RELATIONSHIP BETWEEN SECOND TO FOURTH DIGIT RATIO (2D:4D) AND SOME ANTHROPOMETRIC VARIABLES TO ACADEMIC PERFORMANCE AMONG SECONDARY SCHOOL STUDENTS IN KADUNA, NIGERIA.

BY

RAYYAN, KABIR MUHAMMAD

DEPARTMENT OF HUMAN ANATOMY,
FACULTY OF MEDICINE,
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

AUGUST, 2015.

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RAYYAN, KABIR MUHAMMAD
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THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (M.Sc) DEGREE IN HUMAN ANATOMY

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DECLARATION

I, RAYYAN, KABIR MUHAMMAD declare that the dissertation entitled **Relationship between Second to Fourth Digit Ratio (2D:4D) and some Anthropometric Variables to Academic Performance among Secondary School Students in Kaduna, Nigeria.** was performed by me in the DEPARTMENT OF HUMAN ANATOMY, FACULTY OF MEDICINE, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA. under supervision of Prof. S. S. Adebisi and Dr. B. Danborno. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

RAYYAN KABIR MUHAMMAD **SIGNATURE** **DATE**

APPROVAL PAGE

This dissertation entitled **Relationship between Second to Fourth Digit Ratio (2D:4D) and some Anthropometric Variables to Academic Performance among Secondary School Students in Kaduna,** By **RAYYAN, Kabir Muhammad** meets the regulations governing the award of the degree of Master of Science of and is approved for its contribution to knowledge and literary presentation.

Prof. S. S. Adebisi (B.Sc, M.Sc, Ph.D) _____ _____
Chairman Supervisory Committee Signature Date
Department of Anatomy
Faculty of Medicine,
Ahmadu Bello University, Zaria.

Dr. B. Danborno (B.Sc, M.Sc, Ph.D) _____ _____
Member Supervisory Committee Signature Date
Department of Anatomy
Faculty of Medicine,
Ahmadu Bello University, Zaria.

Prof. S. S. Adebisi (B.Sc, M.Sc, Ph.D) _____ _____
Head, Signature Date
Department of Anatomy
Faculty of Medicine,
Ahmadu Bello University, Zaria.

Prof. Z.A. Hassan _____ _____
Dean, School of Postgraduate studies Signature Date
Ahmadu Bello University, Zaria.

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DEDICATION

This dissertation is dedicated to my mother, Mrs Zainab Asabe Rayyan. May this work stand as a small gesture of my abiding gratitude.

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ABSTRACT

The second to fourth digit ratio (2D:4D), is a sexually diamophic trait, with males on the average having lower ratios than females. 2D:4D is established in the uterus, therefore its found in fetus, children, and unaffected by puberty. It also appear to be universal across ethnic groups, and it exist in mammals and other primates. 2D:4D is positively associated with prenatal estrogen and negatively associated with prenatal testosterone. The present study is primarily aimed at investigating the existence of the association between digit ratio (2D:4D), with academic performance of secondary school students in Kaduna, Nigeria. A total of 462 students (239 males and 223 females) participated in the study from three secondary schools in Kaduna metropolis. Relevant data were collected through a self-administered questionares after which certain anthropometric measurements including digit length, weight, height and some circumferences which include head, neck, hip and waist. Academic performance of the students were measured from the terminal examinations results obtained from the schools managements. Our study found that low 2D:4D (a correlate of high prenatal testosterone and low prenatal oestrogen) is associated with better performance on Mathematics in males but not in females. There were no correlation between 2D:4D and academic performance, based on the three other subjects considered among the secondary school students in Kaduna, Nigeria. The study also agree with the literature that says 2D:4D ratio tend to be more on the right hand than the left hand. We therefore conclude that 2D:4D ratio is associated with better performance in Mathematics and numerical capability in boys

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The second to forth finger length ratio (2D:4D) is a sexually dimorphic trait that has been known for over 100 years (Baker, 1888), with men, on average, having lower 2D:4Ds than women do. Unlike sexually dimorphic characteristics that appear at puberty, 2D:4D is established by the 13th week after conception (Garn *et al.,* 1975).), therefore this dimorphism found in the fetus (Malas *et al.,* 2005) and in children (Manning *et al.,* 1998; McIntyre *et al.,* 2005); is unaffected by puberty (Trivers *et al.,* 2006) and appeared to be universal across ethnic groups (Manning, 2002) and has been shown to exist in mammals and other primates (Burley and Foster 2004; Brown *et al*., 2002). Based on a large number of studies, it has been concluded that 2D:4D is positively associated with prenatal estrogen and negatively associated with prenatal testosterone (Manning, 2002; Danborno *et al*., 2007 and Breedlove 2010). Evidence such as this does not include direct measurements of prenatal testosterone, but its sex dependent pattern led Manning *et al.,* (1998) to suggest that 2D:4D may be negatively correlated to prenatal testosterone and positively related to prenatal estrogen.

In recent years, the so-called second (2D) to fourth (4D) digit ratio has received a lot of research attention. In the past 7 years, many papers have documented relationship between 2D:4D and human traits and behaviors. This ratio seems to be established in utero (Csatho *et al*. 2003a; Manning *et al.,* 1998; Williams *et al*., 2003). Some evidence suggests that the index finger (digit 2) is an indicator of prenatal estrogen levels while the length of the ring finger (digit 4) appears to

be determined by prenatal testosterone levels (Manning, 2002). Although both digits could be investigated in isolation as they would indicate different hormones, research typically looks at the correlates of the ratio between 2nd and 4th digit (2D:4D). There are some exceptions to this general practice. For instance, Robinson and Manning (2000) found an association between homosexuality and the 4th, but not the 2nd digit (controlled for height); Manning and Wood (in Manning, 2002) report that boys with long 4th digits adjusted for height reported more physical aggression compared to participants with short 4th digits while recently Danborno *et al.,* (2010) were able to show that the ratio can be a predictor of birth weight.

However, the 2D:4D literature suggests that the balance between male and female prenatal hormone levels rather than these hormone levels in isolation triggers neurological and behavioral processes (Manning, 2002). The growing list of psychological correlates of 2D:4D and the short list of psychological correlates with the digits separately may suggest that investigating the main effects of one sexual hormone might not make too much sense without taking into account the other hormone level. Note that this remark applies to the role of hormone levels *in utero* and does not necessarily generalize to fluctuating hormone levels.

The heritability of 2D:4D has been examined in three twin samples (Paul *et al.,* 2006; Voracek and Dressler 2007, and Gobrogge *et al*., 2008). The point estimates from these studies indicate substantial additive genetic effects. However, it is also obvious, from the wide confidence intervals, that the power of previous studies to detect significant common environmental effects, or sex differences in the variance components, was limited. Within each sex, 2D:4D has been

found to be associated with a variety of physical and psychological characteristics. For example, men with lower 2D:4D are more aggressive, more athletic, less feminine (on the Bem Sex Role Inventory), and more musically talented (Bailey and Hurd, 2005; Manning and Taylor, 2001; Rammsayer and Troche, 2007; Sluming and Manning, 2000). Women with lower 2D:4D have higher waist-to-hip ratio, are more masculine (on the Bem Sex Role Inventory), and are more athletic (Csathó *et al.*, 2003a; Manning *et al.*, 2000; Pokrywka *et al*., 2005). Among both men and women, 2D:4D is correlated positively with verbal intelligence and agreeableness, and negatively with numerical intelligence and physical fitness (Hönekopp *et al*., 2006; Luxen and Buunk, 2005). Autistic individuals have also been found to be gifted in identifying recurrent patterns, processing perceptual information, and often have exceptional memories and are less likely to misremember data (Mottron, 2011). These are characteristics that are useful in order to perform well in practical and theoretical examinations.

A number of recent studies have reported an association between digit ratio and performance on a range of measures assessing cognitive abilities and personality (e.g., Austin *et al.*, 2002; Bailey and Hurd, 2005; Csatho *et al*., 2003a; Manning, 2002), and sexual orientation and identity (e.g., Rahman and Wilson, 2003; Robinson and Manning, 2000; Williams *et al.*, 2000). For example, a significant association between digit ratio and spatial navigation and picture recall skills has only been found for females (Csatho *et al.*, 2003b) whilst significant associations with mental rotation ability and academic performance have typically only been reported for males (Manning and Taylor, 2001; McFadden and Romano *et al.*, 2006), although Kempel *et al.*, (2005) have recently reported poorer performance of high digit ratio females on mirror picture and shape unrolling tasks. Reports of digit ratio in relation to aspects of mathematical performance are less common.

Luxen and Buunk (2005) found a significant correlation between right hand digit ratio and numerical skills, with numerical skills being higher in individuals with lower masculinised digit ratios. Kempel *et al.,* (2005) also found that females with more masculinised digit ratios performed better on a numerical IQ task (continuing numerical series). In the mathematical cognition literature, it has been argued that mathematical thinking depends in part on an underlying "number sense" (Dehaene *et al.,* 2003), which is biologically determined and has a long evolutionary history. This number sense allows us to compare and approximate numerical quantities, and such abilities have been repeatedly demonstrated in studies with very young infants (Lipton and Spelke, 2003; Xu, 2003).

Finally Hopp *et al*., (2012) have found that low 2D:4D is related to practical and theory examination marks in Brazilian male dental students. They suggest that their finding supports a theoretical link between high prenatal testosterone and high intelligence. The lack of a relationship between 2D:4D and examination marks in female dental students indicate that prenatal testosterone does not influence female intelligence in the same manner as that in males, even though the studies is consistent with that of Coco *et al.,* (2011) evaluated a group of 48 male students, and found a significant correlation between 2D:4D and success in admission tests for a medical school in Italy

1.2 Statement of Research Problem

In developing countries like Nigeria, anthropological data are scarce and where they are available, they are not properly documented. This make it difficult to evaluate some phenotypic, physiological and psychological characteristics from the available data. Recently, studies from 2D:4D ratio signals such qualities as height, intelligence, aggression, health and fertility in man, this study is intended to accumulate data on 2D:2D ratio among secondary schools students in Kaduna, Nigeria, and correlate it with some specific anthropometric parameters like head circumfernce, BMI, WHR etc.

1.3 Justification of the Study

Prenatal testosterone has been proposed to directly influence intelligence or academic performance by modulating the developmental processes of neuronal proliferation, migration, differentiation, and apoptosis. This is thought to increase the density of neuronal networks in certain areas of the brain related to cognition, learning and memory, either by decreasing apoptosis of brain cells during development, or increasing migration of cells to one of those areas (Mrazik & Dombrowski, 2010). Differences in prenatal hormone exposure can lead to different traits in personality, aggression, behaviour and ability to perform tasks such as playing sports, driving carefully, investing money or doing manual labour. Low 2D:4D has been correlated to success and profitability in financial trading (Coates *et al.*, 2009), success in sports such as rugby, sprinting and running (Manning *et al.*, 2007) and numeric capabilities and ability to understand information communication technology (Brosnan, 2006).

In this present research, we consider the possibility that digit ratio (2D:4D), as a putative marker for prenatal testosterone (Manning 1998), could be use to provide a basis locally in which brilliant students can be selected based on the study of their digit ratio and to some extend, their head size. Recently, Hopp *et al,*. (2012) reported an association between 2D:4D and intelligence in dental students of a Brazillian University. In addition there is no published data about the relationship between digit ratio and academic performance in Nigerian children. It's against this backdrop that the present study seeks to find out what's the academic performance of students in relation to their 2D:4D in Nigeria with a view to finding out how it is influenced by other anthropometric parameters, ethnicity, and socio-economic factors and to make recommendations where necessary.

1.6 Aims of Study

This study is aim to investigate the exitence of association between 2D:4D ratio with academic performance of secondary school students in Kaduna, Nigeria.

1.7 Objectives of the Study

With the emergence of the importance of digit ratio as a pointer to height, intelligence, aggression, health and fertility, the present study is designed to investigate:

i. The relationship between 2D:4D and academic performance among secondary schools students.
ii. Sex differences in 2D:4D ratio among some Nigerians students.
iii. The relationship between 2D:4D and head circumference
iv. The relationship of 2D:4D ratio with BMI of students

v. Relationship between 2D:4D and waist, hip and neck circumference.

1.4 Significance of Study

The results of the present study will provide bases in which brilliant students can easily be selected based on their head sizes and 2D:4D ratios. It could also be possible to use the data to determine in which course of study a student could performe well. The outcome of the study could also provide the basis for appealing to government at all levels to bring programs specifically to suit each of the people's peculiar needs. This study could help create awareness on the use of some body parameters to come to some psychological conclusions. This study will also create awareness to authorities and the general public on the importance of digit ratio as a pointer to certain biological attributes of man and demonstrate how the knowledge of biological anthropology applies to numerous fields of science and medicine

1.5 Hypothesis

a. There is a correlation between academic performance and digit ratio of the students
b. There is a negative relationship between 2D:4D with socio-economic status of the students.
c. There is a positive relationship between 2D:4D with height, weight, head circumference, hip circumference etc.

1.6 The Study Encountered the Following Limitations

i. Inability to trace academic records of some students who had already participated in the study.

ii. Lack of complete academic records of some students.

iii. Lack of co-operation by some school authority.

iv. Limited time were allocated for the study by the schools authorities, thereby making it difficult to get the required number of students.

v. Different subjects combinations of some students, as some students who participated in the studies do not offer some of the general subjects under the consideration.

vi. Loss of questionnaires.

CHAPTER TWO

LITERATURE REVIEW

2.1 Evidence of Androgen effect on Digit Ratio

The relative length of the index finger to the ring finger, *i.e*., the second-to-fourth digit ratio (2D:4D), is sexually dimophic in humans and non-human species, such as other primates, rodents, avian, lizard, and amphibian species (Chang, 2008 and Voracek, 2006). In male fetuses, testosterone secretion from testes starts at about the 9th week of gestation, and testosterone levels peak between 10 and 20 weeks (Knickmeyer and Baron-Cohen, 2006), and this ratio does not change between the ages of 2 and 25 years (Manning *et al.,* 1998) Male fetuses produce more than 2.5 times the testosterone levels observed in female fetuses (Daftary, 2006). In the second trimester, male testosterone production declines and remains at low levels until after birth (Word, *et al.,* 1989). From around three months after birth, there is a second peak in human male testosterone levels (Andersson *et al.,* 1998). There is now clear evidence that exposure to high testosterone levels during early development has permanent effects on various sex-typed behaviors in humans (Cohen-Bendahan, *et al., 2005*; Collaer and Hines, 1995).

Evidence of testosterone effect on 2D:4D is provided from the studies of males and females with congenital adrenal hyperplasia (CAH). CAH causes excessive androgen production from the adrenal glands during gestation. Although postnatal treatment brings androgen levels back to normal (Hines, 2003), CAH affected girls show masculinised and defeminised play behavior in comparison to normal controls (Hines, 2003; Knickmeyer *et al.,* 2006). A similar effect was not observed in boys, but CAH affected boys appear to have normal prenatal testosterone levels

(Hines, 2003). Although studies on girls with CAH support the idea that prenatal testosterone affects sex-typed play behavior in humans, too, these studies have limited internal validity because CAH affected girls differ from normal controls in that they have masculinised genitalia and a severe medical condition (Cohen-Bendahan *et al.*, 2005; Hines, 2003; Knickmeyer *et al.*, 2005). Furthermore, studies on CAH affected individuals cannot elucidate whether normal variation of prenatal testosterone within each sex has any effects on sex-typed play behavior. This question was addressed in a longitudinal study by Auyeung *et al.* (2006), which related amniotic testosterone (measured around the 16th week of gestation) to sex-typed play behavior at age nine years as indicated by mothers answering the Pre-School Activities Inventory (Golombok and Rust, 1993). Higher testosterone levels were clearly related to more masculine play behavior in girls and boys. Several lines of evidence indicate that 2D:4D is negatively related to early testosterone exposure. Indeed, digit ratios offer a valid test of the organizational hypothesis that androgens act early in life to masculinize various human behaviors (Breedlove, 2010) This sex difference is already apparent at the end of the first trimester (Malas, *et at.,* 2006). The sex difference in 2D:4D as well as individual values, show considerable stability across childhood and adolescence (McIntyre, *et al.,* 2005; Trivers, *et al.*, 2006).

Moreover, the development of the digits in utero and prenatal concentrations of estrogens and testosterone are linked genetically through the action of *Hox* genes (homeodomain-containing homeotic genes). Specifically, in vertebrates, including humans, *Hox* genes play a crucial role in differentiation of both the urogenital system (including the testes and ovaries) and digit length. (Hérault *et al.,* and Piechel *et al.,* 1997). Humans have 39 *Hox* genes organized into four clusters (A, B, C and D) found on chromosomes 7, 17, 12 and 2, respectively, and each cluster is made up

of 9 to 13 genes (Krumlauf, 1994). *Hox* genes are expressed during embryogenesis and in the adult, and recently it has become apparent that sex steroids such as oestradiol and testosterone may regulate the expression of *Hox*A9, *Hox*A10 and *Hox*A11 (Daftary and Taylor, 2006). In mice, deregulation of *Hox*D alters the relative lengths of digits and affects growth of the genital bud and differentiation of the penis.(Kondo *et al.,* 1997). In humans, the hand-foot-genital syndrome, a result of *Hox*A13 mutation, is characterized by defects in the digits, toes, and genitalia. (Mortlock 1997)

Furthermore, the presence of estrogen receptors on bone cells and the influence of 17β-estradiol and progesterone on the *Hox* genes confirm the suggestion that endogenous sex hormones regulate growth of the phalangeal bones. A study estimated the genetic contribution in general and heritability for the formation of digit ratios at up to 66%; no other significant environmental effects were detected.(Paul *et al.,* 2006) Evidence suggests that the 2D:4D ratio is a marker for estrogen and testosterone concentrations toward the end of the first trimester of pregnancy. (Manning 1998,2002; Lutchmaya *et al.,* 2004), and that this ratio reflects the action of *Hox* genes on differentiation during early pregnancy. This association has been explained by the finding that the same gene group influences both the formation of the distal limbs and of the urogenital system. The homeobox genes (*Hox*A and *H0x*D) not only control the differentiation of fingers and toes but also the development of the urogenital system and so indirectly determine the prenatal production of androgens (Peichel *et a.,* 1997; Herault *et al.,* 1997). This influence becomes most evident when mutations such as the hand-foot-genital syndrome occur. This syndrome caused by a mutation in *Hox*A13 results in anomalies of the distal limbs (*e.g.* brachydaktyly) and in the genital system (Manning and Bundred, 2000). The homeobox

hypothesis explains the correlation of 2D:4D and prenatal testosterone in an indirect way through a common genetic underpinning.

In addition, testosterone sensitivity depends on the number of CAG repeats in the androgen receptor gene, and the number of these repeats is related to 2D:4D (Manning *et al.,* 2002). But there is also evidence for a causal link. It could be demonstrated that the sensitivity to testosterone is determined by the number of CAG triplets found at one end of the androgen receptor gene. Normal variation in triplet number varies between 11 and 30 CAG repeats. Whereas a low number of triplets is associated with high sensitivity, a high one relates to low sensitivity. Importantly, the number of CAG triplets and 2D:4D are positively correlated. Taken together a low CAG number is associated with high sensitivity to testosterone and with low 2D:4D (Manning *et al.,* 2003).

Also, high prenatal testosterone levels delay the onset of menarche, and 2D:4D is negatively related to self-reported menarcheal age in women (Manning, 2002). In sum 2D:4D appears to be negatively affected by prenatal testosterone in humans. At the same time, 2D:4D appears unrelated to circulating steroid levels (Hönekopp *et al.,* 2006) and can thus be regarded as useful for studying long lasting effects of prenatal testosterone in humans. For this reason, 2D:4D has become increasingly popular for studying effects of early androgenisation on human adult behavior and physiology (Voracek and Loibl, 2009). The theory of fluctuating asymmetries assumes that the right side of the body is more influenced by testosterone than the left side. Therefore, the effects of testosterone may be seen specifically on the right hands (Manning, 2002). Prenatal testosterone inhibits the growth of the left hemisphere and promotes the growth

of the right. (Papaioannidou *et al.,* 2007) . human 2D:4D is currently regarded as an anatomical indicator of the organizational masculinizing effects of prenatal androgens, especially testosterone, on the brain (Voracek, 2009).

Finally, recent experimental work on the fetuses of mammals (rats and mice) has essentially confirmed that the 2D:4D ratio is negatively associated with prenatal testosterone and positively associated with prenatal estrogen (Manning, 2012; Talarovicova *et al.,* 2009; Zhengui and Martin, 2011).

