RELATIONSHIP BETWEEN HAND GRIP STRENGTH, SOME HAND DIMENSIONS AND BODY VARIABLES OF SECONDARY SCHOOL STUDENTS IN KANO METROPOLIS, NIGERIA

BY

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DECLARATION

I hereby declare that the work in thisthesis titled ***“Relationship between hand grip strength, some hand dimensions and body variables of secondary schools students in Kano metropolis, Nigeria”***was performed by me in the department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, under the supervision of Dr. B. Danborrnoand Prof. Kolawale. V. Olorunshola

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree at any institution or elsewhere for the award of any certificate.

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Signature **Date**

CERTIFICATION

This thesis entitled **"*Relationship between hand grip strength, some hand dimensions and body variables of secondary schools students in Kano metropolis, Nigeria*"** by**Kabiru Bilkisu UMAR** meet the regulation governing the award of Masters of Science (MSc.) degree inthe Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, under the supervision of Dr. B. Danborno and Prof. K. V. Olorunshola**.**It is therefore approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty **ALLAH**, His mercy, love and comfort is incomparable. Also to our noble prophet **MUHAMMAD** (SAW), his companions and those who fellow his right path to the day of resurrection

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LIST OF ABBREVIATIONS

ACSM American College of Sport Medicine

BMI Body Mass Index,

HGS Hand Grip Strength

HT Height,

L Left handed

LD1 Left First Digit

LD2 Left Second Digit

LD2: LD4 Left second and fourth Digits ratio.

LD3 Left Third Digit

LD4 Left Fourth Digit

LD5 Left Fifth Digit

LDI Left Digit Index,

LHGS Left Hand Grip Strength

LHGS Left hand grip strength

LHL Left Hand Length

LHL: HT Left hand length to height ratio.

LPL Left Palmar Length

LPL/W Left palmar length to width ratio.

LPL: Left Palmar length

LPW Left Palmar Width

LSI Left Shape Index

R Right handed

R2D: R4D Right Second and Fourth Digits ratio:

RD 5 Right Fifth Digit,

RD1 Right First Digit.

RD2 Right Second Digit

RD3 Right Third Digit,

RD4 Right Fourth Digit,

RDI Right Digit Index,

RHGS Right Hand Grip Strength.

RHL Right Hand Length,

RHL: HT Right hand length to Height ratio.

RPL Right Palmar Length.

RPL/W Right palmar length to width ratio.

RPW Right Palmar Width

RSI Right Shape Index.

SD Standard deviation

SEE Standard error of estimate

W/H; Waist to hip ratio.

WT: Weights

ABSTRACT

Hand grip strength (HGS) is an anthropometric variable that is affected by a number of factors including age, gender and body size**.** This study was designed to determine the relationship between HGS, some hand dimensions and body variables of secondary school students in Kano metropolis in which eight hundred subjects (400 males and 400 females) participated in the study. The hand dimensions, waist and hip circumferences were measured using digital vernier caliper and inelastic tape respectively. A stadiometerwas used to measure the height and weight of the participants. The HGS of right and left hands were measured using a standard adjustable digital hand grip dynamometer at sitting position. Descriptive statistics (mean ± standard deviation) was used to express the data. Independent sample t-test and Pearson's correlation was used to find differences and relationship respectively.The regression analyses was performed to generate model for HGS prediction. Statistical significance was declared at $p<0.05$. Data was analyzed using SPSS (IMB, corporation, NY) version 20. In this study, asignificant difference was observed among 17 – 18 and 19 -20 age groups in right-handed female participants with no such differences in the left-handed female participants. In the body variables the level of sexual dimorphism was noticed only in weight and hip circumferences. Derived indices and ratio also show some level of sexual dimorphism in the right and left second to fourth digit ratio, right digit index and right hand length to height ratio. For 17 – 18 aged group the significant difference exist between the sexes in HGS and hand dimensions. Sexual dimorphism was also observed in the body variables with the exception of weight and waist circumference. Level of sexual dimorphism was also shown in the derived indices and ratios. In 19-20 age groups similar pattern of significant difference was noticed in HGSand hand dimensions. Sexual dimorphism was also noticed only in height and weight, and in the derived indices and ratios gender differences exist with exception of both left and right shape indices, body mass index, and waist to hip ratio and left palmar length to width ratios. The correlation was observed in all the study variables with left and right HGS with few exceptions. The regression model for the right HGS of male predict the outcome variable (RHGS) significantly ($P < 0.05$) well with income variables (RHL, LD4, LD2, HT, WT, HC, RPL and RPW) also contributing significantly ($P < 0.05$) to the model. For the left HGS similar tends was noticed with few exception .In female participants the regression model do not predict the outcome variable (RHGS) significantly ($P > 0.05$) in both left and right hand grip strength. In conclusion, the HGS is shown to be higher in the dominant hand. Gender differences and correlation was observed among the study variables. The regression model predict the outcome variable (HGS) significantly ($P < 0.05$) well among the male participants then the female counter part.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

The power of hand grip is the result of forceful flexion of all finger joints with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions (Blair, 2002)**.** Hand grip strength is an anthropometric variable that is affected by a number of factors including age, gender and body size **(**Kenjile*et al.,* 2005**).** The human hand is unique in being free of habitual locomotor duty and devoted entirely to functions of manipulation (Markze, 1971). There are 35 muscles involved in movement of the forearm and hand, with many of these involved in gripping activities (Waldo, 1996; Hall, 2007). Grip strength has long been thought as a possible predictor of overall body strength, but little if any research that correlated the two was found (Fry *et al.,* 2006). Smith *et al.* (2006) found a direct correlation in grip strength and overall body strength in very old and oldest females.

Many of the research studies correlated grip strength to various other physical variables including nutritional status, rotator cuff weakness, fatigue, overall physical function anthropometric traits; weight, height, hand length (Benefice and Malina, 1996; Guo *et al*., 1996; Ross and Rosblad, 2002; Budoff, 2004; Kenjile *et al.* 2005). Hip and waist circumferences measurement is a good marker of fat mass, bone mineral content and lean bodymass which are strongly correlated with maximum isometric grip force (Sartorio*et al.,* 2002; Rashid and Ahmed, 2006; Foo, 2007).

