table 4.12 showed comparism in different categories of intelligence between males and females. In this study, it was observed under low category, males were higher than females (males, 9.96%; females, 6%), under average category, males were also higher than females (males, 27.33%; females, 31.87%). However under good category, females were higher than males (57.70%, 49.00%) respectively.

4.7.2 Body mass index and test of intelligence in subjects

Table 4.13 and 4.14 showed relationship between BMI and test of intelligence in males and females respectively. However, no significant difference was observed in both tables.

Table 4.14: Sex and test of intelligence

parameters		Test of intelligence				Total
		Low%	Average%	Good%	Very% good	
SEX	male	25(10.0)	80(31.9)	123(49.0)	23(9.2)	251
	female	18(6.0)	82(27.3)	173(57.7)	27(9.0)	300
Total		43(15.0)	162(59.2)	296(107)	50(18.6)	551

n= 551, χ^2=5.617, p =0.132

Table 4.15: BMI of male subjects and test of intelligence

Variable		Test of intelligence				Total
		Low%	Average%	Good%	Very% good	
BMI	under weight	3(9.1)	7(21.2)	21(63.6)	2(6.1)	33
	normal weight	22(10.8)	65(32)	97(47.8)	19(9.4)	203
	over weight	0(0)	8(61.5)	3(23.1)	2(15.4)	13
	obese	0(0)	0(0)	2(100)	0(0)	2
Total		25(19.9)	80(114.8)	123(234.5)	23(30.8)	251

$\square^2$= 12.517, P =0.186, n=251; BMI= body mass index

Table 4.16: BMI of female subjects and test of intelligence

parameter		Test of intelligence				Total
		Low	Average	Good	very good	
BMI	under weight	1(3)	9(27.3)	15(45.5)	8(24.2)	33
	normal weight	11(5.3)	58(27.9)	126(60.6)	13(6.3)	208
	over weight	5(10.9)	12(26.1)	24(52.2)	5(10.9)	46
	obese	1(7.7)	3(23.1)	8(61.5)	1(7.7)	13
Total		18(26.9)	82(104.4)	173()	27(219.8)	300

□²=14.58, p=0.103; n=300, BMI= body mass index

4.8 Association between cranial capacity, intelligence and ethnicity

4.8.1 Cranial capacity, intelligence and ethnicity in male.

The result showed a significant effect of cranial capacity on studied ethnic group (p 0.05). While the Igbo's had the mean cranial capacity of 1489.24, that of the other's was 1449, Yoruba's was 1445.25 and 1400.25 for Hausas (Table 4.17)

Table 4.17 also showed variation in test of intelligence with different ethnic groups with Others scoring higher than Hausa, Yoruba and Igbo, but not statistically significant. From the present study, it was observed that cranial capacity could not be used to predict intelligence in male subjects.

4.8.2 Cranial capacity, intelligence and ethnicity in female.

The present study showed that cranial capacity in Others was higher than Yoruba, Hausa, and Igbo. Significant (p 0.05). However, Igbo scored higher mark in the test of intelligence than Yoruba, others and Hausa as shown in Table 4.18

.**Table 4.17: Cranial capacity, intelligence quotient score and ethnicity in male**

Variables	Hausa(n=150) Mean ± SD	Igbo(n=21) Mean ± SD	Yoruba(n=50) Mean ± SD	Others(n=30) Mean ± SD	f	p
cc(mm^3)	1400.22 ± 103.56	1489.24 ± 102.95	1445.25 ± 130.02	1449.24 ± 113.07	5.89	0.001
IQ	15.67 ± 3.96	14.52 ± 4.20	15.54 ± 4.61	16.20 ± 3.56	0.72	0.54

n = 251, one way ANOVA, p□ 0.05; cc = cranial capacity, IQ = intelligence quotient

Table 4.18: Cranial capacity, intelligence quotient score and ethnicity in female

Variables	Hausa(n=183) Mean ± SD	Igbo(n=2) Mean ± SD	Yoruba(n=39) Mean ± SD	Others(n=76) Mean ± SD	f	p
cc(mm^3)	1305.76 ± 124.00	1179.11 ±9.27	1326.72 ±128.18	1381.39 ± 188.18	5.70	0.001
IQ	16.47± 3.57	20.5 ±2.12	17.33±3.00	16.64 ± 3.68	0.23	1.44

n = 300, one way ANOVA, p□ 0.05; cc = cranial capacity, IQ = intelligence quotient

4.9 Intelligence quotient and ethnicity.

4.9.1 Intelligence quotient and ethnicity in male

Table 4.19 showed that majority of male subjects fell under good category of intelligence quotient with Others group had larger percentage (73.3%) compared to other ethnic groups of studied.