2.2 Association of Digit Ratio and some Diseases Condition

Association of digit ratio and diseases condition have attracted considerable research attention. This is because prenatal sex hormones may affect the development of a number of organ systems including the cardiovascular system (Kraemer *et al.,* 2006) . Prenatal conditions are likely to be powerful antecedents of coronary heart disease (Manning *et al.,* 2000). It was implicated that high prenatal testosterone levels in the aetiology of left-handedness, autism, dyslexia, migraine, stammering and in disorders of the immune system resulting from effects on the thymus. (Geschwind *et al.,* 1985a). Further, first trimester exposure to oestrogen and progesterone may lead to cardiovascular anomalies such as ventricular septal defect, pulmonary stenosis, patent ductus arteriosus or transposition of the great vessels.(Levy *et al.,* 1973; Heinonen *et al.,* 1977).

It was also reported by Arato *et al.,* (2004), that more 'feminized' (*i.e*., larger) 2D:4D bilaterally in male and female schizophrenia patients compared to same-sex controls they deduced that low fetal androgen/estrogen ratio may predispose to schizophrenia, and endocrine factors may be involved in disturbed hemispheric lateralization. Schizophrenia is a severe mental disorder

characterized by some, but not necessarily all, of the following features: emotional blunting, intelectual deterioration, social isolation, disorganized speech and behaviour, delusions and hallucinations. (dictionary .com). Another study showed female schizophrenia patients had shorter second digit lengths than female controls, with no difference among males, interpreted as a protective effect of prenatal estrogen in females (Procopio *et al.,* 2005). To date, it is unknown whether the normative pattern of 2D:4D sexual differentiation holds among individuals at high-risk for schizophrenia.

Research has shown that male survivors of myocardial infarction have lower testosterone and higher estradiol levels than age-matched controls. (Aksüt *et al.,* 1986 and Phillips *et al.,* 1994). In fact, incipient coronary heart disease may be traced from prenatal life. First-trimester exposure to excess levels of estrogens and progesterone may lead to cardiovascular anomalies. (Heinonen *et al.,* 1977). Thus, high 2D:4D ratios in men are likely to be correlated with premature myocardial infarction and a better prognosis after myocardial infarction. (Manning *et al.,* 2000) Digit ratios that include ring-finger length (ie, 4D) may be useful biomarkers for predisposition to myocardial infarction in Greek men, but not in Greek women **(**Kyriakidis *et al.,* 2008)

It has been found that men with a low 2D:4D ratio tended to have their first myocardial infarction's later in life than men with high 2D:4D ratios .(Lutchmaya *et al.,* 2004). Although the effects of 2D:4D ratio on the cardiovascular system have been shown in means of myocardial infarction, the link between 2D:4D ratio and atherosclerotic formations have not been shown in the literature yet.

Low digit ratios were proposed as proxy markers for short CAG-triplet repeat lengths on the androgen receptor, predisposing patients for cancer development. (Manning *et al.,* 2002). Positive correlations between 2D:4D and the amount of CAG triplets on the androgen receptor gene were reported (Manning *et al.,* 2003), and thus, low digit ratios could predispose patients to carcinogenesis and short CAG sequences would contribute for disease prognosis.

Males diagnosed with prostate cancer presented more masculinized digit ratios, especially when compared to males that presented no prostatic lesion at all. Digit ratios could provide a possible putative marker for the screening of patients in risk to develop prostatic malignancies, if and when correlations are confirmed by larger studies. It also points to the necessity of further investigation of the relations between prostate cancer and genetic and hormonal factors that could be represented by digit ratios.(Hopp *et al.,* 2011).

Furthermore, 2D:4D ratio may also be a predictor of fertility, the pattern of differentiation of the central nervous system, and the expression of a number of adult onset diseases, such as immune dysfunction, breast cancer, and myocardial infarction. (Manning *et al.,* 2000 and Kyriakidis *et al.,* 2008). Recent findings support a low 2D:4D in children with autism (Milne *et al.,* 2006). There is a relationship between 2D:4D and psychopathology. Children with autism manifest lower 2D:4D ratios than population norms (Manning *et al.,* 2001). Some behavioural traits with an excess of males have been shown to be associated with low values of 2D:4D, e.g. left hand preference (Manning *et al.,* 2000), good visualspatial ability, autism and Asperger's syndrome. (Manning 2001).

2.3 Geographic and Ethnic Variation in Digit Ratio

Manning and collegues have shown that digit ratio vary greatly between different ethnic groups (Manning *et al.,* 2000, Manning *et al.,* 2004). This variation is far larger than the difference between sexes, as Manning puts it "There is more difference between a pole and a Finn than a man and a woman". The variation appears to be related to latitude, such that more northerly population have higher digit ratios.

Manning's hypothesis in 1998 has received great resonance by researchers within and outside psychology. Accordingly, over the past decade, 2D:4D research has developed into a substantial research program, which numbered about 500 published reports (Voracek and Loibl, 2009). Presently, 2D:4D research is published at a rate of about 1–2 journal papers per week, and these researches came from more than 25 different countries or ethnic groups. Thereby reporting ethnic as well as geographic differences in digit ratio. (Voracek *et al.,* 2009). In international perspective, digit ratio is rather high in the United Kingdom, amounting to 0.97 or 0.98 in most studies. (Manning 2002). It is low in Sweden (0.95) (Voracek *et al.,* 2009), very low in Finland (0.93) (Manning 2002), but exceptionally high in Denmark (1.02) (Voracek *et al.,* 2006), and again rather high in Poland (0.99) (Manning 2000), much higher than in Germany (about 0.96) (Manning 2000).

Considerable geographical and ethnic differences in 2D:4D ratios do not claim that these differences in 2D:4D are the main factor in determining variation in family size between human groups. The rate of infant mortality and the economic value of children vary considerably across human populations (Harris, 1989). These and other factors are likely to have powerful effects on

birth rates. However the 2D:4D ratio may correlate with within and between population variance in fertility. If this proves to be the case it will be valuable to know the geographical and ethnic pattern of 2D:4D and whether the digit ratio explains some of the variance of family size across populations.

2D:4D is highly significant in similar population (Manning *et al.,* 2000; Peters *et al.,* 20002). Low mean ratios have been found in a black population and similar "masculinized" ratios have been reported in Afro-Caribbean sample from Jamaica (Manning *et al.,* 2000). It is not yet known how wide spread such low ratios are in black populations, and there is considerable between population variation in mean 2D:4D in Caucasian groups. Further data are necessary before we can get an accurate overall view of ethnic pattern in 2D:4D

2.4 Digit Ratio and Birth Weight

Birth weight is closely associated with the health and survival of the newborn. The relationship between maternal malnutrition and consequent low birth weight babies and the perinatal morbidity and mortality is now an accepted fact.

Low birthweight has been defined by the World Health Organization (WHO) as weight at birth of less than 2,500 grams (5.5 pounds), (Wilcox, 2001). The definition of low birth weight does not take into account the gestational period (Ojha and Malla, 2007). This practical cut-off for international comparison is based on epidemiological observations that infants weighing less than 2,500g are approximately 20 times more likely to die than heavier babies.2 More common in

developing than developed countries, a birthweight below 2,500 g contributes to a range of poor health outcomes.

Ronalds *et al.,* (2002) reported that 2D:4D ratio is associated with body size and proportion at birth in men, and that men who had higher 2D:4D were shorter at birth. This is because men with higher 2D:2D ratios were exposed to little testosterone prenatally. low 2D:4D is positively correlated with birth weight and head circumference but in males only. (Ronalds *et al.,* 2002).

Also Danborno *et al.,* (2010) has demonstrated the association between 2D:4D and birth weight, and birth weight could be predicted most especially form the left hands. Based on that, 2D:4D ratio could serve as a means to obtain an estimate of birth weight for individuals who do not know their birth weight. (Danborno *et al.,* 2010).

2.5 Digit Ratio and Sporting Ability

Being a successful athletes, someone has to posses some unique qualities which include visual-spatial awareness, speed, endurance, and strength. For example, elite footballers require spatial judgment, cardiovascular efficiency, speed, and occasionally strength. All of these qualities would be beneficial in direct male–male competition. The behavioral limits as dictated by the rules of sporting events are constantly tested by competitors, to the point where an official with total control is almost always required to police the contest (Manning and Taylor, 2001). Furthermore, the monetary and status rewards of achieving sporting success can often make the athletes more desirable to members of the opposite sex. It follows that sport mirrors intrasexual selection in that being successful in competition between males leads to the acquisition of

resources which in turn promotes access to females. To date, athletic ability has been linked to digit ratios in a variety of sports. Pokrywka *et al.,* (2005) found that female elite athletes in a range of sports had significantly lower 2D:4D digit ratios when compared to a control group of females not involved in sporting activities. Similarly, Paul *et al.,* (2006) demonstrated that participation in the highest levels of sport (competition at national level at least) was significantly and negatively associated with digit ratio, with the strongest correlations being found in the analysis of running ability. The same patterns have been found with male athletes, again encompassing a variety of sporting disciplines.

Ability in slalom skiing (Manning, 2002) was found to significantly correlate with digit ratio. The study found that skiers had lower digit ratios than nonskiers, and that the skiers with the lowest digit ratios recorded the fastest times over a 200-m slalom course. Similarly, an extensive study into English professional football (Manning and Taylor, 2001) found that first team players had lower mean 2D:4D ratios than reserve players, and that that the tested international players had lower mean 2D:4D ratios than players yet to play internationally. The authors provided early evidence that prenatal androgen exposure may enhance development of the cardiovascular system, as later suggested by Pokrywka *et al.,* (2005). Further work, considering endurance running, found that men with low 2D:4D ratio tend to run faster than men with high 2D:4D ratio, and that digit ratio explained up to 25% of variance in endurance running (Manning et al., 2007). This value is significantly greater than the figure of 10% reported for other sports which require a combination of strength and aerobic efficiency (Manning and Taylor, 2001). It is not yet known, however, if the association between digit ratio and sporting performance is only related to well-developed cardiovascular systems, or if the list of associated traits is more extensive. Further

characteristics may include the ability of muscle to generate power. This may be an important factor, as it has been shown that a positive relationship exists between maximal aerobic capacity and physical strength and performance in elite soccer leagues (Wisloff *et al.,* 1998), and that young elite players have higher isometric strength than nonelite players (Hansen *et al.,* 1999). In addition, an investigation considering elite skiers (Neumayr *et al.,* 2003) reported that two main factors are crucial in success at international level: high levels of aerobic capacity and muscle strength. However, the most compelling suggestion for a link between 2D:4D and strength is the relationship reported with hand-grip strength (Fink *et al.,* 2006), as hand grip strength is correlated to strength in other muscle groups.

Longman *et al.*, (2011) also reported that digit ratio is a predictor of ability in rowing, a sport which requires both cardiovascular efficiency and high power output, in males but not females. This in turn suggests that fetal testosterone exposure has long-term effects on traits associated with physical power in males but not females, suggesting a sex-difference in the capacity to respond to such exposures.

Research also indicates that male Indian swimmers have a significantly lower digit ratio whereas female Indian swimmers do not show significant difference in digit ratios. Digit ratio evaluation may be considered as one of the screening tools to select prospective athletes for training and recruitment to sports camps after clearly establishing the relationship between digit ratios and athletic performance in various sports. (Sudhakar *et al.,* 2013).

2.6 Digit Ratio and Fertility

2D:4D is significantly correlated with sperm counts, estrogen, and testosterone levels (Manning *et al.,* 1998; Neave *et al.,* 2003), sexual orientation (McFadden and Shubel, 2002; Robinson and Manning, 2000; Williams *et al.,* 2000), and a number of other variables related to health and fertility (Manning, 2002). These relationships are thought to arise from the influence of prenatal androgens on 2D:4D, since adult phalangeal ratios are obtained by the 13th–14th week of gestation (Garn *et al.,* 1975), More generally, a number of findings from 2D:4D research are suggestive for the hypothesis that 2D:4D may be a correlate of display traits that signal mate quality and reproductive fitness. This includes evidence for associations of 2D:4D with men's hand-grip strength (Fink *et al.,* 2006), with men's courtship behaviour (Roney and Maestripieri, 2004) and with wearing of wedding rings (Manning, 2002, Voracek, 2008a).

Androgens and a functioning androgen receptors are known to be necessary for normal development of the human penis. (Baskin *et al.,* 1997; Vogt 2007; Byne 2006). Although several studies have demonstrated that postnatal androgen exposure is important for penis growth, Husmann 2002; Welsh *et al.,* 2010; Herman *et al.,* 2000; Macleod *et al.,* 2010). Penis formation and its capacity to grow are determined foetally by foetal androgen action.(Baskin *et al.,* 1997; Vogt, 2007) Foetal androgen levels in males are elevated between weeks 8 and 24 of gestation, with peak levels occurring between weeks 14 and 16.(Byne *et al.,* 2009) Activation of androgen receptors by prenatal testosterone also appears to contribute to the development of male internal genital structures and the differentiation of male external genitalia.(Byne, 2006).

Manning *et al.*, (2004) observed that the mean testis volume was significantly negatively correlated with the right digit ratio in azoospermic men. These observations have led to the suggestion that patterns of digit formation may be related to gonad function.(Manning, 1998; Voracek 2003; Robinson 2000). Like digit development, penile growth is influenced by prenatal testosterone. (Baskin 1997 and Vogt 2007).Androgens and a functioning androgen receptor are known to be necessary for normal development of the human penis. (Baskin 1997; Vogt 2007; Byne 2006).

On the other hand infertility may be cause by mutation of *Hox* genes concerned with the development of the urogenital system and the limbs (including the formation of the fingers). Humans have 39 *Hox* genes organized into four clusters (A, B, C and D) found on chromosomes 7, 17, 12 and 2, respectively, and each cluster is made up of nine to 13 genes (Krumlauf, 1994). *Hox* genes are expressed during embryogenesis and in the adult, and recently it has become apparent that sex steroids such as oestradiol and testosterone may regulate the expression of *Hox*A9, *Hox*A10 and *Hox*A11 (Daftary and Taylor, 2006). Little is known about the effects of *Hox* gene mutation on fertility. However, in recent years it has become apparent that mutation of *Hox*A13 can lead to linked effects on the formation of the hand, foot and urogenital system (hand-foot-genital syndrome): (Goodman and Scambler, 2001; Mortlock and Innis, 1997). Individuals with hand-foot genital syndrome have distal limb abnormalities including delayed ossification, fusion and shortening of the carpals and tarsals affecting the first, second and fifth fingers and the second to fifth toes. Urogenital abnormalities include hypospadias in males (indicating perturbations of prenatal testosterone production), Mullerian duct fusion in females and ectopic ureteric orifices (Goodman and Scambler, 2001).

Synpolydactyly is another syndrome involving perturbations of finger development that is caused by *Hox* gene mutation, in this case mutation of *Hox*D13 (Goodman and Scambler, 2001). *Hox*D13, in common with the related *Hox*A13 gene, has an important role in the development of the distal limbs and urogenital system and some affected males have hypospadias (Goodman and Scambler, 2001). Hand-foot-genital syndrome and synpolydactyly are rare syndromes with noticeable phenotypic effects on fingers and fertility. However, Manning *et al.,* (1998) have suggested that mildly deleterious mutations in, or variation in sex steroid

Regulation of, *Hox* genes may link less obvious variation in finger morphology with fertility. Two finger traits, finger length adjusted for height and digit ratio have been considered as correlates of ejaculate characteristics. Manning (2002) has reported that fourth digit length adjusted for height is shorter in azoospermic men compared with men producing spermatozoa. 2D:4D is a sexually dimorphic trait with lower mean 2D:4D in males (longer fourth digits relative to second digits) compared with females (Galis *et al.,* 2009; Manning and Fink, 2008). The 2D:4D is likely to be determined in utero or within the first 2 years of life, and remain fixed thereafter (Manning *et al.,* 1998). The 2D:4D is thought to be influenced by prenatal testosterone and oestrogen concentrations (Lutchmaya *et al.,* 2004). Azoospermic men have been reported to have higher 2D:4D (i.e., shorter fourth digits relative to second digits) than men producing spermatozoa (Manning *et al.,* 1998). In addition, Wood *et al.,* (2003) have reported that surgical retrieval of spermatozoa has lower success rates from men with high 2D:4D compared with men with low 2D:4D.

In another research by Sutcliffe *et al.,* (2010), children conceived by intracytoplasmic sperm injection have shorter fingers than expected for their height and this effect is found in both males and females. There was also weak evidence that female intracytoplasmic sperm injection children have higher 2D:4D than control children. Perturbations in finger length in intracytoplasmic sperm injection children may be dependent on mutations in the *Hox* genes in sex steroid regulation of *Hox* genes. Such perturbations could indicate lowered fertility and reduced sexual attractiveness in males. Higher values of 2D:4D in intracytoplasmic sperm injection females could suggest higher fertility in comparison to female controls

2.7 Digit Ratio and Academic Performance

Prenatal testosterone has been proposed to directly influence intelligence or learning ability skills, this is achieved by modulating the developmental processes of neuronal proliferation, migration, differentiation, and apoptosis. This is thought to increase the density of neuronal networks in certain areas of the brain (Mrazik and Dombrowski, 2010). Neuropsychological and various neuroimaging studies have revealed that processing of different forms of quantitative information and different aspects of arithmetic learning appear to be subserved by distinct neural circuitry (Dehaene 1989; Zorzi *et al.,* 2002). Dehaene and colleagues proposed a triple-code model whereby three distinct systems of representation (quantity, verbal, and visual) are recruited, dependent upon the demands of the number processing task (Dehaene and Cohen, 1995; Dehaene *et al.,* 2003). These systems are located within the left angular gyrus (verbal processing of numbers), posterior superior parietal cortices (spatial and non-spatial attention), and a bilateral segment of the intraparietal sulcus (core number and magnitude processing). In particular, it has been consistently found that magnitude comparison (Dehaene *et al.,* 1999,

2003), mental number line (Zorzi *et al.,* 2002), and many arithmetic tasks (Dehaene, 1999; Rivera *et al.,* 2005) engage the bilateral intraparietal sulcus, although other regions are also engaged (e.g., frontal regions associated with working memory; Rivera *et al.,* 2005). The intraparietal sulcus is also active when non-human animals engage in numerical activities, and is anatomically very close to the visual-spatial and posterior spatial-attentional systems. Parietal activation appears greatest in the right hemisphere during some aspects of mental arithmetic (Reiss *et al.,* 1986), and number comparison. Whereas left frontal, angular gyrus, and cingulate cortices are strongly activated during the retrieval of exact arithmetic facts (Dehaene *et al.,* 1999). Regions within the two hemispheres thus appear to be differentially engaged for different quantitative abilities, with a right-hemisphere advantage for tasks requiring more abstract (e.g., relative magnitude) numerical relations and a left-hemisphere advantage for tasks requiring more discrete quantitative information.

Studies have correlated digit ratio (and by implication prenatal testosterone) to autism and Aspergers' Syndrome, concluding that autistic children had the lowest digit ratio (which could be translated as an excess in prenatal testosterone), while Aspergers' children, who have communication impairments similar to autistic children but are thought to have normal or high IQ (Mottron, 2011) have higher-than-autistic but lower-than-normal 2D:4D (Manning *et al.,* 2001). In addition, low 2D:4D has been correlated with numeric capabilities and ability to understand information communication technology (Brosnan, 2006 and Brosnan *et al.,* 2011), and is also thought to correlate with learning in manual labour tasks (Rosler, 1957). Digit ratio, and therefore prenatal testosterone can influence cognitive skills and analysis of situations in order to develop better solutions to a given problem (Coates *et al.,* 2009). Earlier reports have shown that

individuals with higher cognitive skills are more patient and have a greater ability to plan and persevere, as well as a greater perception of situations (Brosnan 2006). Previous research has successfully negatively correlated 2D:4D to success in written admission tests for a medical school, but failed to replicate such a correlation to written exams taken throughout the six years of the course (Coco *et al.*, 2011).

Right hand 2D:4D is negatively related to theory and practical marks in male dental students. The effect size for these correlations is similar and 2D:4D is not predictive of the ratio between practical and theory marks. It is suggested that 2D:4D is a proxy for ability in theory and practical dental examinations. There is correlational evidence that 2D:4D is negatively associated with prenatal testosterone and the ratio between prenatal testosterone and prenatal oestrogen (Breedlove, 2010; Lutchmaya *et al.*, 2004; Manning, 2002; Manning and Fink, 2008; Manning *et al.*, 1998).