There are various studies concerning the effects of sports on anthropometric measurements and physical status of the human body (Hunt et al., 1985; Colak, 1995; Guo*et al.,* 1996; Hughes *et al*., 2004; Cagatey *et al.,* 2008). It is also recommended that measurement of handgrip strength using a hydraulic dynamometer can reveal the physical readiness of an athlete (Hunt *et al.,* 1985;Frederiksen*et al.,* 2002; Poliquin, 2006). With references to hand dominancy, the handgrip strength is reported to be higher in dominant hand in right handed subjects, but no such significant differences between sides could be documented for left handed people (Chatterjee and Chaudhuri, 1991; Incel*et al.,* 2002; Nurgul *et al.*, 2002). It was also found that on average,hand grip strength in the dominant hand was 12.7 % stronger for right handed people whereas left handed subjects showed no such difference between the dominant and non-dominant hand (Petersen *et al.* 1989; Armstrong and Oldham, 1999). Recent research has demonstrated an association between hand grip strength (HGS) and indicators of fitness in contemporary college-age males (Young, 2003; Gallup *et al.,* 2007; Shoup and Gallup, 2008).

Within adult populations, HGS is also a good predictor of health parameters such as protein loss (Windsor and Hill, 1988), bone-mineral density (Kritz-Silverstein and Barrett-Connor, 1994; Foo *et al.,* 2007; Sinaki*et al.,* 1989), muscle mass (Guimaraes*et al.,* 2007), physical functioning (Fredericksen*et al.,* 2002; Stenholm *et al.,* 2008; Arroyo *et al.,* 2007), and is negatively correlated with disability (Giampaoli*et al.,* 1999), morbidity (Hughes *et al.,* 1997), and mortality rates in adults(Rantanen*et al.,* 2000; Sasaki *et al.,* 2007).

Arden and Spector (1997) showed the heritability of HGS to be lower among females, after controlling for age, height and weight, while Reed *et al.* (1991) estimate the heritability of male HGS to be higher after adjustments of weight, height, age, and various anthropometric measures such as fatness, muscle mass and frame size (Mathiowetz*et al.,* 1985; Kamarul*et al.,* 2006; Vianna*et al.,* 2007). It was also suggested supplementary increases in testosterone enhance HGS as well as lean body mass in elderly men with low serum T (Page *et al.,* 2005; Smih*et al.,* 1997; Wang *et al.,* 2000). In particular, research on male adolescents (15-17 years) has shown a strong relationship between testosterone and levels of verbal and physical aggression (Olweus*et al.,* 1980; Schaal*et al.,* 1996). This same effect is absent in studies of boys before and at the beginning of puberty (Susman*et al.,* 1987; Inoff-Germain*et al.,* 1988). Dominance is also positively correlated with testosterone levels in adult males (Mazur and Booth, 1998; Gallup *et al.,* 2007; Archer and Thanzami, 2007).

1.2STATEMENT OF RESEARCH PROBLEM

Some studies found a correlation between grip strength and hand performance. Though in theory, one would believe the two are correlated but more studies may be necessary from other populations. The information related to the correlations of hand-anthropometry, some body variables and grip strength in Hausas community is scanty. A general rule often used to suggests that the dominant hand grip strength is approximately 10% stronger than the non-dominant hand. Hence, this rule has not yet been confirmed in the previous studies. The ratio between the length of the index and ring digit (2D:4D) may also be correlated with *in utero* testosterone level. The gap in the literature is lack of studies on correlation of testosterone influenced variables such as digit ratio with hand grip strength.

1.3 JUSTIFICATION OF THE STUDY

The information on correlations between hand grip strength, hand dimensions and body variables among Kano metropolis indigence is nonexistent. For many games such as volley ball, basketballetc. in which the use of the hand is essential, hand morphology and grip strength may be of functional significance for effective performance. Therefore, reference data on various form of hand dimension and grip strength may be of paramount importance in solving problems associated with hand games and injuries.

1. 4 AIMS AND OBJECTIVES OF THE STUDY

1.4.1 Aim of the study

To investigate the relationship of HGS with some hand dimensions and body variables among Hausas of Kano metropolis.

1.4.2 Objectives of the study

The objectives of the study are to:

i. compare the HGS of dominant and non-dominant hands of both sexes.

ii. investigate if sexual dimorphism exist in HGS, hand dimensions (digit length, palmar length and width, and hand length), 2D:4D ratio, digit index, shape index, palmer length to width ratio, hand length to height ratio, and body variables (height, weight, waist circumference, hip circumference, waist to hip ratio, body mass index).
iii. establish baseline data for HGS, 2D:4D ratio, digit index, shape index, palmer length to width ratio, hand length to height ratio, height, weight, waist circumference, hip circumference, WHR, BMI
iv. investigate the relationship between the HGS and digits length (D1 to D5) among Hausas of Kano metropolis.
v. predict the amount of HGSfor a givendigits length and body variables(height, weight, waist circumference, hip circumference).
vi. determine influence of age on HGS

1.5 SIGNIFICANCE OF THE STUDY

The estimation of HGS is of immense importance in determining the efficacy of different treatment strategies of hand and also in hand rehabilitation. The reliability and valid evaluation of HGS is also of paramount importance in determining the effectiveness of various surgical and treatment procedure. The grip strength is also of use as functional index of nutritional status of an individual. The data on hand dimension can be used for the designing of suitable hand tools, orthotics, gloves etc. for the Hausas. The assessment of HGS may be used in the investigation and follow up of patients with neuromuscular disease. Many exercises in gyms and fitness centers across the country indirectly work on individuals' grip. Other exercises such as dead lifts, bent over rows among others also depend upon the athlete's level of grip strength.

1.6 RESEARCH HYPOTHESES

i. There will be sex difference in hand grip strength of dominant and non-dominant hands among Hausas of Kano metropolis.

ii. There is relationship between hand grip strength, selected hand dimensions and body variables.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ANATOMICAL CONSIDERATION OF THE HAND

2.1.1 Griping and Hand Evolution

The typical primate hand is characterized by a diminutive thumb in combination with long, curved fingers. In contrast, the human hand has a much larger, more muscular, mobile, and fully opposable thumb combined with fingers that have shortened and straightened. This striking exception to the primate pattern clearly requires an evolutionary explanation (Marzke and Marzke, 2000). Although no comprehensive account has been offered, there is general agreement that the anatomical reconstruction of the hand during human evolution was somehow linked with tool behavior. According to Young, (2003) the tools were hand-held weapons that were hurled or swung as bludgeons at adversaries during disputes, providing the aggressors with advantages that in various ways promoted reproductive success. The resulting selection for improved throwing and clubbing prowess, prolonged over millions of years, led to numerous anatomical changes throughout the body, including those that characterize the evolution of the human hand. (Guimaraes, *et al* 2007).