4.9.2 Intelligence quotient and ethnicity in female

Table 4.20 showed that majority of female subjects fell under good category of intelligence quotient with Yoruba group had larger percentage (58.9) compared to other ethnic group studied.

Table 4.19: intelligence quotient and ethnicity in male

IQ classification					
Ethnic group	**Low%**	**Average%**	**Good%**	**Very good%**	**total**
Hausa	12(8)	56(37.3)	65(43.3)	17(11.3)	150
Igbo	2(9.5)	10(47.6)	7(33.3)	2(4)	21
Yoruba	7(14)	12(24)	29(58)	2(4)	50
Others	4(13.3)	2(6.7)	22(73.3)	2(6.7)	30
total	25(44.8)	80(115.3)	123(207.9)	23(26)	251

χ^2=20.65, p=0.014; n=251

Table 4.20: intelligence quotient and ethnicity in female

Ethnic group	**IQ**	**classification**			
	Low%	Average%	Good%	Very good%	total
Hausa	12(6.6)	52(28.4)	106(57.9)	13(7.1)	183
Igbo	0(0)	0(0)	1(50)	1(50)	2
Yoruba	1(2.7)	9(23.1)	23(58.9)	6(15.4)	39
Others	5(6.6)	21(27.6)	43(56.6)	7(9.2)	76
total	18(15.9)	82(79.1)	173(223.4)	27(81.7)	300

χ^2=8.198, p=0.514; n=300

CHAPTER FIVE

DISCUSSION

5.1 Discussions

In the present study, it was observed that males were heavier than females; the possible reason for this difference could be sexual dimorphism in body composition (Adebisi, 2003; Loomba-Albrecht and Styne, 2009). Wells (2007) also reported a considerable dimorphism in body composition between adult, males and females. In addition, the patterns of sexual dimorphism are physiologically caused by hormonal factors and hold across all human population (Gatford*et al*. 1998; Rosenbaum and Leibel, 1999). It is well established that adult females surpass males in absolute and relative amount of subcutaneous fat tissue, while males exhibit a quantitative higher amount of fat free body mass including bone as well as soft tissue, lean body mass i.e muscle mass throughout adult life (kyle*et al*, 2001; Shen*et al*, 2009).

The findings in the present study indicated that majority of study subjects in their early adulthood have normal weight. The prevalence of normal weight was more in females than the males. This might be due to the consciousness of the females to societal perception which encourages slender shaped females. This was consistent with the reports of some researchers such as Olusanya*et al* (2009) in Nigeria and Yahia*et al* (2008) in Lebanon.

Sexual dimorphism was observed in craniometric parameters in this study. Cranial capacity, cranial breadth, cranial height and brain weight was higher in males than in females. This observation was in agreement with previous works by Willerman*et al*., (1991), Lynn(1993); Harvey *et al*.,(1994); Reiss *et al*.,(1996); Good *et al*.,(2001), and this could be generally by bigger frame of the average males than the average females. Moreover, it has been shown that gender differences in brain weight could be attributed to activities in which the specific sex

excelled (Andy 1992; Rushton and Osborne, 1995). Another possible reason for this difference could be differences in the number of cortical neurons. Pakkenberg and Gundersen (1997) reported that men had about 4 billion more cortical neurons than women. Also, study in Hawaii (Nakashima, 1986) suggested that environmental and variant ecological conditions could cause changes in head dimensions such as cranial capacity and head shape. In addition, the fact that environmental pressures produce noticeable differences between people with respect to the cranial capacity is an important factor in enabling man to adapt to life in diverse environmental conditions (Irmak *et al*, 2004). Also, Rushton (1994) indicated that genetic factors are accounted for phenotypic variance in cranial capacity.