In addition, experimental manipulation (including loss of androgen and oestrogen receptors and addition of androgen and oestrogen blockers and testosterone and estradiol) of sex steroids in the mouse has shown that 2D:4D is dependent on the ratio of prenatal testosterone and prenatal oestrogen (Zheng and Cohn, 2011). That is, when prenatal testosterone is high and prenatal oestrogen is low then 2D:4D is low. Therefore, it is suggested that males with high prenatal testosterone and low prenatal oestrogen tend to have high intelligence. These findings were strengthened when the influence of age and hours of study was removed. It is suggest that this supports the hypothesis of Mrazik and Dombrowski (2010), who have suggested that high

intelligence is linked to high prenatal testosterone through the latter's influence on neuronal proliferation, migration, differentiation, and apoptosis.

Coco *et al.,* (2011) evaluated a group of 48 male students, and found a significant correlation between 2D:4D and success in admission tests for a medical school in Italy. The study, however, failed to replicate this correlation when analysing grades throughout the medical school course. Low 2D:4D is related to practical and theory examination marks in Brazilian dental students. The lack of a relationship between 2D:4D and examination marks in female dental students indicate that prenatal testosterone does not influence female intelligence in the same manner as that in males.(Hopp *et al.,* 2012)

Males score higher on tests of systemizing and females usually score higher on tests of empathy (Baron-Cohen, 2002, 2003). These sex differences may arise as a result of the influence of prenatal testosterone acting on the foetus such that it has an organising effect on the brain and thus facilitates the ability in systemizing but reduces the ability to emphasize. There is indeed evidence that prenatal testosterone (as measured from routine amniocentesis) is positively related to systemizing (Auyeung *et al.,* 2006) and negatively related to empathizing (Knickmeyer *et al.,* 2006). Low 2D:4D was related to a ''masculinized'' score for career interests in groups of both males and females according to different scales (Weis *et al.,* 2007). Significant differences in digit ratios among faculty in science and social science departments have also been demonstrated (Brosnan, 2006). Additionally, significant correlations of finger length (positive) and digit ratio (negative) with realistic interests and significant correlations between finger length (negative) and social interests, a marker of the people–things dimension, have also been reported. Manning,

Reimers, Baron- Cohen, Wheelwright, and Fink (2010) reported that low 2D:4D was found in individuals in male-dominated occupations. Digit ratios have also been associated with recreational, financial, and social risk-taking behaviors (Stenstrom, Saad, Nepomuceno, and Mendenhall, 2011). Thus, digit ratios have been linked to individuals' risk taking. Testosterone and risk taking are closely related, and evidence has suggested an association between 2D:4D and risk taking.

2D:4D ratio is also connected to the choices among Korean military branches, which include different levels of risk and intensity in their training regimens. young males who volunteered for the Marine Corps were characterized by significantly lower digit ratios than were those who volunteered for the other branches of the military. Thus, digit ratios are likely to influence even the type of military service chosen by individuals. (HaengRyang 2012). Higher ability in some numeric competencies such as counting and problem solving (Fink *et al.,* 2006), subitizing (Brookes *et al.,* 2007) as well as numeric IQ (Kempel *et al.,* 2005; Luxen and Buunk, 2005), has also been associated with lower ratio. Brosnan (2008) also reported negative correlations between 2D:4D and numerical SAT scores in 7-year-old school children. This suggests that the relationship between 2D:4D and numeric capabilities may relate to academic attainment.

High concentrations of prenatal testosterone relative to estrogen appear to be related to strong interests in the sector ''Enterprising'' which is characterized by management, organizing, trade and leadership. High values in ''Enterprising'' are also associated with low scores in neuroticism (Jo¨ rin *et al.,* 2004). Low neuroticism shows an association with low 2D:4D. Therefore, it seems logical that high values in Enterprising are related to low 2D:4D. Another study yielded similar

results: a weak positive association between 2D:4D and male-typical occupational interests (McIntyre, 2003). Some of the sexually typical preferences for distinct career interests are reflected in the digit ratio within the sexes. Supposed 2D:4D is a valid marker for prenatal testosterone studies have provide some support for the claim that prenatal sex steroids are related to the development of career interests. (Sophie *et al.*, 2007).

2.8 Head Size and Academic Performance

Head size has been linked to academic performance and intelligence for centuries ago, In 1836, Frederick Tiedmann wrote that there exists "an indisputable connection between the size of the brain and the mental energy displayed by the individual man".(as cited in Hamilton, 1935). Since that time, the quest for the biological basis of intelligence has been pursued by many. Various narrative reviews (Rushton and Ankney, 1996, 2000; Vernon *et al.,* 2000) and a metaanalysis (Nguyen and McDaniel, 2000) have documented a non-trivial positive relationship between brain volume and intelligence in non-clinical samples. In the brain volume literature, there are two general categories of brain volume measures. The first category consists of measures of the external size of the head, such as the circumference of the head. The second category consists of measures of the in vivo brain volume, typically assessed through an MRI scan.

Vernon *et al.,* (2000) reported the population correlation between head size and intelligence to be 0.19. Nguyen and McDaniel (2000) reported population correlations from 0.17 to 0.26 for three different sub-categories of external head size measures. Studies assessing the correlation between in vivo brain volume and intelligence are more rare. Vernon *et al.,* (2000) reported data on 15 such correlations and obtained a population correlation of 0.33. Nguyen and McDaniel (2000)

reported the same population correlation based on 14 correlations. Gignac *et al.,* (2003) reported data with a mean correlation of 0.37.

Despite the fact that microcephaly and macrocephaly are considered reliable indicators of brain pathology, head circumference values below the mean are associated with an increased incidence of lower intellectual abilities. This means that small differences in head size could be important in the interrelationship head circumference–intelligence–learning (Ivanovic *et al.,* 2000b). The explanatory power of head circumference on intellectual ability and scholastic achievement variances increases significantly from the onset of elementary school until the end of high school, in contrast, the explanatory power of body weight and body height decrease significantly (Ivanovic *et al.,* 1996, 2000b). Even more, school drop out correlates with head circumference and not with weight or height; at the onset of elementary school 59% of children had suboptimal head circumferences, percentage that decreased significantly to 40% in high school graduates (Ivanovic *et al.,* 1996). The relationships between head circumference, brain development and intelligence have been studied since the time of Broca and Galton, who concluded that variations in brain size (estimated indirectly by measuring head circumference) are related with intelligence (Vernon *et al.,* 2000). Even in the elderly, head circumference has been found to positively and significantly correlated with intelligence.

Recent findings from monozygotic and dizygotic twins, found a positive correlation between brain size and intelligence (Anderson, 1999; Pennington *et al.,* 2000). Also several communications have described that head circumference in the first year of life may predict later intelligence (Botting *et al.,* 1998; Nelson and Deutschberger, 1970). In this respect, the

interrelationship between intelligence and nutritional background, reflected by a decreased head circumference, can be affected by birth weight and other variables (Botting *et al.,* 1998; Ivanovic, 1996; Ivanovic *et al.,* 1989, 1996, 2000a,d, 2002; Leiva *et al.,* 2001 Reiss *et al.,* 1996; Rushton, 2000).

However, other authors found that impaired fetal growth was not associated with poorer cognitive performance in adult life; adaptations made by the fetus in response to conditions that retard growth seem to be largely successful in maintaining brain development (Martyn *et al.,* 1996). Intelligence has been described as the best predictor of school achievement (Ivanovic *et al.,* 1989, 2002) and significantly explained by maternal intellectual quotient (IQ), by brain volume and nutritional status during the first byear of life. The impact of early childhood malnutrition on head circumference, brain development and later on intelligence is still a matter of controversy due to the fact that these variables are influenced by socio-economic and cultural factors that are co-determinants of intelligence, of nutritional status and of brain development; head circumference below −2 S.D. of the mean may be an indicator of severe undernutrition and accurately reflects retarded brain growth during the first year of life (Winick and Rosso, 1969a). The long-term effects of severe undernutrition at an early age may result in delayed head circumference growth, delay of brain development and decreased intelligence and scholastic achievement, variables that are strongly interrelated (Ivanovic *et al.,* 2000, 2002; Leiva *et al.,* 2001).

2.9 Digit Ratio Research in Non-Human Animals

Little research has examined digit ratios in non-human species several animal experimentation studies have yielded evidence that the expression of digit ratios during developmental phases can be manipulated by appropriate means. For example, testosterone, administered prenatally, alters digit ratios in birds (Romano *et al.,* 2006), as does alcohol, which acts as an endocrine disruptor (of sex hormones, such as testosterone), when administered prenatally in rats. Digit ratios in birds are changed through prenatally administered estradiol (Saino *et al.,* 2006), but not through postnatally administered estradiol.

Lower 2D:4D was observed in the right rear paw of male versus female mice (Brown *et al.,* 2002a). Among non-human primates, McFadden and Bracht (2002) have reported a number of interesting sex differences in the relative lengths and weights of metacarpals and metatarsals. The ratio of the second to fourth metacarpal did not show significant sex differences in baboons or gorillas, and this ratio was actually significantly higher in males versus females (i.e., a reversal of the 2D:4D sex difference in humans) in the left hand of chimpanzees. Because these studies did not measure lengths of phalanges, however, it is unclear how comparable the results are to the human literature that has focused specifically on finger length ratios. This comparability problem is compounded by the finding that the 2D:4D finger length ratio is not correlated with the ratio of the second to fourth metacarpals in humans (Phelps, 1952; reviewed in Manning, 2002). As such, it is possible that different developmental processes may determine relative lengths of phalanges and their associated soft tissues versus the relative lengths of metacarpals.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Participants

The subjects that participated in this study were secondary school students from Kaduna, Kaduna State, Nigeria. (n=462, mean age 16.84 ±1.94 years).

3.2 Study Location

The study was conducted in three (3) randomly selected secondary schools in Kaduna metropolice, namely Federal Government College, Kaduna, Capital School and Technical College, Kaduna. In each of the school, terminal results of the students were collected from their form masters/mistress. Anthropometric measurements of the required parameters of these students was taken.



Figure 3.1: Map of Nigeria showing Kaduna State

Source: Geographic and information system (GIS)

3.3 Kaduna State

Kaduna metropolis (fig. 3.1) is located at latitude 11º 3' N and longitude 7º 25' E. It is the capital city of Kaduna State, a state that shares boundaries with Kano, Katsina and Zamfara to the north, Fedreral capital territory and Nassarawa to the south, Plateau and Bauchi to the east and Niger to the west. The town is largely a heterogeneous town, with major ethnic groups being of Hausa, Fulani, Kataf, Gbagyi, Jabba and many other minor groups (Akinbabijo, 2012).

Kaduna State has a total land area of 45,711.188 sq. kilometres with a population of 6,113,503 persons (National population census, 2006) and therefore a population density of 134 persons per sq. kilometer. Kaduna State is divided into 23 Local Government Areas Birni-Gwari, Chikun, Giwa, Igabi, Kajuru, Ikara, Jaba, Kachia, Jema'a, Kaduna North, Kaduna South, Kagarko, Kaura, Kauru, Kubau, Kudan, Lere, Makarfi, Sabon-Gari, Sanga, Soba, Zango-Kataf, and Zaria.

3.3.1 Drainage

The river Kaduna has its source from tributeries of river Niger which flows for 550Km through Nigeria. It got its name from the crocordile that live in the river and sorrounding area. The river flow from east to western part of the state.

3.3.2 The climate of Kaduna

The climate of the study area is a tropical savanna climate, with distinct wet and dry seasons (Aw climate Koppens classification). Kaduna experiences six (6) months of rainy season and six (6) months of dry season. The rainy season is from May to late October, while the dry season is from early November to April, this is as a result of the interplay of the two dominant air masses within the region i.e. the tropical continental air messes (cT) and Tropical maritime air masses (mT)

(Iguisi and Abubakar, 1998). Climate is an important factor that determines the form of any architecture. In Nigeria the Hausa live in northern Savannah type of climate (Moughtin, 1985). The rainfall intensity is very high between the months of July and August. As a result though the environment is generally dry, crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water-logging (Udo, 1970). Dry season is the period of harmattan: a transition period between the wet and the hot seasons. It is a period when there is little or no rainfall (Ati, 2002). Daytime temperatures fluctuate between 16 and 32ºC in November with clear sky of sunshine hours of between 8.9 and 9.5 (DURP, 1979). December to January in Kaduna is characterized by the suspension of fine dust particles in the air, due to Harmattan winds which cause surface turbulence. Visibility is poor, disrupting air navigation while sun's rays barely reach ground surface. This action reduces night temperatures to 14ºC, with sunshine hours between 8.7 and 9.5. Daytime temperature may drop to 31ºC, giving a variation of 17ºC, and the highest in the year. This extreme diurnal temperature range is another characteristic of the Savanna type of climate (Areola *et al.*, 2006).

3.3.3 Natural vegetation

Nigeria has six Climatic Zones (Bureau for Public Enterprises, 2003-2007); The Mangrove Swamp, Swamp Forest, Rain Forest, Guinea Savanna, Sudan Savanna and Sahel Savanna. The Sudan Savanna approximates in a belt from Latitude 8º north to Latitude 12º north of the Equator, in Nigeria (Anuforom and Okpara, 2004). This region definitely includes Kaduna, which is located at latitude 11º 3' N and longitude 7º 25' E. The Sudan Savanna is typified by tall tropical 'savanna' grass (Ati, 2002); the elephant grass (Areola *et al*., 2006). Trees are scattered, typical of wet dry climate. This vegetation is mixed with scrubs and thorny bushes, adapting

itself to the climatic rhythm of longer water-drought and shorter summer rain. They are mostly deciduous, shedding their leaves in the dry season to conserve water which would have been lost by transpiration; lying dormant and searching for ground water. (Anselem and Ojonigu, 2010).

3.4 Methodology

Data for this study were collected from student participants. An informed verbal consent was taken from school students who are willing to participate in the survey. In order to encourage more candidates and reliable responses, participants were made to complete the self-administered questionnaire in confidence with their peers unable to see their answers.

Anthropometric measurements on participants were carried out by the researcher and a well-trained female research assistants. In order to reduce observation errors, anthropometric measurements were read twice independently and the mean of the two measurements was taken as the actual value. In each of the school visited, terminal results of the students were collected from their teachers for academic performance correlations.

3.5 Data Collection Technique

Samples for the present cross-sectional study were randomly collected from secondary school students in Kaduna metropolice.

3.6 Sampling Size Determination

The total number of students included in the study was calculated from the formular:

$n = z^2 pq/d^2$ (Naing and Rusli, 2006)

where

n = the desired sample size

z = the standard normal deviate, usually set at 1.96 (≈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 $(1.96)^2 (0.5)(0.5)/(0.05)^2 = 384$

Thus, a minimum number of 384 students was required to be used in this study in order to draw valid conclusions from it. However, a total of 462 male and female secondary school students was recruited consisted of students belonging to the SSS1and 2 classes.

3. 7 Anthropometry

3.7.1 Finger Length Measurements

(Method of Manning *et al.,* (1998))

Digit length was measured on the ventral surface of the hand from the basal crease of the digit to the tip using a digital venier caliper (MicroMak, USA) measuring to 0.05mm. This measurement has been reported to have high degree of repeatability (Manning *et al.,* 1998). All measurement was made twice in order to assess repeatabilities.

3.7.2 Height

The height of each subject was taken using standard metre rule with the subject standing upright on stadiometre placed on a flat ground. The subject stands with weight distributed evenly on both

feet, heels together and the head positioned and looks straight ahead being sure that the line of vision is at right angles to the body, and level with the ground (Cogill, 2001). The correct position of the head is in the Frankfort horizontal plane. The arms hang freely by the sides. The head, back, buttocks and heels are positioned vertically so that the buttocks and the heels are in contact with the vertical board.

3.7.3 Weight

Weight of each individual was taken using weighing scale that recorded to the nearest 0.1Kg with the subject standing upright. The weight is evenly distributed on both feet, arms to the sides, shoulders relaxed. Shoulder blades, buttocks and heels slightly touch the measuring rod. The subject was asked to look straight ahead (Frankfort Horizontal Plane position of the head), inhale deeply and stand fully erect while the examiner lowers the horizontal bar to the crown of the head and takes the measure (NHNES, 1998). Heavy jewellery if any was removed and pockets empty. Light clothing can be worn excluding shoes, belts and sweaters.

3.7.4 Head Circumference

Head circumference was measured with inelastic measuring tape positioned just above the eyebrows and above the supraorbital ridge and place posteriorly to give the maximum circumference. The measuring tape was pulled sufficiently tightly to compress hair and yield a measure that ‘approximates’ cranial circumference.

3.7.5 Waist Circumference (WC)

This measurement was taken at the midpoint between the lowest rib and the iliac crest. The measurement tape was place perpendicular to the long axis of the body and horizontal to the floor, with sufficient tension to avoid slipping off but without compressing the skin. The measurement was made at the end of a normal expiration to the nearest 0.1 cm.

3.7.6 Hip Circumference (HC)

The subject was made to stand erect, the weight evenly distributed on both feet. The tape was placed at the maximum extension of the buttocks, horizontal to the floor, with sufficient tension to avoid slipping off. The tape was held a bit tighter but without compressing the buttocks. The zero end of the tape was held under the measurement value recorded to the nearest 0.1 cm.

3.7.7 Neck Circumference (NC)

NC was measured in the midway of the neck, between the mid cervical spine and mid anterior neck, to within 1mm, using non stretchable plastic tape with subject standing upright. In men with laryngial prominence (Adam's apple) it is to be measured just below the prominence, while taking this reading, the subject was asked to look straight ahead, with shoulders down but not hunched. Care was taking not to involve the shoulder – neck muscles (trapezius) in the measurement. Subject with any thyroid disorder or cushing's disease will be excluded from the study.

3.8 Anthropometric Correlations

3.8.1 2D:4D Ratio and Sex

Finger lengths data on subjects was classified on the basis of their sex and subjected to statistical analysis to test the hypothesis that there is strong sexual dimorphism in the 2D:4D ratio in man

3.8.2 2D:4D Ratio and Waist-Hip Ratio (WHR)

To investigate the relationship between waist-hip ratio and 2D:4D, the digit ratios was obtained from the subjects and is compared statistically with the means of the subjects' waist-hip and obtain the correlation.

3.8.3 2D:4D Ratio and Ethnicity

To study the effect of ethnicity, digit ratio of subjects collected was classified according to their ethnic groups and compared statistically.

3.8.4 2D:4D Ratio and Heterosis

This enables us to check the differences of 2D:4D in heterotic and non-heterotic children as it varies amongst the ethnic groups. This was achieved by comparing 2D:4D of children born by parents from different ethnic group (heterosis) and parents from the same ethnic group (non-heterosis).

3.8.5 2D:4D Ratio and Body Mass Index (BMI)

To study the relationship between 2D:4D ratio and BMI, digit ratio of subjects was classified to their BMI and compared statistically. The BMI is an index that uses the variables weight and height to measure body fat and protein stores, usually in adult rather than children. It is to be calculated as the rapport of weight in kilogramme by square of height in metres (m^2). i.e: BMI (kg/m^2) = weight (kg) / height (m^2) i.e, a subject's weight (body mass) relative to height. It is a measure of body mass corrected for height which is used to assess the extent of weight deficit or excess. BMI also provides a practical indicator of adiposity and hence overweight or obesity.

3.8.6 2D:4D Ratio and head circumference

Digit ratio of students was classified and compared with their head sizes

3.8.7 Head Circumference and Academic Performance

Head size was assessed with academic performance, as head circumference values was compared to terminal results of the student.

3.9 Ethical Approval

Ethical approval was obtained from Ahmadu Bello University Teaching Hospital Health Research Ethics Committee and permission to conduct the study was obtained from the authorities of participating schools. Only subjects who gave informed consent to participate with the research were included in this study.

3.1O Inclusion and Exclusion Criteria

3.10.1 Inclusion Criteria

A subject selected for the purpose of this study must fulfill the following criteria;

i. Must be a student of one of the participating schools, from SS1 and SS2 classes.
ii. All subjects should be mentally and physically fit.
iii. Must have been born in Nigeria (so as to minimize effect different environments on the subject).
iv. Must have full academic records with the school management

3.11.2 Exclusion Criteria

i. Any subject that does not meet the above set inclusion criteria.
ii. Also any subject that has some form of deformity in the body areas targeted for anthropological assessment that could hinder accurate measurement.
iii. Subjects with incomplete academic records
iv. Those suffering from serious disease conditions such as sickle cell anaemia.