The throwing and clubbing motion that begins in the legs progresses through the hips, torso and arms and ultimately imparts accumulated kinetic energy to the hand or hands holding the weapon. The entire body is involved, but the role of the hands is crucial. Natural selection must have acted strongly on the hands from the outset of aggressive throwing and clubbing behavior. Indeed, analysis of the evolution of the human hand provides an opportunity to falsify or lend credence to the throwing-and-clubbing proposal (Young, 2003).

Grasping a spheroid and precisely controlling its release, required for accurate throwing, demands a grip that differs from one that can firmly grasp a cylindrical club-handle and absorb the reaction force of impact without release of the weapon. This implies that the human hand should manifest two unique grips – one specialized for throwing, the other for clubbing (Napier, 1956).

The chimpanzee hand will be taken as a model for the hand of the hominid ancestor (Sibley, 1992; Ruvolo, 1997). The grips of the chimpanzee differ profoundly from those of humans (Napier, 1960). For suspension from horizontal supports, chimpanzees use a 'hook grip' of the four flexed fingers (Napier, 1960; Marzke and Wullstein, 1996). With vertical supports, a diagonal hook grip is used (Susman, 1979; Marzke*et al.,* 1992). The thumb may touch the support, but does not squeeze it against the palm. Chimpanzees use this grip when flailing with sticks, but when the arm swings forward the hand tends to lose its grip, possibly due to weakness of the thumb and its inability to overlap the index finger (Marzke*et al.,* 1992; Marzke and Wullstein, 1996). Because the thumb is weak and short, its distal phalanx is relatively immobile and its distal pad cannot be opposed to those of the fingers, it cannot generate a firm pinch or squeeze (Marzke and Wullstein, 1996; Marzke, 1997).

The human thumb is longer, the palm and fingers are shorter, and the fingers have lost their curvature (Susman, 1979). The distal phalanges have gained large apical tufts which support broad, palmar, fibrofatty pads that distribute pressure during forceful grasping and whose deformation accommodates the pads to uneven surfaces (Napier, 1965; Susman, 1988; Marzke and Shackley, 1986). Apart from thickening of the fifth metacarpal and enlargement of its base, the balance of strength and robusticity has shifted radially, to the thumb, second and third fingers (Susman, 1979; Marzke and Shackley, 1986).

Napier (1956) provided a provocative answer: the human hand gained two new grips. 'In spite of the multiplicity of activities of the hand', he wrote, '… there are only two prehensile actions: these are called the precision grip and the power grip' (Napier, 1965). These two patterns of movement, which are anatomically and physiologically distinct, provide the basis for all prehensile activities (Napier, 1960). The precision grip is employed where precision of movement is required, whereas the dominant characteristic of the power grip is application of force (Napier, 1960). In each of these grips the carpometacarpal joint of the thumb, in full abduction or adduction, is stabilized by congruent articular surfaces and tension of ligaments. In the intermediate position, the joint is most unstable (Napier, 1955). It was suggested that the 'precision grip' is a throwing grip, and the 'power grip' is a clubbing grip. 'Precision' and 'power' suggest typical uses for the grips (Young, 2003).

It has been proposed that the earliest hominid specialization was aggressive throwing and clubbing, and that this behavior increased reproductive success during a prolonged period, driving natural selection that progressively improved its effectiveness. If these assertions are correct, the evolution of the human hand should provide evidence of this process in its anatomical structure (Young, 2003).

2.1.2 Embryology of the Hand

Initially, the limb bud consists of a mesenchymal core derived from the somatic layer of lateral plate mesoderm that will form the bones and connective tissues of the limb, covered by a layer of cuboidal ectoderm at the end of the fourth week of development. Ectoderm at the distal border of the limb thickens and forms the apical ectodermal ridge (AER) (Sadler, 2012).

This ridge exerts an inductive influence on adjacent mesenchyme, causing it to remain as a population of undifferentiated, rapidly proliferating cells. As the limb grows, cells farther from the influence of the AER begin to differentiate into cartilage and muscle (Moore and Persaud, 2008). During the 6-week-old embryos, the hand plates and footplates form the terminal portion of the limb buds and is separated from the proximal segment by a circular constriction. Later a second constriction divides the proximal portion into two segments, and the main parts of the extremities can be recognized. Fingers and toes are formed when cell death in the AER separates this ridge into five parts (Sadler, 2012).

In the processes of hand development different category of abnormalities may occur, this include extra fingers or toes (polydactyly). The extra digits frequently lack proper muscle connections. Abnormalities with an excessive number of bones are mostly bilateral, while the absence of a digit such as a thumb (ectrodactyly) is usually unilateral. Polydactyly can be inherited as a dominant trait but may also be induced by teratogens. Abnormal fusion of fingers (syndactyly) may also result which is usually restricted to the fingers or toes (Moore and Persaud, 2008; Sadler, 2012). Normally mesenchyme between prospective digits in the handplates and footplates breaks down. In 1/2000 births this fails to occur, and the result is fusion of one or more fingers and toes. In some cases, the bones actually fuse (Sadler, 2012). Cleft hand and foot (lobster claw deformity) consists of an abnormal cleft between the second and fourth metacarpal bones and soft tissues. The third metacarpal and phalangeal bones are almost always absent, and the thumb and index finger and the fourth and fifth fingers may be fused (Sadler, 2012).

2.1.3 Gross Anatomical Description of the Hand

The word "hand" is sometimes used by anthropologist (evolutionary anatomists) to refer to the appendage of digits on the forelimb such as when researching the homology between the three digits of the bird hand and the dinosaur hand. Some evolutionary anatomists use the term hand to refer to the appendage of digits on the forelimb more generally — for example, in the context of whether the three digits of the bird hand involved the same homologous loss of two digits as in the dinosaur hand (Xu *et al*., 2009).

There are five digits attached to the hand. The four fingers can be folded over the palm which allows the grasping of objects. Each finger, starting with the one closest to the thumb, has a colloquial name to distinguish it from the others: index finger, pointer finger, or forefinger, middle finger or long finger, ring finger little finger, pinky finger, or small finger. The thumb (connected to the trapezium) is located on one of the sides, parallel to the arm. A reliable way of identifying and hands is from the presence of opposable thumbs. Opposable thumbs are identified by the ability to be brought opposite to the fingers, a muscle action known as opposition (Marieb, 2004; Xu *et al*., 2009).

The human hand has 27 bones, not including the sesamoid bone, the number of which varies between people, 14 of which are the phalanges (proximal, intermediate and distal) of the fingers. The metacarpals are the bones that connects the fingers and the wrist. Each human hand has five metacarpals and 8 carpal bones (Marieb, 2004).