Cerebral index was higher in females than males significantly indicating that gender is an important factor in this case. This agrees with the work of Nooranipour and Farahani (2008). This study showed correlation between brain weight (head size) and test of intelligence, which might be as a result of differences in cultural background and socioeconomic status. Jensen (1994) reported effect of environmental factors such as nutrition and differential stress during pregnancy on brain size and cognitive ability. This suggests that population difference in cranial capacity and cranial dimension are attributed to race, age and geographical factors (Golalipour*et al*, 2003). The lower correlation between brain weight and test of intelligence observed can only partly be understood from the fact that much of brain is not involved in producing intelligence as such variation in size or mass of that tissue will lower the magnitude of the correlation as stated by Rushton(1995).

Intelligence quotient test showed significant difference between males and females with female's scoring higher than males. This might be because of differences in eye –hand motor coordination. Kimura *et al* (1992) stated that women excelled better than men in eye – hand

motor coordination. Also, according to Eysenk (1999) individual brain size is affected by nutrition and early experience, this can be due to the reason that males are more subjected to physical activities and attention is given much to females. Also, closely observing the test-taking behaviour of female subjects and noted that they worked very diligently, typically more interested than male subjects and recheck their answers.

Male students are less interested, more anxious, work less efficiently, or give up sooner on items they find difficult, perhaps because the problems have less meaning for them (Nell, 2000).

In addition, the differences between individuals and between groups in general intelligence is largely due to genetics and environment (Bouchard 2004). This study disagrees with the report of Lynn and mulhem (1999).This shows, conversely, that unrelated people reared together grow less similar over time. Between childhood and adulthood the influence of the shared home environment on IQ decreases, whereas the effect of genetic similarity increases (Plomin*et al*.,2001). The most likely reason why larger brains are, on average, more intelligent than smaller brains is that they contain more neurons and synapses, which make them more efficient (Haier *et al*., 1995).

The study showed association between parental education and parental occupation with child's test of intelligence, this in accordance with Hawaii Family Study of Cognition which was used to ascertain the associations of parental cognitive ability, parental education and paternal occupation with offspring cognitive ability. Parental cognitive ability was substantially associated with parental education and paternal occupation only trivially associated with offspring performance.

This study showed variations of cranial capacity with ethnic groups which could be attributed to genetic and environmental Influences and food habits as reported by Kasai *et al*. (1993) and Golalipour*et al*. (2003).

On the effect of ethnicity on cranial capacity, study found no effect of cranial capacity on intelligence test score. It may therefore be suggested that, size would not be expected to increase cognitive competence more than modestly because larger brains have larger neurons and more myelinated axons connecting them as reported by Deacon (1990). It is perhaps because of this reason that people with larger than normal brains are not necessarily brighter (DeMyer, 1986); indeed, there appears to be a plateau and perhaps a decrease in IQ in the largest brains (Reiss *et al.*, 1996).

It has also been argued that there are important aspects of human intelligence that IQ tests fail to measure, such as creativity, practical intelligence, social intelligence and emotional intelligence. Some of these constructs are more securely grounded than others, and not all of them are wholly independent of IQ. This is because psychometrically measured IQ leaves out much cognition relevant to intelligent behaviour. In particular, IQ tests by design ignore one well studied area of intelligence, known to be independent of IQ scores: expertise (Ackerman, 1996; Ericsson & Lehmann, 1996).

Another aspect of the present study is the finding of relationship between BMI and intelligence test score. In this sense, it was observed that there was a significant negative correlation between intelligence test score and BMI. The present results coincided with diverse findings that establish a negative relationship between BMI and cognitive abilities (Halkjaer*et al*., 2003; Hirshman*et*

al., 2004). This association may perhaps be explained based on potential genetic factors as suggested by Teasdale *et al*. (1992).

Study showed association of age with cranial capacity, this is consistent with the work of previous researchers which explained that a curvilinear pattern of growth and change, with an overall decrease in brain volume following the late teens as brain tissue is replaced with cerebrospinal fluid (CSF). Pfefferbaum*et al*. (1994) demarcated cell growth, myelination, pruning, and atrophy, finding that from 3 months to 30 years, cortical gray matter volume (mainly cell bodies) peaked at around age 4 years and then declined steadily throughout the lifespan; cortical white matter volume (myelin sheath) increased steadily until about age 20 years and appeared stable thereafter; and cortical CSF remained stable from 3months to 20 years and then increased exponentially from 21 to 71 years.