3.11 Statistical Analysis

Data was expressed as mean ± standard deviation (SD). Students' t-test will be used to check for the difference in 2D:4D in the right and left hands of subjects and between females and males, academic performance, waist-hip ratio, and head circumference. Pearson correlation will be applied to test the relationship between 2D:4D and height, weight and BMI, head circumference and academic performance. Statistical significance difference will be deemed acceptable at $P < 0.05$. SigmaStat 2.0 for Windows (San Rafael, CA) will be used for the statistical analyses, MS

Excel 2010 and Sigmaplot 2001 will be used to plot bar charts with error bars and correlation graphs respectively. Student's academic performance was accessed from the academic records of the students obtained from the schools authorities, the records are from the four general subjects of English, Mathematic, Biology and Economics. These results were correlated with 2D:4D and other anthropometric variable using pearson correlations. Linear regression was used to generate equations for predicting academic performance from digit ratio and digit lengths

CHAPTER FOUR

RESULTS

4.1 Analysis of Study Population

Four hundred and sixty two (n = 462) students subjects both male and females aged 13 to 23 years old were considered for this study. These were composed of two hundred and thirty nine (n = 239) male and two hundred and twenty three (n = 223) females. The population size cut across three secondary schools in Kaduna metropolice. In each of the schools, academic records of selected subjects of each participating student was collected from the schools managements and computed against there digit ratio and other anthropometric variables.

The population size was categorized according to ethnic groups into four groups respectively: Hausa, Yoruba, Igbo and others. Then according to geopolitical zones into six groups: North-West, North-East, North-Central, South-West, South-East and South-South.

4.2 Anthropometric Variables and Academic Performance of Overall Sample Population and according to Sex

Data was collected from the student subject a pre-designed questionnaire. Descriptive statistics of the entire sample population of the student is shown on Table 4.1. From Table 4.1, the mean age, of overall subjects, that of females and males subjects are (16.84±1.94) years, (16.20±1.17) years and (17.44±2.30) years respectively. Also from the Table digit length of both hand were statistically significant at $p < 0.001$ but on the other hand digit ratio (2D:4D) of both hand were statistically not significant (Right 2D:4D, $p = 0.084$, Left 2D:4D, $p = 0.245$.

Academic performance, were statistically significant at $p = 0.001$ for all the subjects considered. Weight and height were statistically significant at $p = 0.001$ respectively but BMI does not show any significant difference.

Figure 4.1 is a graph showing the comparison of academic performance of the students according to gender in which in all the four subjects considered, female subjects are doing better than their males counterparts most especially in English Language and Biology.

Table 4.1: Mean and standard deviation of age, anthropometric variables and academic performance of overall sample population and according to sex (n = 462)

	All subjects		Female		Male			
Parameters	Mean ± SD	Min – Max	Mean ± SD	Min – Max	Mean ± SD	Min – Max	t	p
n	462		223		239			
Age (yrs.)	16.84 ± 1.94	13.00 – 26.00	16.20 ± 1.17	13.00 – 21.00	17.44 ± 2.30	13.00 – 26.00	-7.22	0.001
Height (cm)	162.41 ± 9.30	57.50 – 183.00	158.85 ± 6.30	143.00 – 177.00	165.73 ± 10.38	140.00 – 183.00	-8.54	0.001
Weight (kg)	53.67 ± 8.06	32.00 – 80.00	51.74 ± 7.78	36.00 – 80.00	55.48 ± 7.90	32.00 – 75.00	-5.13	0.001
BMI (kgm^{-2})	20.28 ± 2.67	14.02 – 30.08	20.52 ± 2.96	15.02 – 30.08	20.63 ± 9.18	14.02 – 27.89	-0.18	0.86
Head circumference (cm)	55.37 ± 2.19	37-00 – 65.00	55.59 ± 1.90	50.00 – 65.00	55.17 ± 2.42	37.00 – 65.00	2.07	0.039
Neck circumference (cm)	32.86 ± 2.49	26.00 – 54.00	31.98 ± 2.12	28.00 – 52.00	33.69 ± 2.53	26.00 – 54.00	-7.86	0.001
Waist circumference (cm)	70.87 ± 6.11	53.00 – 92.00	69.70 ± 6.94	53.00 – 91.00	71.97 ± 4.99	53.00 – 92.00	-4.04	0.001
Hip circumference (cm)	88.82 ± 7.04	62.00 – 112.00	92.16 ± 6.71	78.00 – 112.00	85.70 ± 5.80	62.00 – 112.00	11.09	0.001
Waist-hip-ratio	0.80 ± 0.07	0.61 – 1.16	0.76 ± 0.06	0.61 – 0.92	0.84 ± 0.05	0.61 – 1.16	-17.47	0.001
R2D (cm)	6.79 ± 1.05	2.50 – 8.89	6.49 ± 1.12	2.50 – 8.30	6.49 ± 1.12	2.50 – 8.89	-6.00	0.001
R4D (cm)	7.10 ± 1.05	2.93 – 9.09	6.82 ± 1.12	2.93 – 8.25	7.37 ± 0.90	2.93 – 9.09	-5.84	0.001
R2D:4D	0.95 ± 0.04	0.78 – 1.10	0.95 ± 0.04	0.79 – 1.08	0.96 ± 0.04	0.78 – 1.10	-1.73	0.084
L2D (cm)	6.87 ± 1.04	2.91 – 8.58	6.58 ± 1.10	2.91 – 8.06	7.13 ± 0.89	2.91 – 8.58	-5.92	0.001
L4D (cm)	7.08 ± 1.05	0.84 – 1.10	6.80 ± 1.12	3.22 – 8.33	7.34 ± 0.91	3.22 – 9.01	-5.77	0.001
L2D:4D	0.97 ± 0.04	0.85 – 1.10	0.97 ± 0.04	0.85 – 1.08	0.97 ± 0.04	0.85 – 1.10	-1.16	0.245
Mathematics (%)	48.90 ± 15.63	5.00 – 90.00	51.03 ± 14.63	12.00 – 89.00	46.92 ± 16.30	5.00 – 90.00	2.84	0.005
English (%)	55.57 ± 13.95	6.00 – 86.00	60.44 ± 13.12	9.00 – 86.00	51.03 ± 13.16	6.00 – 81.50	7.69	0.001
Biology (%)	59.64 ± 17.18	9.00 – 94.00	65.74 ± 13.13	23.00 – 94.00	53.94 ± 18.53	9.00 – 94.00	7.85	0.001
Economics (%)	58.54 ± 15.21	6.00 – 91.00	61.51 ± 13.15	10.00 – 91.00	55.77 ± 16.45	6.00 – 91.00	4.13	0.001

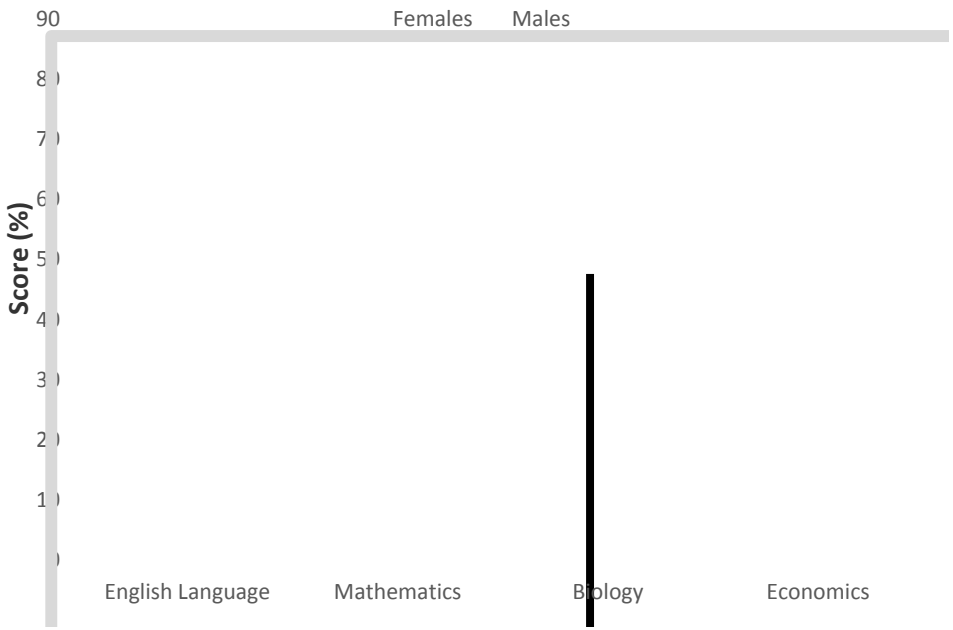


Fig. 4.1: Comparison of academic performance of male and female students subjects, female students performed better than their male counterparts in all four academic subjects. Student t-test indicates significant difference, $p < 0.05$.

Table 4.2 Age, Anthropometric Variable and Academic Performance of Study Participants according to Ethnicity

show age, anthropometric variable and academic performance of study participants according to ethnicity. The subjects were group into the three major ethnic group and other ethnic groups grouped as others. From the Table, most of the anthropometric variables considered were statistically not significant except head circumference, waist circumference and WHR. Age and academic performance were statistically significant at $p = 0.001$.

Figure 4.2 is a graphical representation of academic performance across the major ethnic groups in Nigeria. From the graph Igbo ethnic group perform best among the four ethnic groups in all the four academic subjects considered, followed by the Yorubas while the Hausas performed least.

Table 4.2: Mean and standard deviation of age, anthropometric variables and academic performance of study participants according to ethnicity

	Hausa	Igbo	Yoruba	Others		
	n = 184	n = 42	n = 43	n = 192		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	17.20 ± 1.70	15.45 ± 1.13	15.98 ± 1.86	16.99 ± 2.13	13.54	0.001
Height (cm)	162.31 ± 11.49	164.02 ± 7.43	161.30 ± 6.83	162.33 ± 7.65	0.64	0.593
Weight (kg)	52.82 ± 8.12	53.91 ± 8.14	52.01 ± 7.57	54.78 ± 8.00	2.53	0.056
BMI (kgm^{-2})	20.65 ± 10.48	20.01 ± 2.64	19.97 ± 2.49	20.77 ± 2.64	0.26	0.851
Head circumference (cm)	55.18 ± 2.38	56.24 ± 2.12	55.44 ± 1.76	55.33 ± 2.08	2.69	0.046
Neck circumference (cm)	32.54 ± 2.06	32.86 ± 1.78	33.00 ± 3.47	33.14 ± 2.72	1.89	0.130
Waist circumference (cm)	69.21 ± 6.31	72.48 ± 5.40	70.37 ± 4.48	72.21 ± 6.01	9.10	0.001
Hip circumference (cm)	88.47 ± 6.67	89.14 ± 8.13	88.07 ± 5.96	89.25 ± 7.37	0.58	0.627
Waist-hip-ratio	0.78 ± 0.07	0.82 ± 0.05	0.80 ± 0.04	0.81 ± 0.07	6.31	0.001
R2D (cm)	6.69 ± 11.17	6.88 ± 10.03	6.91 ± 0.81	6.82 ± 1.03	0.93	0.424
R4D (cm)	7.01 ± 1.11	7.20 ± 1.00	7.14 ± 0.82	7.15 ± 1.03	0.73	0.535
R2D:4D	0.95 ± 0.04	0.96 ± 0.04	0.97 ± 0.03	0.95 ± 0.04	1.51	0.211
L2D (cm)	6.77 ± 1.11	6.96 ± 0.99	6.97 ± 0.84	6.91 ± 1.01	0.86	0.461
L4D (cm)	7.01 ± 1.14	7.14 ± 1.01	7.10 ± 0.84	7.11 ± 1.01	0.38	0.769
L2D:4D	0.97 ± 0.04	0.97 ± 0.04	0.98 ± 0.03	0.97 ± 0.04	2.12	0.097
Mathematics (%)	48.89 ± 15.73	56.55 ± 16.89	53.22 ± 15.42	46.19 ± 14.60	6.61	0.001
English (%)	53.18 ± 14.19	66.18 ± 9.89	57.72 ± 13.82	55.04 ± 13.49	10.98	0.001
Biology (%)	56.16 ± 16.55	71.81 ± 11.80	65.81 ± 16.68	58.88 ± 17.47	12.35	0.001
Economics (%)	56.89 ± 16.39	67.64 ± 11.27	63.28 ± 13.51	57.02 ± 14.31	8.12	0.001

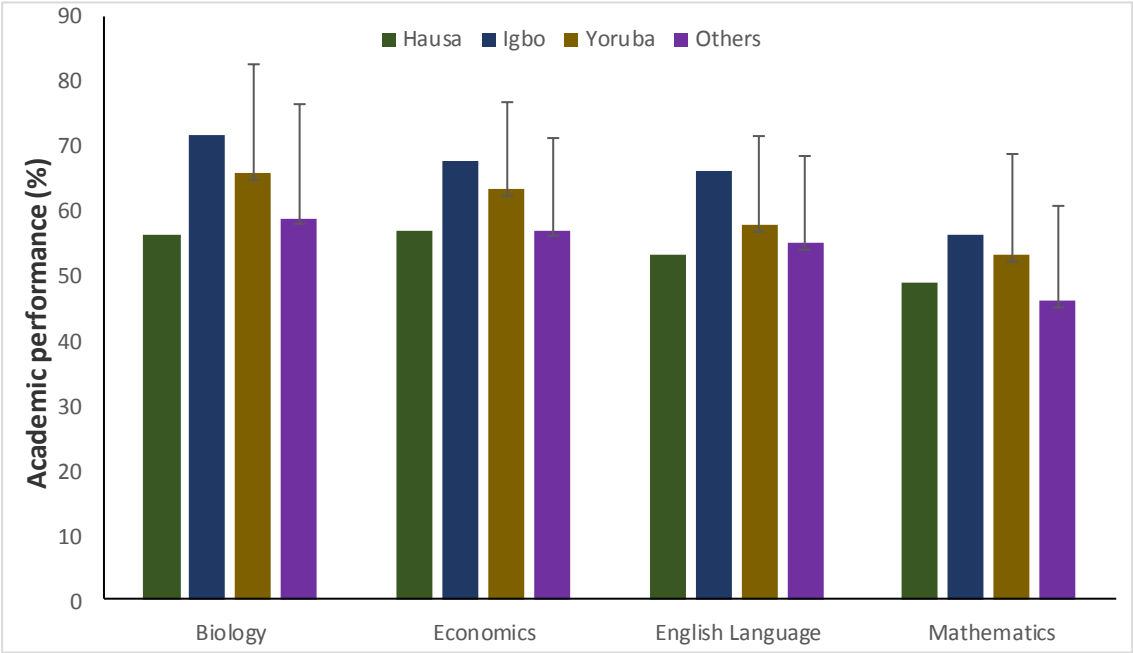


Fig. 4.2: Comparison of academic performance based on ethnicity of the subjects. The Igbos performed best followed by the Yorubas in all the four subjects. One way analysis of variance indicates significant difference in the school performance and statistical significantl different with $p < 0.01$

Table 4.3 and 4.4 show mean and standard deviation of age anthropometric parameters and academic performance of student participants according to Geo-Political zones of Nigeria. From table, 4.3, age ($p < 0.001$), Height ($p = 0.01$), Neck ($p < 0.001$), Waist Circumference ($p = 0.002$), WHR ($p < 0.001$) and Left 2D4D ($p = 0.034$), were statistically significant, also the academic performance were statistically significant in all the subjects considered with South-East zone having the highest performance in virtually all the subjects followed by South-South and South-West, while the North-West has the least performance in all the subjects.

Similar pattern was maintained for male subjects participants in Table 4.4 for Geo-Political zones in which age ($p = 0.002$), height ($p = 0.015$), head circumference ($p < 0.001$), Waist circumference ($p = 0.04$), were significant statistically. English Language and Biology scores were also significant at ($p < 0.001$) and ($p = 0.003$) respectively.

Also in fig. 4.3 which demonstrated academic performance across the six Geo-political zones of Nigeria show that South-East is the best academically followed by South-South and South-West. As the trend use to be the southern part of the country perform better than the Northern counterpart

Table 4.3: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to geo-political zones

	North-central	North-east	North-west	South-east	South-south	South-west		
	n = 31	n = 19	n = 117	n = 27	n = 11	n = 18		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	16.06 ± 1.15	16.32 ± 0.75	16.49 ± 1.13	15.44 ± 1.12	15.64 ± 1.12	15.89 ± 1.28	4.96	0.001
Height (cm)	160.42 ± 6.65	155.50 ± 4.99	158.13 ± 6.31	161.48 ± 5.42	160.91 ± 6.38	159.11 ± 6.25	3.09	0.010
Weight (kg)	52.13 ± 8.38	48.00 ± 7.58	51.50 ± 7.54	53.93 ± 8.70	52.55 ± 6.33	52.72 ± 7.37	1.44	0.213
BMI (kgm^{-2})	20.25 ± 2.89	19.86 ± 3.18	20.63 ± 3.05	20.66 ± 3.02	20.30 ± 2.15	20.83 ± 2.80	0.34	0.892
Head circumference (cm)	55.23 ± 1.69	55.79 ± 2.74	55.38 ± 1.66	56.19 ± 2.24	56.36 ± 1.96	55.94 ± 1.96	1.59	0.165
Neck circumference (cm)	32.10 ± 1.80	31.21 ± 1.18	31.61 ± 1.56	32.59 ± 1.58	33.00 ± 1.95	33.44 ± 4.88	4.19	0.001
Waist circumference (cm)	70.71 ± 6.51	66.95 ± 7.38	68.49 ± 7.03	73.89 ± 5.82	71.91 ± 6.64	71.17 ± 5.24	4.06	0.002
Hip circumference (cm)	92.39 ± 6.88	89.68 ± 6.78	92.74 ± 6.55	92.52 ± 7.55	91.36 ± 5.24	90.56 ± 6.87	0.95	0.451
Waist-hip-ratio	0.77 ± 0.05	0.75 ± 0.05	0.74 ± 0.06	0.80 ± 0.05	0.79 ± 0.04	0.79 ± 0.04	9.08	0.001
R2D (cm)	6.76 ± 0.95	6.11 ± 1.28	6.35 ± 1.25	6.85 ± 0.75	6.71 ± 0.94	6.73 ± 0.67	2.02	0.076
R4D (cm)	7.05 ± 0.84	6.44 ± 1.37	6.67 ± 1.25	7.20 ± 0.70	7.11 ± 1.01	6.99 ± 0.64	2.02	0.077
R2D:4D	0.96 ± 0.06	0.95 ± 0.05	0.95 ± 0.04	0.95 ± 0.04	0.95 ± 0.04	0.96 ± 0.04	0.39	0.858
L2D (cm)	6.82 ± 0.92	6.14 ± 1.26	6.43 ± 1.21	6.96 ± 0.78	6.90 ± 0.88	6.87 ± 0.72	2.46	0.034
L4D (cm)	7.02 ± 0.87	6.45 ± 1.28	6.66 ± 1.25	7.16 ± 0.74	7.02 ± 0.94	6.96 ± 0.72	1.72	0.130
L2D:4D	0.97 ± 0.04	0.95 ± 0.04	0.97 ± 0.03	0.97 ± 0.04	0.98 ± 0.03	0.99 ± 0.03	2.37	0.040
Mathematics (%)	52.08 ± 10.09	53.63 ± 12.61	48.45 ± 16.02	57.35 ± 14.42	48.91 ± 13.99	55.00 ± 11.03	2.26	0.049
English (%)	59.42 ± 12.58	59.63 ± 11.31	58.63 ± 14.02	68.35 ± 8.87	65.64 ± 7.28	59.78 ± 14.13	2.94	0.014
Biology (%)	68.02 ± 11.32	64.68 ± 9.64	62.83 ± 13.30	73.76 ± 10.16	69.09 ± 12.97	67.83 ± 16.72	3.85	0.002
Economics (%)	60.61 ± 13.12	58.82 ± 9.50	60.06 ± 13.35	68.69 ± 12.46	59.96 ± 10.41	65.58 ± 14.71	2.55	0.029

Table 4.4: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to geo-political zones