There are 35 muscles involved in movement of the forearm and hand, with many of these involved in gripping activities. During gripping activities, the muscles of the flexor mechanism in the hand and forearm create grip strength while the extensors of the forearm stabilize the wrist (Waldo, 1996). There are four major joints of the hand, carpometacarpal, intermetacarpal, metacarpophalangeal, and interphalangeal joint, with nine extrinsic muscles that cross the wrist and 10 intrinsic muscles with both of their attachments distal to the wrist (Hall, 2007). These muscles include the pronator radii teres, flexor carpi radialis, flexor carpi ulanris, flexor sublimisdigitorum, and Palmaris longus on the extrinsic layer and the flexor profundusdigitorum, flexor policus longus, pronator quadratus, flexor pollicus brevis, and abductor pollicus brevis on the intrinsic layer.Each of these muscles is active during gripping activities(Moore and Persuad 2008).

In fact, all the flexor muscles of the hand and forearm responsible for grip strength are closely related anatomically, physiologically and biomechanically to each other to perform the task, showing close affinity to each other (Koley*et al*., 2009; Koley*et al*., 2010; Koley and Kumaar, 2012). The radial nerve innervates the finger extensors and the thumb abductor, thus the muscles that extends at the wrist and metacarpophalangeal joints (knuckles); and that abducts and extends the thumb. The median nerve innervates the flexors of the wrist and digits, the abductors and opponens of the thumb, the first and second lumbrical. The ulnar nerve innervates the remaining intrinsic muscles of the hand. All muscles of the hand are innervated by the brachial plexus (C5–T1) and can be classified by innervation (Ross and Lamperti, 2006).

2.1.4 Anthropometry of the Hand Variable

The human hand is unique as it is not used for locomotion, but is devoted entirely to functions of manipulation and tactile sensation (Barut and Demirel, 2012; Kanchan and Krishan, 2011). It is also used as a tool, as a symbol, and as a weapon. The hand is known toplay a part in artistic activities, as it is designed for grasping and the precise movements' essential form any creative endeavors (Kanchan and Krishan, 2011). The size of the hand is important for its function (White, 1980). It is known that while doing a daily activity by hand, the force projected by the hand anddigits depends partly on the hand elements and dimensions (Chroni*et al*., 2001; Boz*et al*., 2004).

The sexually dimorphic traits of the human body have been described (Frayer and Wolpoff, 1985; Pheasant, 2003), as has sexual dimorphism related to the hand (Boz*et al*., 2004; Buffa *et al*., 2007; Kanchan and Krishan, 2011; Kanchan and Rastogi, 2009). Hand and foot dimensions have been used for the determination of sex of an individual (Kanchan*et al*., 2010). The shape of the hands of individuals varies considerably, and while function is not totally dependent on shape, some professions are known to benefit from certain characteristics (Napier, 1990). Kanchan and Rastogi (2009) reported a greater hand (shape) index in males in both North and South Indians; however, the left hand (shape) index showed statistically significant sex differences in both ethnic groups. It was also stated that the left hand (shape) index is a poor indicator of sex. (Kanchan*et al*., 2010)

Finally, it was that the hand (shape) index of the right hand and palm of both males and females were similar, whereas the left hands of males were more robust and/or wider than those of females with regard to hand (shape) index (Kanchan and Rastogi, 2009). The hand shape and hand digit indices were greater in males than in females. Thus, it was concluded that the hands of males were more robust and/or wider than those of females with regard to hand-shape index, and that the grasping ability of males was better than that of females in relation to digit index (Barut *et al*., 2014).

The differences between hand-shape index values suggest that Iranian individuals have slimmer hands than Turkish people. With respect to digit index values, the grasping ability of males in both countries is similar, whereas the grasping ability of Turkish females was greater than that of Iranian females. This suggests that Turkish females have stronger hands than Iranian females. Ibeachu*et al*. (2011) reported that the hand-shape index (calculated in an identical fashion to this study) values of Nigerian males were greater than those of females for both hands, indicating that the hands of males were more robust and/or wider than those of females (Napier, 1990). The hand-shape index values of Nigerian males and females were lower than Turkish group for both hands. This suggests that the hands of Nigerian individuals are slimmer than those of Turkish people. Kanchan*et al*. (2011) reported that the hand (shape) index values of males were significantly greater than those of females, and as reported in the Turkish population (Barut *et al*., 2014).

It was noted that hand morphology differs among populations. In the study by Davies *et al*. (1980), although no index values were calculated, significant differences among three ethnic groups (West Europeans, Indians from Punjab and West Indians) regarding hand dimensions in females were highlighted. Additionally, Gnaneswaran and Bishu (2011) have pointed out that each population or ethnic group has unique anthropometric characteristics of the hand and upper extremity. Various hand measurements tend to differ among ethnic groups (Okunribido, 2000). Population differences have been noted and suggested that each population to be studied separately (Aboul-Hagag*et al*., 2011).

Early in life hormones have an organizational effect on body, and the amount and timing of hormones will have a life-long effect. The timing and extent of prenatal hormone exposure, in particular androgens control not only the development of the genital system but also the development of the appendicular skeleton (Auyeung *et al*., 2013; Hiort, 2013; Gobrogge*et al*., 2008). The prenatal interaction of androgens with homeobox genes Hoxaand Hox d leads this organizational effect as these genes control the differentiation of genital system and appendicular skeleton (Gillam *et al*., 2008). There is good evidence from human and nonhuman species that events occurring during prenatal development can have life-long effects on an organism (Cohen-Bendahan*et al*., 2005). Statistically significant ethnic differences in level of androgens were established in the literature which may also be considered for prenatal period (Manning, 2002). The hormonal differences between different ethnic groups or different populations may constitute an explanation for the differences with respect to different population (Barut *et al*., 2014). The differences between the physical environment, working conditions and climate features of each ethnic group or population may also contribute to these differences; however each of these factors cannot explain alone the discrepancies between studies (Pheasant, 2003; Stanford *et al*., 2013).

In in the previous studies that evaluated hand anthropometric measurements according to hand preference in both sexes in a Turkish population sample, including the hand-shape index, digit index and palmar length/width ratio. They found that the right and left hands of males were more robust than those of females and the length/width ratios of both the right and left hands indicated a rectangular narrow hand structure (Kulaksiz and Gozil, 2002; Barut *et al*., 2014).

In relation to digit index values, both study groups exhibited a similar grasping ability. The hands of males are more robust and/orwider than those of females and the grasping ability of males is greater than that of females, and the hands of females are narrower than those of males, suggesting sexual dimorphism in hand morphology. As most of the somatic sexually dimorphic traits are affected by prenatal exposure totestosterone (Gobrogge*et al*., 2008) this different exposure between sexes may have also contributed to the sexual dimorphism in hand morphology (Buffa *et al*., 2007; Dogan*et al*., 2008; Manning, 2002).