The fact that general intelligence shows concomitant increases during childhood and adolescence and then (slow) decreases between ages 25 and 45, and (faster) decreases after age 45, showed an average decline in test scores with increasing age decline of mental ability with age is part of the general organic process which constitutes the universal phenomenon of senescence (Brody, 1992) and Deary (2000). Richard (1999) reported that age is an important variable because the male advantage in General Mental Ability does not emerge until the late adolescent growth spurt when brain size differences peak. Girls mature faster than boys, which give them an early advantage in language development and may mask later cognitive differences.

CHAPTER SIX

6.0 Summary, Conclusion and Recommendation

There was no relationship between Craniometric parameter and test of intelligence for males. However, in females there was a relationship between cranial length, cranial capacity, brain weight, cerebral quotient and index with test of intelligence. There was relationship between anthropometric parameters and test for intelligence. This was observed between BMI and test of intelligence in females, and between chest and waist circumferences and test for intelligence in males. Paternal level of education influenced cranial breadth, cranial capacity, brain weight, cerebral quotient, weight, height, neck circumference and chest circumference. Maternal level of education also influenced height, weight, cranial capacity, cranial height, brain weight, neck circumference, chest circumference and mid upper arm circumference.

Conclusion

Ethnic difference was observed in the Craniometric parameters except cranial height. There was no relationship between Craniometric parameters and test of intelligence in males, while in females some relationship was observed. Relationship was observed between anthropometry and test of intelligence.

Recommendation

The following further researches on this work are recommended:

- To find out the basis of genetic factors, which accounted for the phenotypic variance in cranial capacity.

- On whether environmental factors exert more influence on different ethnic groups.
- Using more detailed examination with better assessments of brain size such as magnetic resonance imaging.

Contributions to knowledge

- Positive correlation was observed between cranial capacity and test of intelligence: male (r = 0.04); female (r = 0.15).
- Negative correlation was observed between test of intelligence and anthropometric parameters (body mass index) in females (r = -0.11)
- Remarkable sexual dimorphism was observed in cranial capacity in students of Ahmadu Bello University. Male: 1422.50; female: 1326.80 (p □ 0.005).
- Ethnic differences was observed in cranial capacity and intelligence among students of Ahmadu Bello University (p □ 0.005).

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Questionnaire for the Study of Cranial Capacity in relation to Intelligence and Other Anthropometric Parameters among Students of Ahmadu Bello University.

Biological data of respondent

Research ID____

I. Age_____ II. Sex_____

III. State of origin_____ IV. Tribe_____

Ethnic background:

I. Father's ethnic group _____
II. Mother's ethnic group_____
III. Grandfather's ethnic group_____

Socioeconomic Background:

I. Father's occupation: working/ business/others_____
II. Mother's occupation: working/ business/others_____
III. Father's level of education: none/primary/ secondary/above secondary_____
IV. Mother's level of education: none/ primary/ secondary/above secondary_____

Craniometric parameters:

I. Cranial length (cm) _____
II. Cranial breadth (cm) _____
III. Cranial height (cm) _____
IV. Cranial capacity (cm cube) _____
V. Cerebral index_____

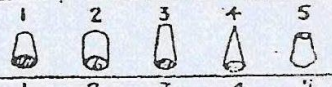
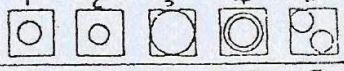
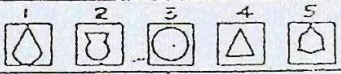
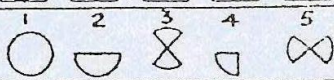
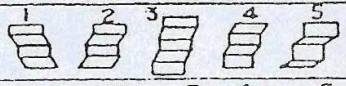
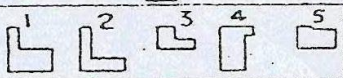
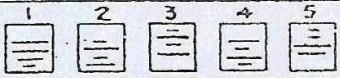
Anthropometric parameter:

I. Height (cm) _____
II. Weight (kg) _____
III. BMI_____
IV. Waist circumference_____
V. Hip circumference_____
VI. Neck circumference_____
VII. Mid upper arm circumference_____
VIII. Chest circumference_____