	North-central	North-east	North-west	South-east	South-south	South-west		
	n = 29	n = 7	n = 146	n = 14	n = 7	n = 11		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	17.48 ± 2.87	16.43 ± 1.51	17.92 ± 2.21	15.71 ± 0.91	16.14 ± 3.39	16.58 ± 2.23	3.90	0.002
Height (cm)	166.45 ± 6.74	170.50 ± 5.16	165.45 ± 7.63	168.64 ± 9.45	168.43 ± 7.52	153.33 ± 4.28	2.88	0.015
Weight (kg)	55.90 ± 8.10	55.43 ± 7.70	55.46 ± 7.70	55.93 ± 7.66	55.36 ± 6.87	51.50 ± 13.47	0.58	0.713
BMI (kgm^{-2})	20.15 ± 2.52	19.02 ± 2.20	20.22 ± 2.32	19.59 ± 1.72	19.50 ± 1.83	19.77 ± 2.42	0.71	0.616
Head circumference (cm)	55.55 ± 1.72	56.43 ± 2.15	54.95 ± 1.91	56.36 ± 1.95	57.57 ± 3.69	52.08 ± 10.50	4.12	0.001
Neck circumference (cm)	33.93 ± 2.37	33.57 ± 2.15	33.76 ± 2.69	33.79 ± 1.67	33.43 ± 2.57	32.42 ± 4.54	0.61	0.691
Waist circumference (cm)	72.31 ± 4.52	72.00 ± 4.00	71.99 ± 4.86	71.93 ± 3.69	72.29 ± 4.61	66.17 ± 15.37	2.35	0.042
Hip circumference (cm)	84.86 ± 6.94	85.43 ± 6.11	86.07 ± 5.38	84.71 ± 5.62	86.00 ± 6.73	79.58 ± 19.88	1.89	0.097
Waist-hip-ratio	0.86 ± 0.06	0.84 ± 0.04	0.84 ± 0.05	0.85 ± 0.03	0.84 ± 0.04	0.84 ± 0.06	0.77	0.572
R2D (cm)	7.01 ± 0.77	7.49 ± 0.50	7.14 ± 0.69	7.13 ± 1.19	7.60 ± 0.45	6.74 ± 1.84	1.35	0.246
R4D (cm)	7.35 ± 0.82	7.90 ± 0.58	7.43 ± 0.69	7.42 ± 1.21	7.82 ± 0.51	6.96 ± 1.93	1.48	0.197
R2D:4D	0.96 ± 0.03	0.95 ± 0.05	0.96 ± 0.04	0.96 ± 0.04	0.97 ± 0.02	0.97 ± 0.02	0.64	0.672
L2D (cm)	7.10 ± 0.81	7.64 ± 0.60	7.20 ± 0.70	7.17 ± 1.16	7.51 ± 0.51	6.79 ± 1.88	1.20	0.308
L4D (cm)	7.31 ± 0.75	7.90 ± 0.54	7.41 ± 0.71	7.35 ± 1.20	7.73 ± 0.55	6.98 ± 1.91	1.37	0.237
L2D:4D	0.97 ± 0.03	0.97 ± 0.04	0.97 ± 0.04	0.98 ± 0.04	0.97 ± 0.03	0.97 ± 0.04	0.07	0.997
Mathematics (%)	46.26 ± 18.29	44.86 ± 20.30	47.25 ± 14.63	57.86 ± 18.67	49.36 ± 12.90	48.88 ± 21.53	1.27	0.280
English (%)	53.45 ± 13.75	48.29 ± 13.51	49.01 ± 12.76	65.57 ± 10.23	55.07 ± 15.91	50.50 ± 15.76	4.57	0.001
Biology (%)	55.29 ± 19.44	52.14 ± 19.04	50.87 ± 18.39	70.00 ± 11.55	67.64 ± 25.60	54.21 ± 18.24	3.72	0.003
Economics (%)	54.81 ± 13.33	49.00 ± 20.48	54.45 ± 17.15	65.93 ± 9.62	64.14 ± 16.98	61.50 ± 18.17	2.16	0.060

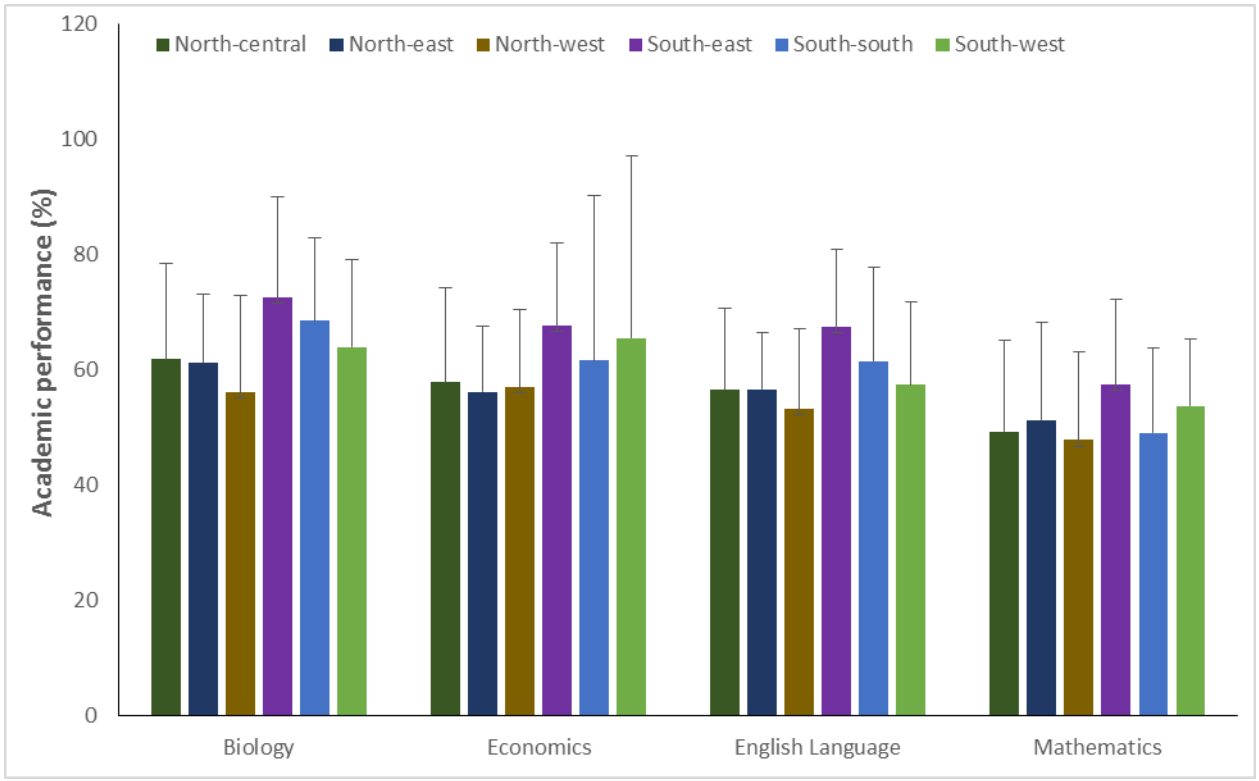


Fig. 4.2: Comparison of academic performance based on geo-political zones of the subjects. The South-East performed best followed by the South-South in all the four subjects. One way analysis of variance indicates significant difference in the school performance and statistical significantl different with $p < 0.001$

Table 4.5 and Table 4.6: Mean and Standard Deviation of Age, Anthropometric Variables and Academic Performance of Student Participants According to Age Category.

From the Table 4.5, left hand 2D:4D were statistically significant among the age category grouped into three classes of 13-14, 15-17 and 18 and above years. Right 2D:4D as well as digit length did not show any significant difference. Academically the age groups were statistically significant in all the three subjects at ($p < 0.001$), except for Mathematics at ($p = 0.078$).

On the other hand digit ratio does not show any significant different among the male age groups in table 4.6 but academic performance were significant at ($p < 0.001$) in all the three subjects except for Economics, ($p = 0.009$).

In the overall, age group is significance with academic performance in which 13-14 years class which happens to be the youngest class and 18 and above class which is the oldes and the least performed academically.

Table 4.5: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to age category

	13 -14 (yrs.)	15 – 17 (yrs.)	≥ 18 (yrs.)		
	n = 14	n = 185	n = 24		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	P
Age (yrs.)	13.86 ± 1.17	16.10 ± 0.74	18.33 ± 0.76	179.39	0.001
Height (cm)	163.71 ± 5.53	158.66 ± 6.39	157.46 ± 4.70	5.02	0.007
Weight (kg)	54.14 ± 8.48	51.63 ± 7.82	51.13 ± 7.13	0.76	0.470
BMI (kgm^{-2})	20.18 ± 3.04	20.53 ± 3.02	20.58 ± 2.40	0.10	0.908
Head circumference (cm)	55.79 ± 1.67	55.67 ± 1.86	54.83 ± 2.18	2.17	0.117
Neck circumference (cm)	31.71 ± 1.44	32.04 ± 2.19	31.63 ± 1.93	0.53	0.592
Waist circumference (cm)	70.86 ± 5.82	69.52 ± 7.16	70.46 ± 5.78	0.40	0.672
Hip circumference (cm)	90.36 ± 6.32	92.22 ± 6.92	92.71 ± 5.11	0.59	0.555
Waist-hip-ratio	0.79 ± 0.05	0.75 ± 0.06	0.76 ± 0.04	2.04	0.132
R2D (cm)	6.02 ± 1.60	6.51 ± 1.10	6.64 ± 0.93	1.44	0.238
R4D (cm)	6.33 ± 1.60	6.82 ± 1.09	7.10 ± 0.91	2.14	0.120
R2D:4D	0.95 ± 0.04	0.95 ± 0.04	0.93 ± 0.05	2.43	0.090
L2D (cm)	6.08 ± 1.63	6.60 ± 1.07	6.75 ± 0.93	1.73	0.180
L4D (cm)	6.22 ± 1.62	6.80 ± 1.09	7.08 ± 0.90	2.66	0.072
L2D:4D	0.98 ± 0.06	0.97 ± 0.03	0.95 ± 0.03	3.20	0.043
Mathematics (%)	46.36 ± 22.26	52.03 ± 13.89	46.04 ± 13.95	2.58	0.078
English (%)	65.39 ± 7.52	61.43 ± 12.22	49.92 ± 17.25	9.99	0.001
Biology (%)	72.57 ± 11.11	66.59 ± 12.18	55.21 ± 15.99	10.90	0.001
Economics (%)	67.29 ± 11.80	62.25 ± 12.63	52.44 ± 14.24	7.81	0.001

Table 4.6: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to age category

	13 -14 (yrs.)	15 – 17 (yrs.)	≥ 18 (yrs.)		
	n = 10	n = 112	n = 93		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	13.70 ± 0.48	16.20 ± 0.76	19.57 ± 2.07	169.40	0.001
Height (cm)	161.55 ± 9.22	165.99 ± 7.84	165.05 ± 16.77	0.63	0.534
Weight (kg)	48.10 ± 8.58	54.17 ± 8.07	57.50 ± 7.39	9.12	0.001
BMI (kgm^{-2})	18.29 ± 1.83	19.60 ± 2.22	26.30 ± 2.07	1.03	0.359
Head circumference (cm)	54.90 ± 2.33	55.30 ± 2.13	54.87 ± 4.19	0.49	0.617
Neck circumference (cm)	31.70 ± 2.41	33.32 ± 2.02	34.35 ± 3.24	6.93	0.001
Waist circumference (cm)	69.50 ± 5.46	70.88 ± 4.10	72.96 ± 7.36	4.04	0.019
Hip circumference (cm)	79.30 ± 6.04	85.13 ± 5.75	86.45 ± 8.61	4.73	0.10
Waist-hip-ratio	0.88 ± 0.02	0.83 ± 0.04	0.85 ± 0.05	4.54	0.012
R2D (cm)	7.11 ± 0.54	7.10 ± 0.92	7.15 ± 0.75	0.091	0.913
R4D (cm)	0.73 ± 0.62	7.37 ± 0.94	7.50 ± 0.77	0.70	0.500
R2D:4D	0.97 ± 0.03	0.96 ± 0.03	0.95 ± 0.04	2.71	0.069
L2D (cm)	7.14 ± 0.56	7.14 ± 0.94	7.25 ± 0.76	0.42	0.661
L4D (cm)	7.25 ± 0.56	7.35 ± 0.94	7.46 ± 0.77	0.61w	0.544
L2D:4D	0.99 ± 0.03	0.97 ± 0.04	0.97 ± 0.04	0.67	0.511
Mathematics (%)	42.10 ± 12.18	52.21 ± 16.15	43.31 ± 14.89	9.14	0.001
English (%)	53.50 ± 10.48	55.88 ± 11.74	44.72 ± 13.52	20.50	0.001
Biology (%)	56.60 ± 17.37	59.85 ± 17.15	45.49 ± 18.51	16.77	0.001
Economics (%)	66.00 ± 12.53	57.73 ± 16.39	52.33 ± 16.75	4.78	0.009

4.6 Anthropometric Variables and Academic Performance of Student Participants according to Future Ambition and School Type

From the Table, digit ratio 2D:4D of both hands as well as digit length of both hands were statistically significant, with student interested in studying Law and Sciences having the lowest ratio of 0.96 and 0.94 respectively on the right hand, while Law and Engineering has the lowest ratio of 0.95 each on the left hand. Higher ratio of 2D:4D that is male typical ratio of right and left are associated with student interested in studying accounting.

Academic performance were also significant in all the four subjects with students interested Medicine and Sciences scoring higher marks in Mathematics and English Language. Medical and Engineering students were also found to be best in Biology and Economics. Arts and Law scores lowest in Mathematics, lowest scores in English Language was recorded for students interested in studying Accounting and Arts.

Table 4.8: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to future ambition.

Digit length were statistically significant at $p < 0.001$ on both hands but digit ratio 2D:4D does not show any statistical difference. Academically, like in the case of female subjects, Medical and Science students has the highest scores in Mathematics, with Law students being the lowest in Mathematics. Law and Medicine score higher marks in English Language, while Engineering and Science students were the lowest in English Language. As expected Medical students score highest in Biology and Economics.

Table 4.7: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to future ambition

	Accountancy	Art	Engineering	Law	Medicine	Science		
	n = 21	n = 71	n = 9	n = 30	n = 73	n = 17		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	15.90 ± 1.00	16.52 ± 1.31	15.33 ± 0.71	16.23 ± 1.31	15.96 ± 1.01	16.65 ± 0.93	3.63	0.004
Height (cm)	158.95 ± 5.80	159.72 ± 6.16	161.06 ± 5.08	157.40 ± 5.88	158.62 ± 6.82	157.27 ± 5.54	1.06	0.381
Weight (kg)	51.10 ± 6.16	51.80 ± 8.77	53.78 ± 9.48	52.60 ± 6.18	51.38 ± 7.26	50.35 ± 9.37	0.36	0.877
BMI (kgm^{-2})	20.27 ± 2.64	20.29 ± 3.12	20.63 ± 2.73	21.35 ± 3.18	20.43 ± 2.74	20.34 ± 3.46	0.61	0.696
Head circumference (cm)	55.67 ± 2.08	55.46 ± 1.80	56.67 ± 3.28	55.60 ± 1.33	55.63 ± 1.90	55.18 ± 2.10	0.81	0.546
Neck circumference (cm)	31.90 ± 1.30	31.83 ± 1.70	31.78 ± 1.79	32.37 ± 3.96	32.16 ± 1.65	31.24 ± 2.08	0.81	0.545
Waist circumference (cm)	69.33 ± 5.55	69.10 ± 7.74	71.22 ± 6.16	71.53 ± 6.74	69.53 ± 6.35	68.59 ± 8.17	0.71	0.614
Hip circumference (cm)	93.05 ± 6.70	92.32 ± 7.40	91.33 ± 7.94	92.50 ± 5.16	91.66 ± 6.40	91.71 ± 7.40	0.22	0.955
Waist-hip-ratio	0.75 ± 0.05	0.75 ± 0.05	0.78 ± 0.07	0.77 ± 0.05	0.76 ± 0.06	0.75 ± 0.05	1.53	0.182
R2D (cm)	6.60 ± 0.93	6.36 ± 1.29	7.14 ± 0.38	5.41 ± 1.64	6.89 ± 0.41	6.76 ± 0.31	10.13	0.001
R4D (cm)	6.81 ± 0.94	6.70 ± 1.29	7.49 ± 0.36	5.82 ± 1.66	7.17 ± 0.42	7.16 ± 3.64	8.65	0.001
R2D:4D	0.97 ± 0.04	0.95 ± 0.05	0.95 ± 0.03	0.93 ± 0.06	0.96 ± 0.04	0.94 ± 0.02	3.77	0.003
L2D (cm)	6.65 ± 0.96	6.42 ± 1.24	7.18 ± 0.35	5.52 ± 1.63	7.00 ± 0.39	6.89 ± 0.27	10.62	0.001
L4D (cm)	6.76 ± 0.92	6.66 ± 1.29	7.55 ± 0.45	5.77 ± 1.60	7.18 ± 0.44	7.11 ± 0.39	9.62	0.001
L2D:4D	0.98 ± 0.04	0.96 ± 0.04	0.95 ± 0.03	0.95 ± 0.04	0.98 ± 0.03	0.97 ± 0.3	3.24	0.008
Mathematics (%)	54.91 ± 11.74	46.04 ± 12.42	50.06 ± 17.72	43.63 ± 15.01	56.81 ± 13.09	55.50 ± 19.39	6.83	0.001
English (%)	53.19 ± 10.99	55.83 ± 11.91	60.78 ± 12.76	60.87 ± 12.97	65.97 ± 9.96	62.88 ± 21.49	6.44	0.001
Biology (%)	63.67 ± 17.14	61.90 ± 13.63	70.11 ± 5.50	68.00 ± 9.21	68.62 ± 11.96	64.50 ± 15.88	2.50	0.032
Economics (%)	61.24 ± 11.88	57.62 ± 13.47	64.22 ± 11.89	61.53 ± 12.77	65.21 ± 11.41	60.41 ± 18.40	2.57	0.028

Table 4.8: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to future ambition

	Accountancy	Art	Engineering	Law	Medicine	Science		
	n = 20	n = 46	n = 92	n = 9	n = 29	n = 42		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	16.15 ± 1.66	18.41 ± 3.00	17.46 ± 2.08	16.00 ± 0.87	16.24 ± 1.55	18.14 ± 1.98	6.74	0.001
Height (cm)	158.95 ± 8.50	165.84 ± 18.09	166.44 ± 6.55	163.00 ± 6.63	166.52 ± 7.25	167.45 ± 7.99	2.23	0.052
Weight (kg)	48.60 ± 7.21	57.64 ± 7.31	56.32 ± 7.62	53.56 ± 8.82	54.10 ± 9.00	56.25 ± 6.58	4.65	0.001
BMI (kgm^{-2})	19.17 ± 1.97	23.42 ± 20.34	20.29 ± 2.27	20.13 ± 2.86	19.42 ± 2.41	20.08 ± 2.13	1.11	0.357
Head circumference (cm)	54.45 ± 2.16	55.57 ± 3.63	55.11 ± 1.91	54.44 ± 1.94	55.34 ± 2.64	55.24 ± 1.82	0.80	0.549
Neck circumference (cm)	33.10 ± 5.36	34.54 ± 1.86	33.57 ± 2.23	32.78 ± 1.64	33.31 ± 2.36	33.86 ± 1.73	1.75	0.125
Waist circumference (cm)	68.75 ± 4.34	73.65 ± 4.49	72.45 ± 5.12	71.78 ± 8.48	70.72 ± 4.97	71.64 ± 3.75	3.45	0.005
Hip circumference (cm)	81.65 ± 6.17	87.24 ± 6.57	86.48 ± 5.18	85.00 ± 6.56	83.66 ± 6.34	86.00 ± 4.22	3.94	0.002
Waist-hip-ratio	0.84 ± 0.04	0.85 ± 0.06	0.84 ± 0.04	0.84 ± 0.06	0.85 ± 0.06	0.83 ± 0.04	0.53	0.755
R2D (cm)	6.70 ± 1.00	6.91 ± 1.14	7.17 ± 0.67	5.37 ± 1.57	7.34 ± 0.55	7.33 ± 0.39	10.87	0.001
R4D (cm)	6.97 ± 0.96	7.23 ± 1.12	7.47 ± 0.70	5.72 ± 1.77	7.62 ± 0.57	7.68 ± 0.40	10.40	0.001
R2D:4D	0.96 ± 0.05	0.95 ± 0.04	0.96 ± 0.04	0.95 ± 0.05	0.96 ± 0.02	0.95 ± 0.03	0.75	0.590
L2D (cm)	6.70 ± 1.02	7.06 ± 1.15	7.23 ± 0.65	5.45 ± 1.66	7.39 ± 0.53	7.41 ± 0.43	10.64	0.001
L4D (cm)	6.90 ± 0.96	7.23 ± 1.13	7.44 ± 0.70	5.70 ± 1.62	7.58 ± 0.56	7.66 ± 0.47	10.43	0.001
L2D:4D	0.97 ± 0.03	0.98 ± 0.04	0.97 ± 0.04	0.95 ± 0.04	0.98 ± 0.03	0.97 ± 0.03	0.82	0.537
Mathematics (%)	46.70 ± 12.61	44.15 ± 13.74	44.57 ± 16.70	33.22 ± 17.39	58.74 ± 13.81	50.01 ± 16.81	5.78	0.001
English (%)	50.35 ± 10.59	52.11 ± 10.51	47.61 ± 14.00	57.22 ± 7.34	62.72 ± 9.52	47.88 ± 13.24	7.76	0.001
Biology (%)	59.55 ± 15.29	55.33 ± 14.28	49.03 ± 21.28	59.89 ± 12.69	65.35 ± 12.09	51.74 ± 16.94	4.52	0.001
Economics (%)	52.60 ± 11.74	52.78 ± 15.54	54.48 ± 17.36	60.00 ± 10.55	63.05 ± 13.32	56.77 ± 18.73	1.90	0.095

4.6: Anthropometric Variables and Academic Performance of Student Participants According to Parents' Social Status and Birth Order

Digit ratio did not show any significant different base on the parental income of the female student subjects. Academically Mathematics and English Language scores were the only two out of the four subjects considered are significant statistically. The students from the highest income parents has the highest marks in English Language while the low income children has the lowest marks in English Language. The reverse was the case in Mathematic in which lower income has the highest scores followed by medium income class, while the lowest marks comes from the highest income class.