In Humans, finger length ratio of the index and ring finger (2D:4D) is also a sexually dimorphic trait. The ratio between the length of the index and ring digit (2D:4D) may correlate with *in utero* testosterone levels, with males having on average longer 4th digits relative to their 2nd digits showing a low 2D:4D ratio than females, who have on average, had a higher 2D:4D ratio (Manning *et al*., 1998). The relative lengths of the digits are set before birth and probably by 14 weeks of pregnancy (Manning *et al*., 1998). The 2D:4D ratios have been reported to be negatively correlated with testosterone levels and positively associated with estrogen levels in adults (Manning *et al*., 1998; Manning and Taylor, 2001).

The study of Danborno*et al*., (2008) on Nigerians also demonstrated sexual dimorphism in 2D, 4D and 2D:4D ratio and relationship between 2D, 4D, and 2D:4D ratio to height, weight body circumferences (chest, waist and hip). All somatic sex differences in mammals to date have been found to be due to either androgenic masculinization or effects of the sex chromosomes (Fink *et al*., 2006). Hönekopp and Schuster (2010) conducted a meta-analytic review of 25 previously published studies and found that 2D:4D ratios were significantly negatively correlated with physical prowess (strength, endurance, or both), Based on evidence that the magnitude of the sex difference in 2D:4D ratios is greater in the right than in the left hand (Hönekopp and Watson, 2010). It was concluded furthermore that the association of prenatal exposure to testosterone (as indexed by 2D:4D ratios) and strength pertains only to men, and not to women. Importantly, the statistical associations were obtained even when controlling for age, height, weight, and average digit length, which suggests that it may be prenatal exposure to testosterone per se, rather than other common strength related variables with which it might be vulnerable to confounding, that is responsible for the associations found (Hone and McCullough, 2012).

2.2 ANTHROPOMETRY OF THE BODY VARIABLES

Body mass index (BMI), which relates weight to height, is the most widely used and simple measure of body size, and is frequently used to estimate the prevalence of obesity within a population. Thus, other anthropometric indices such as waist circumference (WC), waist-to-height ratio (W/Ht), and waist-to-hip ratio (WHR) have been used as alternatives to BMI. Waist circumference is increasingly being accepted as the best anthropometric indicator of abdominal adiposity and metabolic risk. Most of these studies show that the incidence of asthma and increased BMI are frequently related. In general, the more BMI increases, the more the incidence of asthma rises, and this effect is generally stronger among women than among men. However, this difference is always very small and seems to be related to the degree of adiposity in women (Lemos-Santos *et al*., 2004). It was indicated that Waist to hip circumference ratio was positively correlated with serum cholesterol, triglyceride and LDL-C in patients with diabetes mellitus (Janssen *et al.,* 2002).

It was reported that body mass index (BMI) is a measure of overall adiposity, whereas, waist circumference (WC), waist-hip ratio (WHR), and conicity index (CI) are reliable proxy measures of abdominal fat (Bose and Mascie-Taylor, 1998). Studies indicate that BMI, WC and WHR could be used independently to identify overweight and obesity (Gill *et al*., 2003). Asian Indians, in common, were reported to have mean and median values of BMI lower than that observed in non- Asians, and also have higher PBF, waist-to-hip ratio (WHR) and abdominal fat at a lower level of BMI (Deurenberg-Yap *et al*., 2000).

Waist circumference, waist-hip ratio (WHR) and waist-height ratio (WHtR) are used to predict the risk of obesity related diseases as they account for regional abdominal adiposity (Grundy *et al.,* 2004; WHO, 2002; Welborn*et al*., 2003). There are studies reporting that both BMI and waist circumference values can equally identify cardio- vascular risk factors (Norgan, 1994; Ko*et al*., 1999; Dalton *et al*., 2003). The American Diabetes Association has stated that it's not clear whether WC can predict cardiovascular risk factor better that BMI (Gallagher *et al*., 1996).

Takahashi *et al* (2009) demonstrated that combining of both waist circumference and BMI was superior to using only one of these parameters. Wang *et al*sug- gested that both BMI and waist circumference, rather than waist circumference alone, should be included in metabolic risk assessment in this high-risk multiethnic Asian population. Uniform anthropometric cutoff values for all Asian ethnic groups are not appropriate to assess obesity-related metabolic complications (Wang *et al*., 2010). It was suggested that BMI, waist circumference, WHR and WHtR were analyzed together to predict multiple metabolic risk factors in males and females (Liu *et al*., 2011).

2.3CLASSIFICATION OF HAND GRIP STRENGTH

Table 2.1: Sex differences rating of HGS

Rating	Males (kg)	Females (kg)
Excellent	> 64	> 38
Very good	56-64	34-38
Above average	52-56	30-34
Average	48-52	26-30
Below average	44-48	22-26
Poor	40-44	20-22
Very poor	< 40	< 20

For individuals over age 50, reduce scores by 10% to adjust for muscle tissue loss due to aging (Helen *et al.*, 2011)

2.4 RESEARCHES RELATED TO GRIP STRENGTH

2.4.1 Grip Strength and Body Fitness

Grip strength has long been thought as a possible predictor of overall body strength, but little if any research that correlated the two was found. Smith et al. (2006) found a direct correlation in grip strength and overall body strength in very old and oldest females. The study revealed that, grip strength was moderately correlated with overall body strength in the very old and oldest populations. Fry et al. (2006) also found a correlation between grip strength and performance in American Men Junior Weightlifting. Though in theory, one would believe the two are correlated and more studies may be necessary for other populations.

Many of the research studies correlated grip strength to various other physical variables including nutritional status, rotator cuff weakness, fatigue, and overall physical function. Yasou*et al.* (2005)found that grip strength had a significant correlation with the muscle strength in 45 degrees shoulder abduction and external rotation in the affected (injured) side. A similar study performed by Budoff, (2004) results revealed an increased prevalence of rotator cuff weakness on the ipsilateral side of a hand injury or disorder

Long-term exposure to obesity was reported to be associated with poor hand grip strength later in life in individuals aged 55 years and older. However, maintaining healthy body weight throughout the life span may help to prevent or delay muscle strength decline in old age (Stenholm *et al.,* 2011). Also according to Massy-Westropp*et al.* (2011) there was very weak positive relationship between higher BMI and right hand grip strength, but for young adults and those in their fourth, fifth and sixth decade, a higher BMI was inversely related to hand grip strength.