NON-VERBAL REASONING TEST

Qu. No		Qu. No
1	□ IS TO ▢ AS ○ IS TO	1
2	IS THE SAME AS	2
3	FROM △ TAKE A AND THERE IS LEFT	3
4	WHICH OF THE FOLLOWING COMES NEXT?	4
5	△ PLACED EXACTLY on top of ▢ GIVES THE FOLLOWING OUTLINE	5
6	IS TO AS IS TO	6
7	IS THE SAME AS	7
8	FROM TAKE AND THERE IS LEFT	8
9	WHICH OF THE FOLLOWING COMES NEXT?	9
10	PLACED EXACTLY on top of GIVES THE FOLLOWING OUTLINE	10
11	□ IS TO AS ▭ IS TO	11
12	IS THE SAME AS	12
13	FROM TAKE AND THERE IS LEFT	13
14	WHICH OF THE FOLLOWING COMES NEXT?	14
15	PLACED EXACTLY on top of GIVES THE FOLLOWING OUTLINE	15
16	IS TO AS IS TO	16
17	IS THE SAME AS	17
18	FROM TAKE AND THERE IS LEFT	18
19	WHICH OF THE FOLLOWING COMES NEXT?	19
20	PLACED EXACTLY on top of ▢ GIVES THE FOLLOWING OUTLINE	20
21	IS TO AS IS TO	21
22	IS THE SAME AS	22

2

QU. Nº		QU. Nº
23	FROM  TAKE  AND THERE IS LEFT  (1 2 3 4 5)	23
24	 WHICH OF THE FOLLOWING COMES NEXT?  (1 2 3 4 5)	24
25	 PLACED EXACTLY ON TOP OF  GIVES THE FOLLOWING OUTLINE  (1 2 3 4 5)	25
26	 IS TO  AS  IS TO  (1 2 3 4 5)	26
27	 IS THE SAME AS  (1 2 3 4 5)	27
28	FROM  TAKE  AND THERE IS LEFT  (1 2 3 4 5)	28
29	 WHICH OF THE FOLLOWING COMES NEXT?  (1 2 3 4 5)	29
30	 PLACED EXACTLY ON TOP OF  GIVES THE FOLLOWING OUTLINE  (1 2 3 4 5)	30

APPENDIX II

ETHICAL CLEARANCE

HEALTH RESEARCH ETHICS COMMITTEE

AHMADU BELLO UNIVERSITY TEACHING HOSPITAL

SHIKA - ZARIA, NIGERIA.

E-mail: abuth@yahoo.com *Website: www.abuth.org*

Chairman of Board: Chief. Shuaib Oyedokun Afolabi *Fnil*
Chief Medical Director: Prof. Lawal Khalid, *MBBS, FMCS, FWACS, FRCS(ED) mnl*
Chairman, Medical Advisory Committee: Prof. Abdullahi Mohammed, *MBBS, FWACP, FICS*
Director of Administration: Barr. Ishak Bello, *LL.B, BL., LL.M, PGDM, AHAN, FCAI*

Our Ref: ABUTH/HREC/TRG /36 *Date:* 10th April, 2014

Your Ref:

ABUTH HREC FULL ETHICAL CLEARANCE CERTIFICATE

Re: **"Study of Cranial Capacity in Relation to Intelligence and other Anthropometric Parameters in ABU Students".**

ABUTH Ethics Committee assigned number:	-	**ABUTH/HREC/G9/2013**
Name of the principal Investigator:	-	**Ganiyu Mujidat Oluwatoyin,**
Address of the Principal Investigator:	-	**Department of Human Anatomy, ABU. Zaria.**
Date of receipt of valid application:	-	**3rd Oct,** 2013
Date of meeting when final determination on ethical approval was made:	-	**8th April, 2014**

This is to inform you that the research described in the submitted protocol, the consent forms and other participant information materials have been reviewed and ***given full approval by the Health Research Ethics Committee.***

Please note: this approval dates from **10th April, 2014– 10th April, 2015**.

No participant recruitment into this research may be conducted outside these dates.

All informed consent forms in this study must carry the ABUTH HREC number assigned to this research and the duration of ABUTH HREC approval of the study.

This HREC expects that you submit your application as well as an annual report for ethical clearance renewal 3 months prior to expiration of study dates. This is to enable you obtain renewal of your approval and avoid interruption of your research.

If there is delay in starting the research, please inform the ABUTH HREC so that starting dates can be adjusted accordingly.

No changes are permitted in the research without prior approval by ABUTH HREC, except in circumstances outlined in national code for Health Research Ethics: http://www.nhrec.net.

ABUTH HREC reserves the right to conduct compliance assessment visits to your research site without prior notification.

Prof. A. I. Mamman
Chairman, ABUTH HREC