As expected age was statistically significant, with children from higher income parents appear too be younger (15.85±1.17), while lower income students appear to be oldest (16.46±1.17). WHR was also significant at P = 0.002 with low income students having the lowest ratio of 0.74. while the medium income students has the highest ratio of 0.77

Table 4.10: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to parents' social status

Digit ratio as well as digit length were not statistically significant, but academic performance were statistically significant in all the four subjects considered. Studentd from the medium income class score the highest marks in all the four subjects, followed by higher income students on the other three subjects except Mathematics in which lower income children are the second. Like the female subjects, low income students aappear to be oldest while the high income are the youngest.

Table 4.9: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to parents' social status

	Low	Medium	High		
	n = 79	n = 83	n = 61		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	16.46 ± 1.17	16.20 ± 1.19	15.85 ± 1.17	4.74	0.010
Height (cm)	157.86 ± 6.04	159.71 ± 6.43	158.95 ± 6.37	1.77	0.173
Weight (kg)	50.94 ± 8.59	51.49 ± 6.48	53.09 ± 8.25	1.38	0.254
BMI (kgm^{-2})	20.41 ± 3.06	20.23 ± 2.70	21.03 ± 3.14	1.35	0.261
Head circumference (cm)	55.47 ± 1.96	55.67 ± 1.82	55.62 ± 1.94	0.25	0.777
Neck circumference (cm)	31.78 ± 1.73	32.31 ± 2.60	31.77 ± 1.82	1.66	0.192
Waist circumference (cm)	68.25 ± 7.37	70.39 ± 6.32	70.66 ± 6.98	2.75	0.066
Hip circumference (cm)	92.33 ± 7.55	91.75 ± 5.91	92.49 ± 6.67	0.26	0.775
Waist-hip-ratio	0.74 ± 0.05	0.77 ± 0.06	0.76 ± 0.06	6.29	0.002
R2D (cm)	6.63 ± 0.92	6.58 ± 1.10	6.21 ± 1.34	2.75	0.066
R4D (cm)	6.95 ± 0.93	6.93 ± 1.06	6.49 ± 1.35	3.65	0.028
R2D:4D	0.95 ± 0.05	0.95 ± 0.05	0.96 ± 0.04	0.78	0.461
L2D (cm)	6.68 ± 0.92	6.68 ± 0.92	6.32 ± 1.32	2.36	0.097
L4D (cm)	6.91 ± 0.91	6.89 ± 1.06	6.51 ± 1.38	2.70	0.069
L2D:4D	0.97 ± 0.04	0.97 ± 0.04	0.97 ± 0.03	0.47	0.625
Mathematics (%)	55.13 ± 15.71	49.28 ± 12.11	48.09 ± 15.32	5.12	0.007
English (%)	57.77 ± 15.91	61.71 ± 11.36	62.17 ± 10.81	2.60	0.007
Biology (%)	64.87 ± 14.17	67.07 ± 12.39	65.06 ± 12.76	0.68	0.508
Economics (%)	62.71 ± 13.55	59.46 ± 12.84	62.75 ± 12.90	1.62	0.201

Table 4.10: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to parents' social status

	Low	Medium	High		
	n = 95	n = 81	n = 63		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	18.18 ± 2.34	16.95 ± 1.96	16.94 ± 2.38	8.80	0.001
Height (cm)	166.01 ± 7.10	165.78 ± 14.13	165.25 ± 8.89	0.10	0.905
Weight (kg)	55.63 ± 8.13	56.49 ± 7.31	53.95 ± 8.18	1.87	0.156
BMI (kgm^{-2})	20.15 ± 2.47	21.92 ± 15.39	19.71 ± 2.31	1.25	0.289
Head circumference (cm)	54.87 ± 2.02	55.95 ± 2.43	54.60 ± 2.73	6.98	0.001
Neck circumference (cm)	33.57 ± 2.39	34.20 ± 2.80	33.22 ± 2.28	2.87	0.059
Waist circumference (cm)	72.03 ± 5.41	72.58 ± 4.76	71.08 ± 4.55	1.62	0.199
Hip circumference (cm)	85.98 ± 6.13	85.99 ± 5.05	84.90 ± 6.22	0.80	0.451
Waist-hip-ratio	0.84 ± 0.05	0.85 ± 0.05	0.84 ± 0.04	0.46	0.633
R2D (cm)	7.20 ± 0.70	6.95 ± 1.07	6.99 ± 0.89	1.99	0.138
R4D (cm)	7.48 ± 0.73	7.25 ± 1.07	7.35 ± 0.90	1.38	0.253
R2D:4D	0.96 ± 0.04	0.96 ± 0.04	0.95 ± 0.03	2.35	0.097
L2D (cm)	7.27 ± 0.73	7.02 ± 1.04	7.07 ± 0.91	1.93	0.148
L4D (cm)	7.46 ± 0.76	7.22 ± 1.05	7.31 ± 0.90	1.57	0.210
L2D:4D	0.98 ± 0.04	0.97 ± 0.04	0.97 ± 0.04	1.24	0.292
Mathematics (%)	47.17 ± 13.25	50.28 ± 18.40	42.23 ± 16.72	4.47	0.012
English (%)	49.75 ± 17.34	53.97 ± 13.86	50.07 ± 12.28	3.20	0.043
Biology (%)	49.75 ± 17.34	59.80 ± 19.00	52.71 ± 17.98	6.95	0.001
Economics (%)	52.28 ± 18.56	60.68 ± 12.38	54.70 ± 16.36	6.13	0.003

Table 4.11 and Table 4.12: Mean and Standard Deviation of Age, Anthropometric Variables and academic Performance of Male Participants according to Birth Order

From the two Tables, of both males and females students, non of the anthropometric parameter and academic performance were statistically significant except WHR ($p = 0.016$) for females and Economics subject performance scores for male students respectively ($p = 0.007$)

Table 4.11: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to birth order

	1st Born	2nd Born	3rd Born	≥ 4th Born		
	n = 47	n = 54	n = 35	n = 85		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	15.87 ± 1.12	15.98 ± 1.11	16.31 ± 0.96	16.47 ± 1.27	3.58	0.015
Height (cm)	159.11 ± 6.88	159.07 ± 6.14	157.81 ± 4.99	158.95 ± 6.47	0.37	0.772
Weight (kg)	50.51 ± 8.22	53.24 ± 8.65	50.84 ± 5.96	51.67 ± 7.53	1.22	0.303
BMI (kgm^{-2})	20.00 ± 3.34	21.04 ± 3.26	20.41 ± 2.15	20.46 ± 2.84	1.07	0.364
Head circumference (cm)	55.43 ± 1.85	55.61 ± 2.08	55.00 ± 1.59	55.89 ± 1.90	1.99	0.117
Neck circumference (cm)	31.70 ± 1.43	32.19 ± 1.94	32.57 ± 3.74	31.74 ± 1.58	1.70	0.168
Waist circumference (cm)	70.32 ± 7.81	71.06 ± 7.04	70.14 ± 4.78	68.16 ± 6.93	2.29	0.080
Hip circumference (cm)	90.87 ± 7.49	93.37 ± 6.50	92.46 ± 5.56	91.85 ± 6.76	1.25	0.292
Waist-hip-ratio	0.77 ± 0.06	0.76 ± 0.06	0.76 ± 0.05	0.74 ± 0.06	3.53	0.016
R2D (cm)	6.39 ± 1.16	6.61 ± 0.83	6.47 ± 1.04	6.48 ± 1.30	0.32	0.808
R4D (cm)	6.70 ± 1.17	6.92 ± 0.87	6.86 ± 1.04	6.79 ± 1.27	0.35	0.792
R2D:4D	0.95 ± 0.04	0.96 ± 0.04	0.94 ± 0.06	0.95 ± 0.04	0.68	0.563
L2D (cm)	6.50 ± 1.16	6.68 ± 0.84	6.62 ± 1.03	6.54 ± 1.26	0.26	0.854
L4D (cm)	6.66 ± 1.18	6.91 ± 0.82	6.83 ± 1.03	6.77 ± 1.28	0.40	0.750
L2D:4D	0.97 ± 0.04	0.97 ± 0.03	0.97 ± 0.04	0.97 ± 0.04	0.82	0.482
Mathematics (%)	47.16 ± 13.62	53.84 ± 13.05	51.40 ± 16.41	51.17 ± 15.28	1.78	0.153
English (%)	59.78 ± 13.69	62.61 ± 11.35	58.69 ± 14.80	59.94 ± 13.23	0.78	0.509
Biology (%)	64.81 ± 13.52	64.06 ± 15.04	64.06 ± 15.04	66.11 ± 12.74	0.38	0.768
Economics (%)	62.09 ± 12.18	63.05 ± 12.96	58.19 ± 14.01	61.52 ± 13.54	1.01	0.387

Table 4.12: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to birth order

	1st Born	2nd Born	3rd Born	≥ 4th Born		
	n = 60	n = 41	n = 42	n = 96		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F	p
Age (yrs.)	16.88 ± 2.29	17.68 ± 2.34	17.33 ± 2.16	17.72 ± 2.31	1.85	0.139
Height (cm)	166.36 ± 8.70	166.11 ± 6.96	166.41 ± 6.90	164.89 ± 13.44	0.36	0.782
Weight (kg)	54.12 ± 8.19	56.79 ± 7.17	55.37 ± 8.14	55.82 ± 7.91	1.04	0.378
BMI (kgm^{-2})	19.50 ± 2.30	20.59 ± 2.41	19.97 ± 2.58	21.65 ± 14.16	0.77	0.512
Head circumference (cm)	55.10 ± 1.93	54.95 ± 3.71	55.21 ± 1.87	55.28 ± 2.25	0.20	0.897
Neck circumference (cm)	33.35 ± 2.32	34.15 ± 3.77	33.50 ± 1.77	33.79 ± 2.27	0.94	0.423
Waist circumference (cm)	71.68 ± 5.12	72.98 ± 5.78	71.50 ± 4.45	71.92 ± 4.79	0.75	0.526
Hip circumference (cm)	84.92 ± 6.17	86.07 ± 6.21	85.95 ± 5.51	85.92 ± 5.56	0.49	0.690
Waist-hip-ratio	0.85 ± 0.05	0.85 ± 0.05	0.83 ± 0.04	0.84 ± 0.05	1.07	0.362
R2D (cm)	6.97 ± 0.99	7.17 ± 0.81	7.18 ± 0.63	7.01 ± 0.96	0.78	0.508
R4D (cm)	7.21 ± 0.99	7.49 ± 0.88	7.55 ± 0.67	7.33 ± 0.94	1.47	0.223
R2D:4D	0.97 ± 0.04	0.96 ± 0.03	0.95 ± 0.04	0.96 ± 0.04	1.40	0.245
L2D (cm)	7.01 ± 1.00	7.24 ± 0.85	7.30 ± 0.61	7.09 ± 0.94	1.15	0.331
L4D (cm)	7.15 ± 1.02	7.45 ± 0.85	7.54 ± 0.69	7.32 ± 0.93	1.87	0.136
L2D:4D	0.98 ± 0.04	0.97 ± 0.03	0.97 ± 0.04	0.97 ± 0.04	2.04	0.110
Mathematics (%)	45.73 ± 15.68	43.98 ± 16.36	50.25 ± 18.02	47.47 ± 15.82	1.18	0.320
English (%)	50.68 ± 12.00	49.74 ± 14.56	53.18 ± 13.82	50.87 ± 13.04	0.52	0.669
Biology (%)	56.18 ± 17.43	51.96 ± 18.95	56.98 ± 19.83	52.06 ± 18.14	1.16	0.328
Economics (%)	59.38 ± 17.36	48.20 ± 14.86	57.24 ± 16.00	56.10 ± 15.92	4.14	0.007

Table 4.13 and Table 4.14 : Handedness of the subject (hand preference)

The study also try to compare the anthropometric variables and academic performance of students based on right or left hand preference, i.e. those that uses right hand prequently versus those that uses left hand (righter versus lefter). Table 4.13 compare the anthropometric variable and academic performance of the student participants that are left-handed based on male and female gender. That is to say female left-handed versus male left-handed, from the Table, height, waist and hip circumfernces are the only statistically significant variables. On ther other hand, Table 4.14 which compare the anthropometric variable and academic performance of the student participants that are right-handed based on male and female gender show that all the variable are statistically significant, and this may be connected to the fact there was large sample size of the students that are right-handed compared to left-handed students that are scarce.

Table 4.13 Handedness male and female(left hand)

Parameter	Female (Left-handed) (n = 21) Mean±SD	Male (Left-handed) (n = 26) Mean±SD	t	P-value
R2D (mm)	6.76±0.64	6.97±0.98	-0.731	**0.470**
R4D (mm)	7.03±0.65	7.40±1.10	-1.170	**0.250**
L2D (mm)	6.82±0.66	6.99±1.00	-0.581	**0.565**
L4D (mm)	7.05±0.70	7.29±1.05	-0.808	**0.425**
Height (cm)	157.65±4.91	162.97±61.85	-2.746	**0.010**
Weight (kg/m^2)	49.29±7.25	53.66±6.51	-1.878	**0.069**
Waist circumference (cm)	67.17±6.10	71.55±4.43	-2.438	**0.020**
Hip circumference (cm)	90.94±5.26	85.11±4.67	-3.469	**0.001**
Head circumference (cm)	54.82±1.42	54.55±2.14	0.432	**0.668**
Neck circumference (cm)	31.82±1.28	33.38±1.81	-2.923	**0.600**
Mathematics (%)	56.61±15.36	49.72±16.44	1.280	**0.210**
English. (%)	59.47±16.47	50.25±15.83	1.688	**0.101**
Biology (%)	65.05±17.17	57.69±15.80	1.321	**0.196**
Economics (%)	62.67±15.26	51.55±17.58	1.993	**0.055**

Table 4.14 Handedness male and female (right hand)

Parameter	Female (Right-handed) (n = 198) Mean±SD	Male (Right-handed) (n =212) Mean±SD	t	P-value
R2D (cm)	6.47±1.15	7.07±0.88	-5.988	**0.001**
R4D (cm)	6.78±1.14	7.36±0.88	-5.722	**0.001**
L2D (cm)	6.56±1.13	7.14±0.88	-5.953	**0.001**
L4D (cm)	6.77±1.14	7.34±0.89	-5.767	**0.001**
Height (cm)	158.93±6.40	165.95±10.62	-8.197	**0.001**
Weight (kg/m^2)	51.93±7.80	55.62±8.00	-4.820	**0.001**
Waist circumference (cm)	69.91±6.97	72.00±5.04	-3.562	**0.001**
Hip circumference (cm)	92.25±6.81	85.74±5.89	10.579	**0.001**
Head circumference (cm)	55.65±1.92	55.21±2.44	2.029	**0.043**
Neck circumference (cm)	31.99±2.18	33.71±2.57	-7.437	**0.001**
Mathematics (%)	50.56±14.50	46.69±16.30	2.585	**0.010**
English. (%)	60.51±12.85	51.09±12.96	7.537	**0.001**
Biology (%)	65.79±12.78	53.63±18.73	7.782	**0.001**
Economics (%)	61.41±12.99	56.10±16.35	3.697	**0.001**

4.6 Anthropometric Variables and Academic Performance of Student Participants according to School Attendance Type

Table 4.15 try to compare anthropometric variables and academic performance of boarding and day school students of the two participating schools. From the Table age were statistically significant with boarding students that tend to be older than the day students (18.43±2.46) and (17.10±1.39) respectively. The weight, height and BMI of the boarding students are also higher than that of the day students. 2D:4D ratio and digit length does not show any statistical difference among the students

Academically, day students performs far better than the boarding student in all the four subjects considered.

Tables 4.18 and 4.19 compare the anthropometric variable and the academic performance of the students from the three scools (FGC, TCK and KCS) that participated in the research. Academically, FGC performed best in all the four subjects considered while TCK is the least and KCS maintained average position for both sexes. On anthropometric variables FGC students are the youngest and taller while TCK are the oldest in both male and female subjects.

Table 4.15 Mean and standard deviation of age, anthropometric variables and academic performance of student participants according to school type day and boarding

	School type			
Parameters	**Bording Mean ± SD n=121**	**Day Mean ± SD n=94**	**t**	**P**
Age (yrs.)	18.43±2.46	17.10±1.39	-4.69	0.001
Height (cm)	163.86±8.00	160.96±7.19	-2.78	0.563
Weight (kg)	56.19±8.53	51.87±6.93	-4.09	0.028
BMI (kgm^{-2})	20.89±2.66	20.00±2.23	-2.65	0.028
Head circumference (cm)	54.74±1.98	55.51±1.94	2.87	0.103
Neck circumference (cm)	33.45±2.43	32.49±2.86	-2.61	0.138
Waist circumference (cm)	72.72±5.77	67.55±5.20	-6.87	0.372
Hip circumference (cm)	89.11±5.98	88.17±6.26	-1.11	0.207
Waist-hip-ratio	0.82±0.06	0.77±0.07	5.44	0.003
R2D (cm)	71.64±5.67	69.84±7.05	-2.02	0.706
R4D (cm)	74.92±6.05	73.23±6.69	-1.91	0.917
R2D:4D	0.96±0.04	0.95±0.04	-0.71	0.211
L2D (cm)	72.60±6.07	70.16±6.52	-2.80	0.531
L4D (cm)	74.75±6.27	73.07±6.40	-1.92	0.463
L2D:4D	0.97±0.04	0.96±0.03	-2.53	0.224
Mathematics (%)	45.06±17.29	53.18±14.60	4.04	0.001
English (%)	47.53±15.48	54.06±14.03	3.23	0.022
Biology (%)	47.34±19.86	56.86±14.18	4.09	0.001
Economics (%)	54.32±18.48	57.01±15.43	1.16	0.018