2.4.2 Grip Strength and Anthropometric Traits

Strong correlations between grip strength and various anthropometric traits, (weight, height, hand length) were reported by several workers (Ross and Rosblad, 2002). In case of relationships of hand grip strength with stature, weight, arm and calf circumferences and various subcutaneous skinfolds, it is found that males attained greater values for those anthropometric variables and also have greater hand grip strength values than their female counterparts (Benefice and Malina, 1996).

It is also found, that age dependent increase of hand grip strength in boys and girls were strongly associated with changes of fat free mass during their childhood (Sartorio et al., 2002). Hand grip strength is found to be a significant determinant of bone mineral content and bone area at the forearm sites and has a positive correlation with lean body mass and physical activity. It determines the muscular strength of an individual (Foo, 2007).

Hip/waist circumferences measurement is a good marker of fat mass, bone mineral content and lean body mass which are strongly correlated with maximum isometric grip force (Rashid and Ahmed, 2006).Nutritional status has also been correlated to handgrip strength. It was reported that grip strength is a strong predictor of an individual's nutritional status. These findings draw parallel to the findings of the anthropometric measurement studies. Ones nutritional status will lead to specific levels of body mass, which in turn has been found to correlate directly to grip strength. This simple method of non-invasive measurement may provide nutritionists and medical professionals with valuable screening data, prior to further more invasive testing (Guo *et al.*, 1996; Kenjile *et al.,* 2005).

The literature has previously been reported that handgrip strength had strong correlations with various anthropometric characteristics such as, body surface area, height, weight, BMI and six hand-anthropometric variables including the shape index, digit index, 2D:4D ratio, palmar length, palmar width, palmar length/width ratio except age and 2D:4D ratio in males, and age, shape index, digit index, 2D:4D ratio and palmar length / width ratio in females (Chatterjee and Chowdhuri, 1991; Koley and Kaur, 2009; Koley and Yadav, 2009;Koley et al., 2010) and males attained a stronger handgrip than their female counterparts (Benefice andMalina, 1996).

Further studies by Koley*et al*., (2011) showed the dominant right handgrip strength, height and weight have significantly positive correlations with Height, Body weight, BMI, Right hand width, Left hand width, Right hand length, Left hand length, Right upper arm length, Right forearm length, Right upper extremity length, Right upper arm circumference, Dominant right hand grip and Non-dominant left hand grip.Recently, it was found that height and lean body mass were important factors for grip and leg strength, especially in male. However, leg strength per body weight was negatively correlated with body fat percentage (Miyatake *et al*., 2012).

2.4.3 Grip Strength and Sport Performances

Anthropometric dimensions and morphological characteristics play an important role in determining the success of an athlete (Keogh, 1999). It is well known, that the interest in anthropometric characteristics and body composition of athletes from different competitive sports has increased tremendously over the last decades. All ball games require comprehensive physical, technical, mental and tactical abilities (Terbizan*et al*., 1996; Werner *et al*., 2006).

There are various studies concerning the effects of sports on anthropometric measurements and physical status of the human body (Hunt *et al*., 1985; Guo*et al*., 1996; Hughes *et al*., 2004). It was reported that physiological and anthropometric parameters investigated in males aged between 10-15 years showed a significant difference between the groups when arm length and whole upper extremity length was considered and volleyball group was the reason for those differences. Although when the forearm length was considered the difference between the groups was not statistically significant. The hand parameters were not investigated in the study but it was also suggested that most of the differences observed in the study were caused by the volleyball playing group (Colak, 1995)

The effect of three different sports branches on the hand morphology and function was evaluated by the study of Cagatey*et al*. (2008). The result revealed that there were statistically significant differences in right and left hand shape indices, right and left hand length/ height ratio values between male basketball, volleyball and handball players. Difference between basketball and handball groups was the reason of the significance. There were significant differences in right and left hand width, right and left hand length, right and left 3rd finger length, right and left grip strength values between female basketball, volleyball and handball players. Handball group was the reason of the significance. There were significant differences in right and left hand width, right digit index, right and left hand length/height ratio values between basketball, volleyball and handball players when all individuals were considered. When right and left hand width values were considered the difference between the basketball and handball groups caused the significance. When right and left hand length/height ratio values were considered the difference between the volleyball and handball groups caused the significance. (Hughes *et al*., 2004)

It is also recommended that measurement of handgrip strength using a hydraulic dynamometer can reveal the physical readiness of an athlete. This information provides valuable data to the coach with regards to an athlete's potential training status. If the athletes grip strength percentage kilograms is below baseline or previous workout, the athlete may be fatigued. If the opposite is true, the athlete will have recovered optimally and performance may increase. This theory draws parallel to the findings of previous studies (Hunt *et al*., 1985; Frederiksen*et al*., 2002). Each of these studies used handgrip dynamometric testing to evaluate physical functioning in surgical, lifestyle, disease and mid to late life subjects.

The reliability of handgrip strength, using the Jamar dynamometer, is high in prepubertal, adolescent and adult male basketball players,the finding of Gerodimos (2012) demonstrated that no significant differences in handgrip strength, between preferred and non-preferred hands possibly due to the continuous use of both hands in basketball. It is not known whether the specificity of basketball training and/or the different use of wrist and digits flexor muscles in basketball players may affect the generalization of athletes of other sports. There is, however, a general believe that the reliability of strength measurements and/or the normative values vary when examining a population with different characteristics (Gerodimos, 2012).

Also according to Koley and Kumar (2012)both male and female players have higher mean values for right handgrip strength than their control counterparts, though statistically significant differences ($p \leq .000$) were found only between female players and controls. The reasons behind these differences might also be due to regular physical exercise and practice. But highly significant gender differences ($p \leq .000$) for softball players for right handgrip strength might be due to both physical and physiological differences between the two genders (Koley*et al.,* 2010).

2.4.4 Grip Strength and Immunity

In a report by the American College of Sport Medicine, it was concluded that, handgrip muscular endurance has been shown to suffer a delayed decline on the second morning following intoxication (*ACSM, 2000*). This research provides further evidence toward the correlation between immune functioning and handgrip strength. Grip strength may also play a role in injury prevention and rehabilitation. In many cases, strengthening of the grip has been a prescription for rehabilitation from injuries such as golf and tennis elbow.

According to Poliquin, (2006) these ailments are often caused by improper strength ratios between the elbow muscles and the forearm muscles. If the elbow flexors, like the biceps and brachialis, are too strong for the forearm flexors, uneven tension accumulates in the soft tissue and results in elbow pain

2.4.5 Hand Grip Strength and Hand Dominancy

With references to hand dominancy, the grip strength is reported to be higher in dominant hand with right handed subjects, but no such significant differences between sides could be documented for left handed people (Incel*et al.*, 2002). Right and left hand grip strength was positively correlated with weight, height and body surface area (Chatterjee and Chaudhuri, 1991).