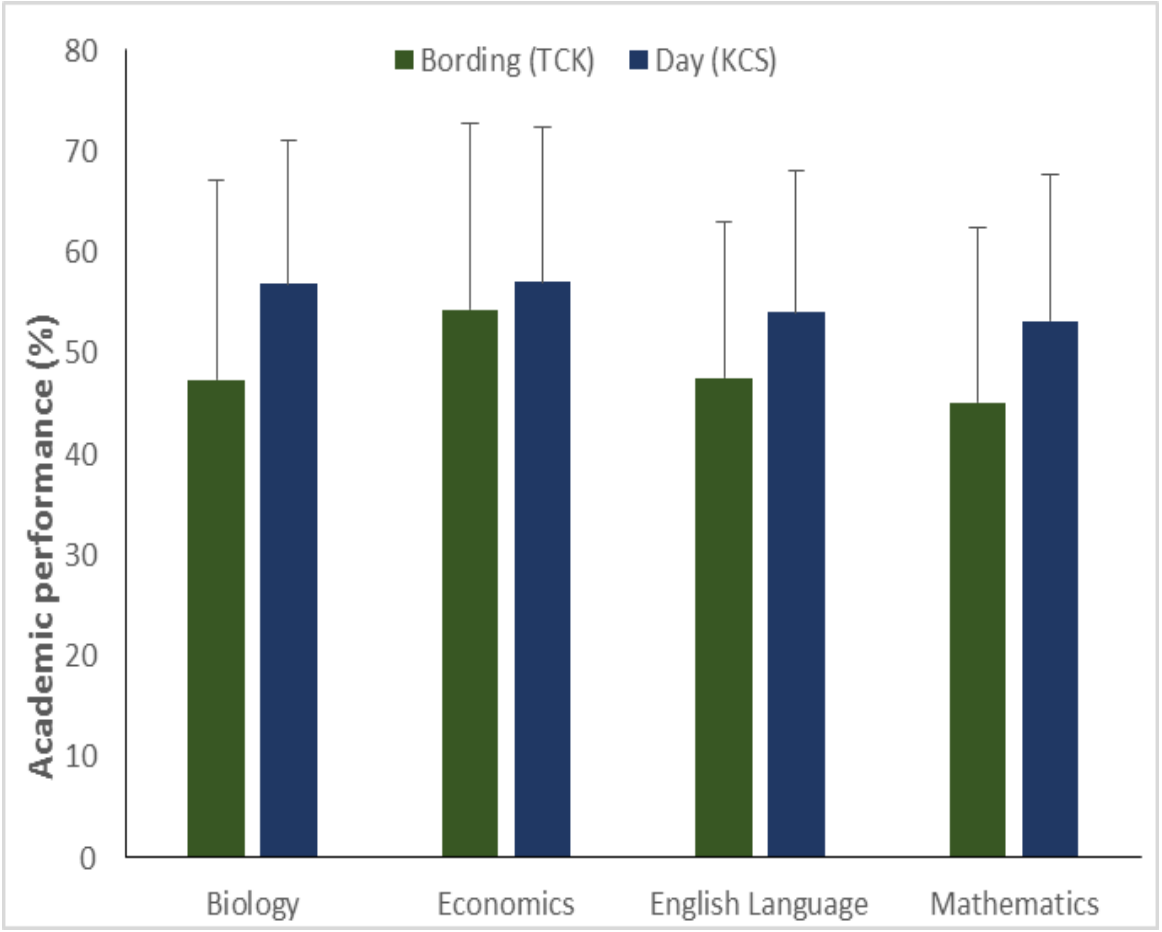


Fig. 4.3 Comparison of academic performance based on boarding and day school type. In all the four academic subjects considered day students perform better than their boarding counterpart. t-test indicates significance difference with $p < 0.05$

Table 4.16: Mean and standard deviation of age, anthropometric variables and academic performance of female participants according to school type

	FGC	KCS	TCK		
	n = 144	n = 51	n = 28		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	P
Age (yrs.)	15.89 ± 1.07	16.57 ± 1.01	17.11 ± 1.32	18.62	0.001
Height (cm)	159.93 ± 6.55	156.81 ± 4.64	157.00 ± 6.44	6.26	0.002
Weight (kg)	52.42 ± 7.92	49.62 ± 6.02	52.05 ± 9.36	2.51	0.084
BMI (kgm^{-2})	20.52 ± 3.04	20.19 ± 2.37	21.10 ± 3.46	0.86	0.423
Head circumference (cm)	55.83 ± 1.70	55.69 ± 2.00	54.18 ± 2.14	9.61	0.001
Neck circumference (cm)	32.29 ± 2.34	31.51 ± 1.39	31.21 ± 1.75	4.78	0.009
Waist circumference (cm)	71.21 ± 6.84	65.35 ± 4.85	69.89 ± 7.53	15.14	0.001
Hip circumference (cm)	92.17 ± 6.94	91.35 ± 5.74	93.57 ± 7.10	0.99	0.374
Waist-hip-ratio	0.77 ± 0.05	0.72 ± 0.04	0.75 ± 0.05	24.30	0.001
R2D (cm)	6.32 ± 1.29	6.84 ± 0.70	6.75 ± 0.47	5.01	0.007
R4D (cm)	6.63 ± 1.28	7.21 ± 0.69	7.08 ± 0.45	6.36	0.02
R2D:4D	0.95 ± 0.04	0.95 ± 0.05	0.95 ± 0.04	0.13	0.882
L2D (cm)	6.42 ± 1.28	6.89 ± 0.67	6.86 ± 0.43	4.45	0.013
L4D (cm)	6.59 ± 1.28	7.19 ± 0.66	7.10 ± 0.97	7.08	0.001
L2D:4D	0.97 ± 0.04	0.96 ± 0.03	0.97 ± 0.03	3.74	0.025
Mathematics (%)	49.25 ± 13.47	55.62 ± 14.90	51.79 ± 18.15	3.70	0.026
English (%)	62.13 ± 10.84	57.84 ± 14.91	56.46 ± 18.38	3.56	0.030
Biology (%)	69.07 ± 10.85	60.68 ± 12.70	57.86 ± 7.96	15.20	0.001
Economics (%)	62.19 ± 12.09	60.45 ± 14.06	59.96 ± 16.57	0.55	0.578

Table 4.17: Mean and standard deviation of age, anthropometric variables and academic performance of male participants according to school type

	FGC	KCS	TCK		
	n = 103	n = 43	n = 93		
Parameters	Mean ± SD	Mean ± SD	Mean ± SD	F	P
Age (yrs.)	16.06 ± 1.24	17.72 ± 1.53	18.83 ± 2.60	50.99	0.001
Height (cm)	165.49 ± 13.63	165.90 ± 6.58	165.93 ± 7.26	0.05	0.952
Weight (kg)	54.12 ± 7.94	54.54 ± 7.07	57.43 ± 7.91	4.82	0.009
BMI (kgm^{-2})	20.81 ± 13.76	19.79 ± 2.04	20.83 ± 2.39	0.22	0.803
Head circumference (cm)	55.35 ± 2.97	55.30 ± 1.88	54.90 ± 1.91	0.91	0.404
Neck circumference (cm)	33.31 ± 2.17	33.65 ± 3.66	34.13 ± 2.21	2.60	0.076
Waist circumference (cm)	71.27 ± 4.98	70.16 ± 4.38	73.57 ± 4.86	9.19	0.001
Hip circumference (cm)	84.38 ± 6.51	84.40 ± 4.55	87.76 ± 4.87	10.40	0.001
Waist-hip-ratio	0.85 ± 0.06	0.83 ± 0.04	0.84 ± 0.04	1.73	0.179
R2D (cm)	6.81 ± 1.14	7.15 ± 0.68	7.29 ± 0.53	7.81	0.001
R4D (cm)	7.11 ± 1.14	7.46 ± 0.63	7.62 ± 0.59	8.55	0.001
R2D:4D	0.96 ± 0.04	0.96 ± 0.04	0.96 ± 0.04	0.03	0.967
L2D (cm)	6.90 ± 1.13	7.17 ± 0.60	7.38 ± 0.60	7.65	0.001
L4D (cm)	7.08 ± 1.14	7.44 ± 0.59	7.59 ± 0.62	8.67	0.001
L2D:4D	0.97 ± 0.04	0.96 ± 0.03	0.97 ± 0.04	1.33	0.266
Mathematics (%)	49.02 ± 16.41	50.28 ± 13.87	43.04 ± 16.60	4.53	0.012
English (%)	57.23 ± 10.50	49.58 ± 11.57	44.84 ± 13.49	26.70	0.001
Biology (%)	63.41 ± 13.96	52.35 ± 14.65	44.18 ± 19.40	33.81	0.001
Economics (%)	59.79 ± 13.32	52.93 ± 16.15	52.62 ± 18.78	5.62	0.004

4.7 Correlation Between Anthropometric Variables and Academic Performance of the Student participant.

Table 4.16 Showed the overall correlation matrix of all the study participants, academic performance and anthropometric characteristics. Pearson's correlation coefficient was used to correlate academic performance and anthropometric variables sixty four percent (64%) of the parameters correlated at $p < 0.01$ and $p < 0.05$.

Academic performance of the students assessed by the results obtained by the student in the first term examination for four general subjects (Mathematics, English, Biology and Economics) show that 2D:4D correlate negatively with three out of the four subjects and statistically not significant for both male and female in Tables 4.15. On the other hand Mathematics scores correlate positively and statistically significant with both right and left 2D:4D for the overall participants.

2D:4D also correlated positively with length of individual digits (i.e R2D, R4D, L2D and L4D) and WHR. Height and weight correlated with almost all the variables except digit ratio, head circumference and Mathematics scores. On the other hand BMI correlated only with neck, waist and hip circumferences.

WHR correlated with all the variables except Right 2D:4D, BMI, Mathematics and Economics scores.

Table 4.18: Pearson's correlation matrix of age, anthropometric variables and academic performance of all study participants (n = 462)

	Age	HT	WT	BMI	HDC	NC	WC	HC	WHR	R2D	R4D	R2D:4D	L2D	L4D	L2D:4D	MATH	ENGL	BIOL	ECON
Age	-	0.12[a]	0.24[a]	0.09	-0.02	0.31[a]	0.21[a]	0.05	0.17[a]	0.21[a]	0.23[a]	-0.01	0.22[a]	0.23[a]	-0.01	-0.17[a]	-0.39[a]	-0.42[a]	-0.29[a]
HT		-	0.46[a]	-0.53[a]	0.16[a]	0.32[a]	0.27[a]	0.02	0.26[a]	0.32[a]	0.33[a]	0.05	0.33[a]	0.34[a]	0.02	0.00	-0.09	-0.15[a]	-0.13[a]
WT			-	0.29[a]	0.31	0.57[a]	0.75[a]	0.59[a]	0.21[a]	0.20[a]	0.22[a]	0.00	0.22[a]	0.23[a]	-0.01	-0.17[a]	-0.13[a]	-0.15[a]	-0.09
BMI				-	0.08	0.14[a]	0.26[a]	0.25[a]	0.04	-0.06	-0.04	-0.05	-0.05	-0.05	0.02	0.00	-0.05	0.01	-0.00
HDC					-	0.30[a]	0.20[a]	0.30[a]	-0.08	0.08	0.08	0.01	0.08	0.08	0.04	-0.03	0.16[a]	0.17[a]	0.12[a]
NC						-	0.48[a]	0.20[a]	0.31[a]	0.26[a]	0.27[a]	0.02	0.28[a]	0.28[a]	0.01	-0.02	-0.08	-0.12[a]	-0.07
WC							-	0.51[a]	0.54[a]	0.17[a]	0.18[a]	0.03	0.19[a]	0.18[a]	0.06	0.15[a]	-0.10[b]	-0.11[a]	-0.08
HC								-	-0.44[a]	-0.04	-0.03	-0.03	-0.03	-0.02	-0.04	0.12[a]	0.07	0.08	0.03
WHR									-	0.21[a]	0.21[a]	0.06	0.23[a]	0.21[a]	0.09[b]	0.08	-0.17[a]	-0.17[a]	-0.11
R2D										-	0.97[a]	0.37[a]	0.98[a]	0.96[a]	0.25[a]	-0.20[a]	-0.10[b]	-0.13[a]	-0.09
R4D											-	0.12[a]	0.97[a]	0.98[a]	0.13[a]	0.29[a]	-0.10[b]	-0.14[a]	-0.11[b]
R2D:4D												-	0.27[a]	0.15[a]	0.53[a]	0.27[a]	-0.04	0.02	0.05
L2D													-	0.97[a]	0.28[a]	0.15[a]	-0.10[b]	-0.14[a]	-0.10[b]
L4D														-	0.05	0.26[a]	-0.10[b]	-0.14[a]	-0.11[b]
L2D:4D															-	0.12[a]	-0.00	0.01	0.05
MATH																-	0.48[a]	0.46[a]	0.43[a]
ENGL																	-	0.63[a]	0.52[a]
BIOL																		-	0.51[a]
ECON																			-

HT = height (cm), WT = weight (kg). BMI = Body Mass Index (kgm^{-2}), HDC = head circumference (cm), NC = neck circumference (cm), WC = waist circumference (cm), HC = hip circumference (cm), WHR = waist-hip-ratio, R2D = right second digit (cm), R4D = right fourth digit (cm), R2D:4D = right-second-to-fourth digit ratio, L2D = left second digit (cm), L4D = left fourth digit (cm), L2D:4D = left-second-to-fourth digit ratio, MATH = Mathematics (%), ENGL = English Language (%), BIOL = Biology (%), ECON = Economics (%). a: correlation statistically significant at $p < 0.01$, b: correlation statistically significant at $p < 0.05$

Table 4.19: Pearson's correlation matrix of age, anthropometric variables and academic performance of males (top right) and females (bottom left) of study participants

	Age	HT	WT	BMI	HDC	NC	WC	HC	R2D	R4D	R2D:4D	L2D	L4D	L2D:4D	MAT	ENG	BIO	ECO
Age	-	-0.16[b]	-0.02	0.07	-0.08	0.02	-0.01	0.15[b]	0.15[b]	0.16[b]	0.02	0.15[b]	0.18[a]	-0.09	-0.03	-0.30[a]	-0.29[a]	-0.25[a]
HT	0.01	-	0.35[a]	-0.19[a]	0.19[a]	0.21[a]	0.22[a]	0.15[a]	0.15[b]	0.21[a]	0.04	0.20[a]	0.20[a]	0.04	0.05	0.08	0.14[a]	-0.01
WT	0.31[a]	0.60[a]	-	0.85[a]	0.29[a]	0.42[a]	0.75[a]	0.86[a]	0.21[a]	0.06	0.01	0.06	0.07	-0.04	-0.07	-0.02	0.00	-0.06
BMI	0.07	-0.80[a]	-0.26[a]	-		0.32[a]	0.65[a]	0.82[a]	0.06	-0.06	-0.02	-0.06	-0.05	-0.06	-0.11	-0.07	-0.08	-0.07
HDC	-0.01	0.77[a]	0.51[a]	0.76[a]	-	0.31[a]	0.16[a]	0.24[a]	-0.07	0.02	0.08	0.03	0.01	0.08	0.11	0.12	0.18[a]	0.12
NC	0.28[a]	0.44[a]	0.65[a]	-0.34[a]	0.56[a]	-	0.44[a]	0.33[a]	0.04	0.22[a]	0.07	0.23[a]	0.23[a]	0.04	0.11	0.16[b]	0.15[b]	0.04
WC	0.27[a]	0.67[a]	0.77[a]	-0.59[a]	0.65[a]	0.58[a]	-	0.67[a]	0.22[a]	0.13[a]	0.07	0.14[b]	0.13[b]	0.05	-0.17[b]	-0.03	0.00	-0.07
HC	0.24[a]	0.68[a]	0.75[a]	0.22[a]	0.66[a]	0.59[a]	0.81[a]	-	0.13	0.03	0.06	0.03	0.04	-0.02	-0.03	-0.10	-0.05	-0.07
R2D	0.09	0.54[a]	-0.06	-0.42[a]	0.46[a]	0.27[a]	0.41[a]	0.43[a]	-	0.97[a]	0.40[a]	0.99[a]	0.97[a]	0.26[a]	0.39[a]	-0.02	0.01	-0.06
R4D	0.12	0.56[a]	0.40[a]	-0.43[a]	0.49[a]	0.30[a]	0.43[a]	0.44[a]	0.95[a]	-	0.17[b]	0.97[a]	0.99[a]	0.13	0.36[a]	-0.02	-0.01	-0.07
R2D:4D	-0.09	-0.08	0.42[a]	0.08	-0.11	-0.11	-0.07	-0.06	0.22[a]	-0.09	-	0.33[a]	0.22[a]	0.56[a]	0.22[a]	-0.02	0.03	0.01
L2D	0.10	0.57[a]	0.43[a]	-0.42[a]	0.47[a]	0.30[a]	0.44[a]	0.44[a]	0.96[a]	0.96[a]	0.07	-	0.98[a]	0.28[a]	0.39[a]	-0.01	0.02	-0.06
L4D	0.11	0.58[a]	0.45[a]	-0.43[a]	0.50[a]	0.32[a]	0.43[a]	0.46[a]	0.93[a]	0.97[a]	-0.08	0.95[a]	-	0.08	0.37[a]	-0.03	-0.02	-0.06
L2D:4D	-0.01	-0.04	-0.04	0.05	-0.06	-0.06	0.03	-0.04	0.24[a]	0.10	0.48[a]	0.27[a]	-0.03	-	0.16[b]	0.07	0.15[b]	0.02
MAT	-0.24[a]	0.13[b]	0.08	-0.12	0.21[a]	0.11	0.07	0.13	0.20[a]	0.18[a]	0.06	0.18[a]	0.16[a]	0.09	-	0.38[a]	0.46[a]	0.41[a]
ENG	-0.36[a]	0.13	-0.07	-0.17[b]	0.21[a]	0.01	0.03	-0.01	0.07	0.07	-0.03	0.04	0.05	-0.03	0.59[a]	-	0.51[a]	0.54[a]
BIO	-0.37[a]	0.06	-0.09	-0.13	0.19[a]	-0.01	-0.02	-0.05	-0.01	-0.03	0.06	-0.04	-0.02	-0.07	0.49[a]	0.66[a]	-	0.50[a]
ECO	-0.23[a]	0.05	-0.02	-0.15[b]	0.17[b]	0.04	0.09	0.05	0.06	0.02	0.11	0.03	0.01	0.07	0.45[a]	0.48[a]	0.48[a]	-

HT = height (cm), WT = weight (kg). BMI = Body Mass Index (kgm^{-2}), HDC = head circumference (cm), NC = neck circumference (cm), WC = waist circumference (cm), HC = hip circumference (cm), WHR = waist-hip-ratio, R2D = right second digit (cm), R4D = right fourth digit (cm), R2D:4D = right-second-to-fourth digit ratio, L2D = left second digit (cm), L4D = left fourth digit (cm), L2D:4D = left-second-to-fourth digit ratio, MATH = Mathematics (%), ENGL = English Language (%), BIOL = Biology (%), ECON = Economics (%). a: correlation statistically significant at $p < 0.01$, b: correlation statistically significant at $p < 0.05$

Table 4.20 showed linear regression equations of Mathematics, English and Biology scores from digit length and digit ratio (2D:4D). From the table,digit length that is R2D, R4D, L2D and L4D are strong possible predictor of Mathematics scores than the other variables. The value of R^2 for predicting Mathematics English and Biology scores using R2D are respectively 0.08, 0.009 and 0.016 respectively, $p < 0.0001$. From this linear someone can be able to predict how well a student can performe in Mathematics, English Language based on the records of the digit ratio or digit length of that individual.

Table 4.20: Linear regression models for predicting performance in Mathematics, English Language and Biology using digit lengths and digit ratios (2D:4D)

Parameters	*Predictive equation*	*SEE*	*R*	R^2	*P*
R2D (cm)	MATH = 19.636 + 4.310 × R2D	14.981	0.289	0.084	0.0001
R4D (cm)	MATH = 20.784 + 3.960 × R4D	15.088	0.265	0.070	0.0001
R2D:4D	MATH = (-7.166) + 58.719 × R2D:4D	15.465	0.153	0.024	0.0010
L2D (cm)	MATH = 20.182 + 4.180 × L2D	15.035	0.278	0.077	0.0001
L4D (cm)	MATH = 21.822 + 3.830 × L4D	15.126	0.257	0.066	0.0001
L2D:4D	MATH = (-2.026) + 524.980 × L2D:4D	15.530	0.123	0.015	0.0080
R2D (cm)	ENGLISH = 64.330 + (-1.290) × R2D	13.895	0.097	0.009	0.0370
R4D (cm)	ENGLISH = 64.520 + (-1.260) × R4D	13.898	0.095	0.009	0.0420
L2D (cm)	ENGLISH = 64.798 + (-1.340) × L2D	13.891	0.100	0.010	0.0320
L4D (cm)	ENGLISH = 65.361 + (-1.380) × L4D	13.885	0.104	0.011	0.0250
R2D (cm)	BIOLOGY = 73.529 + (-2.050) × R2D	17.064	0.125	0.016	0.0070
R4D (cm)	BIOLOGY = 76.077 + (-2.320) × R4D	17.026	0.141	0.020	0.0020
L2D (cm)	BIOLOGY = 74.975 + (-2.230) × L2D	17.041	0.135	0.018	0.0040
L4D (cm)	BIOLOGY = 76.117 + (-2.330) × L4D	17.024	0.142	0.020	0.0020

CHAPTER FIVE

DISCUSSION

5.1 Discussions.

The results of this study pointed to a negative correlation between 2D:4D and academic performance as measured by grades obtained by the students in their first term examination. Three out of the four subjects considered in this study (English language, Biology and Economics) were negatively statisically not significant with digit ratio. On the other hand Mathematics scores were positively statistically significant with 2D:4D for both hands in males. This is consistent with the study of Keogh, (2011) and Brosnan, (2006) who reported positive correlation between digit ratio and numeric capabilities and ability to understand information communication technology (Brosnan, 2006; Brosnan, Gallop, Iftikhar, & Keogh, 2011),

In line with our present study, Hopp *et al,* (2012) who found that right hand 2D:4D is negatively related to theory and practical marks in male dental students. But there is lack of a relationship between 2D:4D and examination marks in female dental students. Improved Mathematical performance in relation to lowere 2D:4D, also agree with the finding of no sex differences in the areas of number, counting, and basic mathematics (Geary, 1996). Significant relationship were also reported to exist between digit ratio i.e lower ratio potentially indicating higher prenatal testosteron was associated with better performance on the numerical measures and number, counting or simple numerical abilities in boys but not girls (Fink 2006). Recently, Coco *et al.* (2011) evaluated a

group of 48 male medical students, and found a significant correlation between 2D:4D and success in admission tests for a school in Italy.