Nurgul*et al*., 2002 reported that stronger grip and pinch strengths were obtained at dominant sides of the participants and only 14.09% of the subjects had stronger non dominant hand grips. A similar picture was obtained for the right handed participants (10.93%) whereas the ratio of stronger non dominant hand was significantly higher for left handed group (33.33%).

Petersen *et al*. (1989) analysed 48 left handed and 262 right handed subjects and found a significant difference between two groups. 48% of left handed subjects had higher grip values at their non-dominant side but this percentage was only 6.9% for right handed subjects. He also questioned whether the 10% rule could be applied to the whole population. It was also found that on average, grip strength in the dominant hand was 12.7 % stronger for right handed people. Left handed subjects showed no such difference between the dominant and non-dominant hand (Armstrong and Oldham, 1999)

A general rule often used suggests that the dominant hand is approximately 10% stronger than the non-dominant hand. Hence, this rule has not been confirmed in previous studies (Reikeras*et al.*, 1983; Armstrong and Oldham, 1999). The 10% rule dates back to 1954, when Bechtol observed that most patients presented a difference of 5% to 10% between their dominant and non-dominant hands on grip measurement (Petersen *et al.*, 1989).

2.4.6 Grip Strength and Physical Health

Recent research has demonstrated an association between hand grip strength (HGS) and indicators of fitness in contemporary college-age males (Gallup *et al.*, 2007; Shoup and Gallup, 2007), suggesting that HGS may be used as a measure of variance in male intra sexual competition during adolescence. The maintenance and elaboration of HGS in human males may have provided a selective advantage to stronger individuals competing for scarce resources (Gallup *et al.*, 2007).

Young (2003) hypothesized that the selection for improved handheld clubbing prowess for protection, hunting and intra sexual competition led to anatomical changes resulting in powerful HGS among males. While some of these selective pressures are less prevalent in modern society, it appears this history has resulted in HGS's association with other sexually selected traits in males, including facial attractiveness (Shoup and Gallup, 2008), mating opportunities, masculine-specific body morphology, and intra sexual adolescent aggression (Gallup *et al*., 2007).

Independent of the proposed relationship with male social behavior, HGS measured by a hand-held dynamometer is also an easily obtainable measure of physical health and muscle function. Within adult populations, HGS is also a good predictor of health parameters such as protein loss (Windsor and Hill, 1988), bone-mineral density (Foo *et al*., 2007; Sinaki*et al.,* 1989), muscle mass (Guimaraes*et al.*, 2007), physical functioning (Fredericksen*et al.*, 2002; Stenholm *et al.*, 2008; Arroyo *et al.*, 2007), and is negatively correlated with disability (Giampaoli *et al*., 1999), morbidity (Hughes *et al*., 1997), and mortality rates in adults (Laukkanen*et al.*, 1995; Rantanen *et al.*, 2000; Sasaki *et al.*, 2007).

Although diet and exercise contribute to one's HGS, a twin study of 1,757 pairs showed that it is highly heritable after adjusting for effects of sex, weight, height and age (Frederiksen*et al.,* 2002). Likewise, these authors report no evidence for a substantial effect of non-additive genetic factors or shared environment. Arden and Spector (1997) showed the heritability of HGS to be lower among females, after controlling for age, height and weight, while Reed *et al.* (1991) estimate the heritability of male HGS to be 0.65 after adjustments of weight, height, age, and various anthropometric measures such as fatness, muscle mass and frame size.

2.4.7 Grip Strength and Sexual Dimorphism

Despite the presence of these correlations for each sex, research has shown striking sex differences in HGS among adult populations, with males far outscoring females (Kamarul*et al.*, 2006; Mathiowetz*et al.*, 1985). Additionally, senescence accounts for a larger percentage of the variation in HGS in men, with male HGS declining more quickly after age of 30 (Vianna*et al.*, 2007). Sex differences have also been observed in forebrain and cardiac sympathtic nervous responses at the onset of handgrip exercise, with smaller cardiovascular response (heart rate and mean arterial pressure) and weaker insular cortex activation observed in women. Interestingly, this may reflect both physiological and psychological sex differences when asked to provide a maximum squeeze of a dynamometer. While greater height, weight, and muscle mass in males has been submitted as an explanation for this effect (Kamarul*et al*., 2006; Kuh, *et al*., 2006), the sexual dimorphism in androgenic hormones (i.e., testosterone) may be the responsible factor. For instance, men with reduced testosterone levels caused by androgen deprivation have been shown to have low grip strength and supplementary increases in testosterone enhance HGS as well as lean body mass in elderly men with low serum T (Page *et al.*, 2005; Sih *et al.*, 1997; Wang *et al.*, 2000).

This hormonal relationship may, in turn, explain HGS's association with indicators of male to male competition. Meta-reviews have demonstrated a positive relationship between testosterone and aggression (Book *et al.*, 2001), with this link often being more clear among males than in females (Archer, 1994).

In particular, research on male adolescents (15-17 years) has shown a strong relationship between testosterone and levels of verbal and physical aggression (Olweus*et al.,* 1980). This same effect is absent in studies of boys before and at the beginning of puberty (10-14 years), when they have not yet experienced an influx of testosterone and reproductive behaviors are less salient (Susman *et al*., 1987; Inoff-Germain*et al.*, 1988). Dominance is also positively correlated with testosterone levels in adult males (Mazur and Booth, 1998), and the act of competing for dominant status can increase testosterone for the winner, while decreasing it for the loser. Although testosterone levels are not associated with levels of aggression in younger males (aged 10-14 years), they did predict perceived dominance in a population of 6-13 year old males (Schaal*et al.,* 1996). Following a connection with testosterone, studies investigating HGS and aggression show that the two positively correlate in late adolescent and adult males (Gallup *et al.,* 2007; Archer and Thanzami, 2007).

The hand grip power of females shows an age-level difference between the young and the elderly in all loads (30, 40 and 50%). However, the required time to reach peak velocity waslonger in the elderly at 50%, and the time is shorter at 30% than at 40 and 50% in both young and elderly groups (Aoki and Demura, 2011).

CHAPTER THREE

3.0MATERIALS AND METHODS

3.1 MATERIALS

The following materials were used:

i. Digital dynamometer (Model EH101, Camry, China) to nearest 0.1 kg.

ii. Digital vaniercaliper (Starrett, 123 Series, U.S.A.), to nearest 0.1 mm.

iii. Measuring tape (Butterfly, China) to nearest 0.1 cm.

iv. Questionnaire.

v. Stadiometer(Model RGZ 160,China)to the nearest 0.1 cm, and to the nearest 0.1 kg for height and weight respectively.