Correlational evidences reported that digit ratio (2D:4D), is negatively associated with prenatal testosterone and the ratio between prenatal testosterone and prenatal oestrogen (Breedlove, 2010; Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer and Manning, 2004; Manning, 2002; Manning and Fink, 2008; Manning et *al.,* 1998). Also, experimental manipulation (including loss of androgen and oestrogen receptors and addition of androgen and oestrogen blockers and testosterone and estradiol) of sex steroids in the mouse has shown that 2D:4D is dependent on the ratio of prenatal testosterone and prenatal oestrogen (Zheng and Cohn, 2011). That is, when prenatal testosterone is high and prenatal oestrogen is low then 2D:4D is low and vice versa. Therefore, our findings suggest that males students with high prenatal testosterone and low prenatal oestrogen tend to have high intelligence. We suggest that this supports the hypothesis of Mrazik and Dombrowski (2010), who have suggested that high intelligence is linked to high prenatal testosterone through the latter's influence on neuronal proliferation, migration, differentiation, and apoptosis. However, we have not found a correlation between 2D:4D and the examination marks in female subjects. This may be because the effect of prenatal testosterone on intelligence differs between the sexes and/or the link between prenatal testosterone and intelligence is particularly strong when prenatal testosterone is high (as it is in males). Prenatal testosterone exposure may directly influence intelligence, by altering neuronal migration, leading to greater right hemisphere development (Geschwind and Behan, 1982), as well as greater coordination within and

between the hemispheres (Alexander, O'Boyle, and Benbow, 1996; Anderson and Harvey, 1996), resulting in males becoming more strongly lateralized than females on certain tasks (Wisniewski, 1998). This could lead to dense neuronal networks in areas related to cognition, learning and memory, either by decreasing apoptosis of brain cells during development, or increasing migration of cells to one of those areas (Mrazik and Dombrowski, 2010). If so, then significant relations between the 2D:4D ratio and performance on basic numerical task may be found. In our studies, we found no significant relationship between 2D:4D ratio and academic performance in girls, but some significant relationships in boys. More recently, Cohen-Bendahan, Buitelaar, van Goozen, and Cohen-Kettenis (2004) noted that female fetuses sharing the womb with an opposite-sex twin are exposed to higher levels of testosterone. Such twins demonstrated a masculinised pattern of dichotic listening performance compared with same-sex female twins. These studies suggest that prenatal exposure to testosterone may affect the developing female and male brain differently. It has in fact been suggested that developmental periods are different for males and females (Taylor, 1969). As 2D:4D is considered a marker for prenatal testosterone exposure, these traits may be negatively correlated with 2D:4D.

Digit ratio, (2D:4D) also show statistical significant differences in future career interest of the students, it shows that lower 2D:4D ratio was associated with students having interest in studying Sciences, accounting and Law, while higher ratio was associate with Arts, Medicine and Engineering among the male subjects. For the female subjects, Law, Engineering and Arts recorded the lowest ratio, that is male typical 2D:4D ratio. This go

in line with the study of Weis *et al*., (2007) who reported that some of the sexually typical preferences for distinct career interests are reflected in the digit ratio within the sexes.

Our results show no statistical difference among the major ethnic groups considered, but still revealed that Hausa Ethnic group has the lowest ratio of 2D:4D in both sexes, while the Yorubas have the highest ratio that is female typical 2D:4D ratio in both males and females.This support the study of Manning and collegues who reported that digit ratio vary greatly between different ethnic groups, and the variation is far larger than the difference between sexes, (Manning *et al.*, 2000, Manning *et al.*, 2004). 2D:4D is highly significant in similar population (Manning *et al.*, 2000; Peters *et al.*, 2000b). Low mean ratios have been found in a black population and similar "masculinized" ratios have been reported in Afro-Caribbean sample from Jamaica (Manning *et al.*, 2000). It is not yet known how wide spread such low ratios are in black populations, and there is considerable between population variation in mean 2D:4D in Caucasian groups.

In line with most study our research shows that the finding of sex differences in 2D:4D is consistent with previous research (Manning, 2002), there were marked statistical differences in the comparison between male and female right hand, wich agree with most studies thats says 2D:4D appears to be more on the right hand. (Manning, 1998,Manning, 2002). On the contrary left handed females versus male left handed do not show statistical difference on most anthropometric variables considered and

academic performance, and will be attributed to the small sample size of the students that are left handed.

2D:4D does not show any statistical significant difference with socio-economic status of the student subject but show some level of statistical significant to academic performance. This is partly due to the fact that the study consider socio economy of the students based on their parental occupation, which may not give full detail of how wealth is being distributed in the family. Also the three schools that participated in the study fall within the same category of being the government schools. With these, socio economy may not show statistical difference. On academic performance, socio economic status show statistical significant different with the studentd from the medium income class score the highest marks in all the four subjects, followed by higher income students, among the male subjects. On the other hand, female students from the highest income parents has the highest marks in English Language while the low income children has the lowest marks in English Language. The reverse was the case in Mathematic in which lower income has the highest scores followed by medium income class, while the lowest marks comes from the highest income class. These asymetry in academic performance reslting from overlapping from highest income earners and medium class income earners can be explained as upper and medium class income earners shares so many similarities in terms of parental level of education, parental care and wealth distribution in the family. All these enhances academic performance and that is why in all the four subjects considrered under academic performance does not favour lower income earner class. Also the study revealed that higher income earners children

appears to be younger, healthier (based on BMI) and more intelligent and can be attributed to abundant resources in the family, improved health care and parental level of education, all these can be achieved because socio-economic status changes the life style, nutrition and ethnic composition of population which lead to changes in distribution of body dimension. (Adebisi 2008).

The study also went further to compare anthropometric variables and academic performance of boarding and day school students of the two participating schools. Kaduna Capital School (KCS) is a day school while Technical College Kaduna, (TCK) is a boarding school. From the results we obtained, age were statistically significant with boarding students appearing older than the day students 18.43±2.46 and 17.10±1.39. Academically, also day students performs far better than the boarding student in all the four subjects considered. These may not be unconnected to the fact that day students receive better parental care and improved educational guidance compared to their boarding students counterpart. Another factor that may likely be responsible for the difference in the performance is the economic status of the students, most students from TCK (boarding school) fall within the lower income class, while most students from KCS (day school) fall within middle and upper class income. The weight, height and BMI of the boarding students are higher than that of the day students. 2D4D ratio and digit length does not show any statistical difference among the students.

Comparison of the anthropometric variable and the academic performance of the students from the three scools that participated in the research, show that Academically,

FGC (a mixed school of boarding and day) performed best in all the four subjects while TCK (a boarding school) is the least and KCS (a day school), maintained average position for both sexes. This may be related to the academic standard of the schools, for instance, FGC is a federal school, with students from all parts of the country, with qualified teachers compared to the other two school, and this made the school to have students from upper and middle classes of people. These certainly will affect academic performance positively. On anthropometric variables FGC students are the youngest and taller while TCK are the oldest in both male and female.This may also be related to socio economic status of the students.

Finally, the study also looked at the age groups of the students in which digit ratio and anthropometric variables were statistically not significant but academic performance were significant in all the four subjects ($p < 0.001$), in the overall, age group is significance with academic performance in which 13-14 years class which happens to be the youngest class and the best academically. 18 and above classes which is the older did not performed well academically. Therefore from this research, it show that the earlier the children are registered in the school the better they perform academically.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

In summary, the present cross-sectional study investigated the academic performance and anthropometric parameters of students based on gender, socioeconomic status, school type, age group and ethnicity. Results of the study showed all the anthropometric variables, length of the digits and academic performance were statistically significant based on gender, academically female subjects are doing better than their males counterparts in all the four subjects considered, most especially in English Language and Biology. Geographically, students from South-East zone which represent the Igbo ethnic group performed best academically followed by Yoruba students from South-West. The Hausas from North-West zone are the least. Other anthropometric variable did not show marked significant differnce based on ethnicity.

The study also investicated the association between digit ratio (2D:4D) and future career interest of the students. Female student interested in studying Law and Sciences have the lowest ratio of 0.96 and 0.94 respectively on the right hand, while Law and Engineering has the lowest ratio of 0.95 each on the left hand. Higher ratio of 2D4D are associated with student interested in studying accounting. Digit ratio does not show statistical difference among the male subjects based on career interest. Academic performance were also significant with students interested Medicine and Sciences scoring higher marks in Mathematics and English Language. Medical and Engineering students were also found to be best in Biology and Economics. Arts and Law scores

lowest in Mathematics, lowest scores in English Language was recorded for students interested in studying Accounting and Arts.

Digit ratio did not show significant different base on the parental income of the female student subjects. Academically, female students from the highest income parents has the highest marks in English Language while the low income children has the lowest marks in English Language. The reverse was the case in Mathematic in which lower income has the highest scores followed by medium income class, while the lowest marks comes from the highest income class. Male Students from the medium income class score the highest marks in all the four subjects, followed by higher income students on the other three subjects except Mathematics in which lower income children are the second. As expected age was statistically significant for both sexes, with children from higher income parents appear too be younger (15.85±1.17), while lower income students appear to be oldest (16.46±1.17). WHR was also significant at P = 0.002 with low income students having the lowest ratio of 0.74. while the medium income students has the highest ratio of 0.77

The study tried to compare anthropometric variables and academic performance of boarding and day school students of the two participating schools. Age wise boarding students that tend to be older than the day students (18.43±2.46) and (17.10±1.39) respectively. The weight, height and BMI of the boarding students were also higher than those of the day students. 2D:4D ratio and digit length did not show any statistical

difference among the students. Academically, day students performed far better than the boarding student in all the four subjects considered.

Correlation matrix showed that 2D:4D correlate negatively with three out of the four subjects and statistically not significant for both male and female. On the other hand Mathematics scores correlate positively and statistically significant with both right and left 2D:4D for the male subject participants. On the other hand 2D:4D and academic performance did not show any significant different among the female subjects. 2D:4D also correlated positively with length of individual digits (i.e R2D, R4D, L2D and L4D) and WHR. Height and weight correlated with almost all the variables except digit ratio, head circumference and Mathematics scores. On the other hand BMI correlated only with neck, waist and hip circumferences.

Finally, linear regression equations rervealed that the digit lengths (that is R2D, R4D, L2D and L4D) are stronger possible predictor of Mathematics scores than even the other variables like digit ratio. English language and Biology scores can also be prediction through the digit ratio and also digit lenghts.

6.2 Conclusion

The study found that low 2D:4D (a correlate of high prenatal testosterone and low prenatal oestrogen) was associated with better performance in Mathematics in males, but not in females. There were no correlation between 2D:4D and academic performance, in both male and female based on the three other subjects considered among the secondary school students in Kaduna, Nigeria. The lack of correlation between 2D:4D and academic performance in female students may not be unconnected to the fact that high prenatal testosterone enhances higher intelligent but the effect of prenatal testosterone on intelligence differs between the sexes.

Inline with other literatures, the study was able to establish the relationship between 2D:4D and future career interest, though with some unexpected results. The study also agree with the literature that says 2D:4D ratio is more stronger on the right hand than the left.

6.3 Recommendations

i. The students should undergo the same type of examinations, and it should be conducted in the same time and the same condition so as to ensure accuracy when dealing with the academic performance. This will provides uniformity in assessment of students performance via their results.

ii. The researcher should be the one to set the type of examinations that he/she wishes. This will help to eliminate the effect of different subjects combinations of the student.

iii. There should be large enough sample size that will come across different ethnic groups of the population, this will ensure enough participation of each ethnic groups.

iv. Digital vanier calliper employed for this study works well for the direct digits measurement but there is need to use both direct measurement and the measurement from the photocopy of hand so as to take the average.

v. The study should be carried out in higher institutions of learning, so as to take care of issue of care interest of the subject. For example career interest should be grouped based on the course of study of the subject.

6.4 Contributions to Knowledge

i. Academic performance of a student can be determined by the use of 2D:4D and digit length. (R = 0.29, 0.27, 0.15, 0.28, 0.26, 0.12 for R2D, R4D, R2D:4D, L2D, L4D and L2D:4D respectively).

ii. Mathematics performance has high affinity to lower 2D:4D (r = 0.12 and 0.27 for right and left hand respectively).

iii. Counterary to the assumption that bigger head size enhances intelligence, the present study found no relationship between academic performance and head size (r = 0.03, 0.07, 0.08 and 0.03 for Mathematics, English, Biology and Economics respectively).

iv. In line with most studies, the research found and confirmed that academic performance favoured female students in all the four subjects considered. ($p < 0.005$)

v. In disagreement with most study, we found that day students performed better than their boarding students counterpart academically ($p < 0.005$).

vi. Socio-economic status of the parents have direct influence on academic performance of their children.

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HEALTH RESEARCH ETHICS COMMITTEE

AHMADU BELLO UNIVERSITY TEACHING HOSPITAL

SHIKA - ZARIA, NIGERIA.

E-mail: abuthshika@yahoo.com website: www.abuth.org

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Director of Administration: Barr. Ishak Bello, LL.B, BL., LL.M, PGDM, AHAN, FCAI

Our Ref: ABUTH/HREC/TRG/36 Date: 3rd November, 2014

Your Ref: _____

ABUTH HREC FULL ETHICAL CLEARANCE CERTIFICATE

RE: *"Second to Fourth Digit Ratio (2D:4D) and Academic Performance among Secondary School Students in Kaduna, Nigeria."*

ABUTH Ethics Committee assigned number:	-	**ABUTH/HREC/L05/2014**
Name of the principal Investigator:	-	**Mr. Rayyan Kabir Muhammad,**
Address of the Principal Investigator:-		**Department of Human Anatomy,**
		A.B.U - Zaria.
Date of receipt of valid application:		**15/5/14**
Date of meeting when final determination		
On ethical approval was made: -		**3rd & 4th Sept,, 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 ABUTH Ethics Committee.***

Please note: this approval dates from ***3rd November, 2014*** **to3rd** ***November, 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. Aisha.I.Mamman
Chairman, ABUTH HREC

APPENDIX II

DEPARTMENT OF HUMAN ANATOMY

FACULTY OF MEDICINE

AHMADU BELLO UNIVERSITY, ZARIA

Dear student,

I am Muhd K. Rayyan, an MSc student in the Department of Human Anatomy of the above named institution. I am carrying out a research on: Relationship between 2D:4D and some anthropometric variables to academic performance among secondary school students in Kaduna. Participation is voluntary. It involves collection of certain information about your personal and family characteristics and measurements of some anthropometric parameter: weight, height, waist circumference, hip circumference, and digits length.

The information collected from you will be used strictly to achieve the objectives of this study and for scientific publication. I assure you that this study has been reviewed and approved by my supervisors and the University Committee on Research Ethics.

Thank you for your understanding.

Yours sincerely,

Muhd K. Rayyan

APPENDIX III

CONSENT TO PARTICIPATE IN RESEARCH RELATIONSHIP BETWEEN 2D:4D AND SOME ANTHROPOMETRIC VARIABLES TO ACADEMIC PERFORMANCE AMONG SECONDARY SCHOOL STUDENTS IN KADUNA.

Introduction

You are kindly being asked to participate in a research study conducted by Muhd K. Rayyan for a Master of Science degree under the supervision of Prof. S.S. Adebisi and Dr. B. Danborno, from the Department of Human Anatomy, Faculty of medicine, Ahmadu Bello University, Zaria.

If you have any questions or concerns about the research, please feel free to contact: Muhd K. Rayyan , Faculty of Medicine, Tel: 08034848484, Dr. B. Danborno, Faculty of Medicine, Tel: 08139429300;

Purpose of Study

i. Study the relationship between digit ratio (2D:4D) and academic performance among secondary schools students.

ii. Investigate the sex differences in 2D:4D ratio among some Nigerians students.

iii. Study the relationship between 2D:4D and head size

iv. Investigate the relationship of 2D:4D ratio with Body Mass Index (BMI) of students

v. Correlate the relationship between 2D:4D and students academic performance with their socio-economic status.

vi. Study the association between 2D:4D and waist, hip and neck circumferences

Procedure

If you volunteer to participate in this study, we would ask your students to do the following things

a. Finger Length Measurements

Digit length shall be measured on the ventral surface of the hand from the basal crease of the digit to the tip using a venier caliper (MicroMak, USA) measuring to 0.05mm.

b. Height

The height of each subject will be taken using standard metre rule with the subject standing upright on stadiometre placed on a flat ground.

c. Weight

Weight of each individual will be taken using weighing scale that recorded to the nearest 0.1Kg with the subject standing upright on stadiometre placed on a flat ground.

d. Head circumference

This would be achieve using inextensible measuring tape (myo tape) place round the head, directly above the eyebrows anterioly and below superior nuchal line posterioly.

e. Waist circumference

Tape will be placed at the narrowest part of the abdoment, that is directly on the umblicus.

f. Hip circumference

Tape will be place at the widest part of the hip that is at the widest protrution of the buttock

g. Neck circumference

Tape will be placed at the middle of the neck below the vocal cord

Potential Risks and Discomforts

No any potential risk and discomfort

Potential Benefits to Participants and/or to Society

The results of the present study will provide a bases in which brilliant students can easily be selected based on their head sizes and 2D:4D ratios. It could also be possible to use the data to determine in which course of study a student could performe well. The outcome of the study could also provide the basis for appealing to government at all levels to bring programs specifically to suit each of the people's peculiar needs. This study could help create awareness on the use of some body parameters to come to some psychological conclusions.

This study will also create awareness to authorities and the general public on the importance of digit ratio as a pointer to certain biological attributes of man and demonstrate how the knowledge of biological anthropology applies to numerous fields of science and medicine

Payment for Participation

No payment

Confidentiality

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.

Participation and Withdrawal

You can choose whether to be in this study or not. If your school volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may exercise the option of removing your data from the study. You may also refuse to answer any questions you dont want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise that warrant doing so.

Rights of Research Participants

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research. This study has been reviewed and received ethical clearance through Ahmadu Bello University Research Ethics Board. If you have any questions regarding your rights as a research participant, you can obtain further information about the research or voice your concerns to:

Dr. B. Danborno,
Department of Anatomy,
Faculty of Medicine,
Ahmadu Bello University.
Tel: 08139429300
E-mail: sbdanborno@yahoo.com

Signature of Research Participant/Legal Representative

I have read the information provided for the study "**Relationship between 2D:4D and some anthropometric variables to academic performance among secondary school students in Kaduna.** " as described herein. I have been given a copy of this form.

_____
Name of Participant

_____ _____
Signature of Participant Date

Signature of Witness

_____
Name of Witness

_____ _____
Signature of Witness date

Relationship Between 2D:4D and some Anthropometric Variables to Academic Performance among Secondary School Students in Kaduna.

Name: Muhd K. Rayyan

Position: MSc Student

Contact Address: Department of Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria

1. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions.
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.
3. I agree to take part in the above study.
4. I agree to the use of anonymised quotes in the publications.

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

APPENDIX IV
QUESTIONNAIRE

School name: _____

Biodata of student

Research I.D. _____Class_____

Sex:_____ Age:_____ Date of Birth:_____

Geopolitical Zone:_____ Handedness:_____ Birth weight (kg): _____

Ethnic Background:_____ Father's Tribe:_____Mother's Tribe_____

Father's Occupation: _____ Mother's Occupation:_____

Family

Birth order (e.g. 2nd, 3rd etc):_____Number of siblings: Males:____ Females:____

Propose course of study _____

Anthropometry

Length of digits (mm)

Hand	**Fingers**				
	I	II	III	IV	V
Right					
Left					

Height (cm): _____ Weight (kg): _____

Waist circumference (cm):_____ Hip circumference (cm):_____

Head circumference (cm)_____ Neck circumference(cm)_____

FOR OFFICIAL USE

Terminal result:

Mathematics _____ English _____ Biology _____ Economics. _____