Plate I:A Stadiometer (Model RGZ 160, China) for measuring height and weight.

Plate II:A digital dynamometer (Model EH101, Camry, China) used for measuring HGS

Plate III: Inelastic measuring tape (Butterfly, China) for measuring waist and hip circumferences

Plate IV: Digital Vernier caliper(Starrett, 123 Series, U.S.A.) for measuring of hand length and breadth)

3.2 LOCATION OF THE STUDY

The study was conducted in Kano metropolis of Northern Nigeria, which is located between latitude 12.2º North and longitude 9.4º East with the Kano city as the capital of the state. Hausa is the lingua franca, but English is the official language.Its metropolitan population is the second largest in Nigeria after Lagos. The Kano Urban area covers 137 km^2 and comprises six Local Government Area (LGAs) - Kano Municipal, Fagge, Dala, Gwale, Tarauni and Nassarawa - with a population of 2,163,225 at the 2006 Nigerian census. The Metropolitan Area covers 499 km^2 and comprises eight LGAs - the six mentioned above plus Ungogo and Kumbotso - with a population of 2,828,861 at the 2006 Nigerian census (Barau, 2007). The principal inhabitants of the city areHausa people. As in most parts of Northern Nigeria, the Hausa Language is widely spoken in Kano.

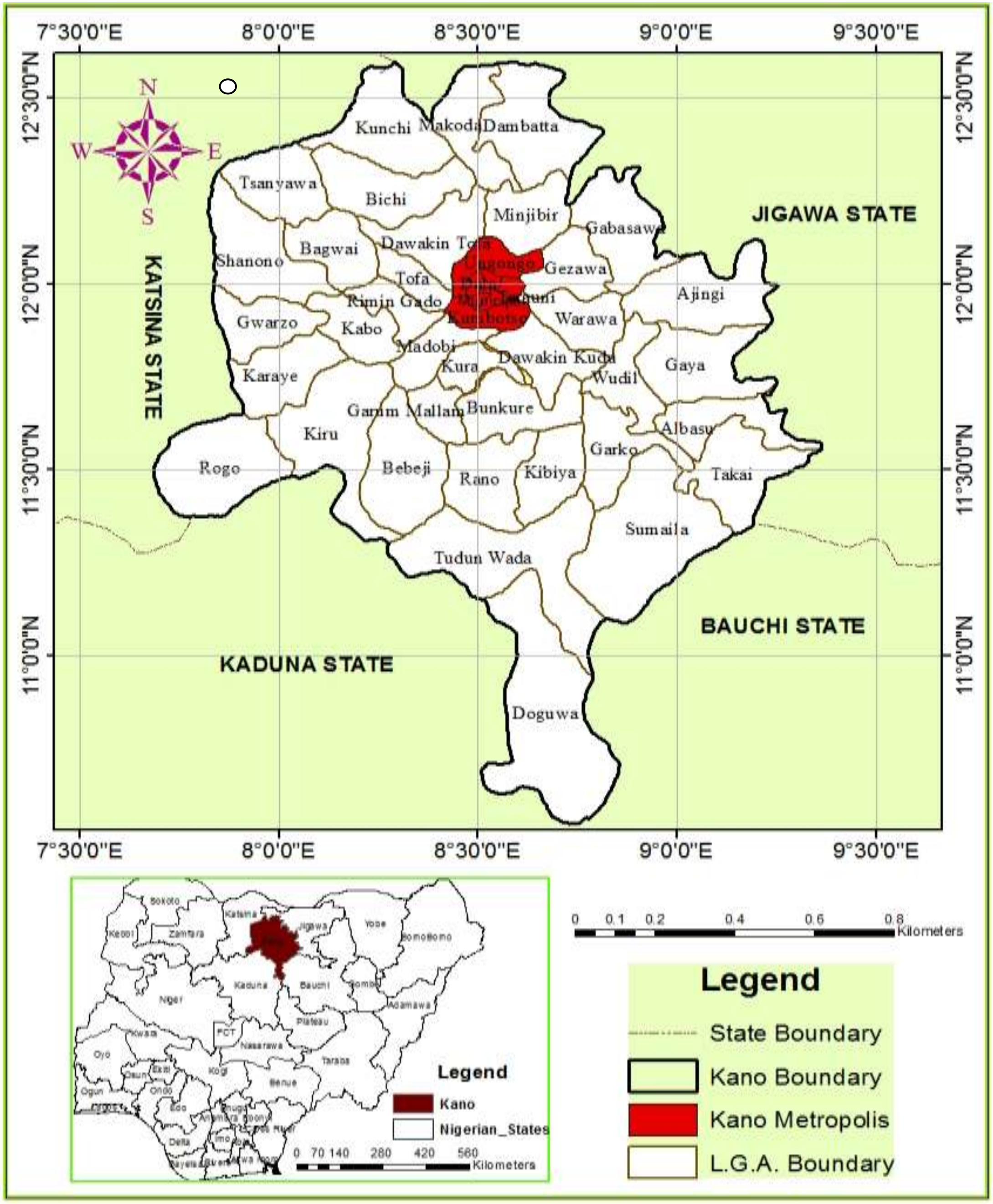

Fig. 3.1: Map of Nigeria showing the location of Kano metropolis

3.3 SAMPLING AND SAMPLE SIZE

Sampling was done randomly. The stratified sampling technique was used to collect data from twelve selected secondary school in Kano metropolis. The sample size for this study was800 subjects comprising both male and female studentsfrom secondaryschools of the metropolis. Although the minimum sample size needed for the study was 384 which was calculated using a formula (Oyejide, 1991) below;

$$n = \frac{Z^2 \quad pq}{d^2} = 384$$

Where n= desire sample size, Z= standard normal deviation 1.96 at 95% confidence level

q= 1 – p, d= degree of precision, p= proportion =0.7 (70%)

3.4 ETHICAL APPROVAL

Ethical approval was obtained from the committee on ethics from Kano State Hospital Management Board (see Appendix VII). Introduction letter was used to seek for permission at selected secondary schools in Kano metropolis.

3.5INCLUSION AND EXCLUSION CRITERIA

All the subjects were apparently healthy (absence of any physical deformity/ sign or symptom of disease) Hausas and within the age range of 14 to 25 (this is within the range by which growth rate is rapid) were included in the study.No restriction of movement in the upper limbs and no history of inflammatory joint disease, neurological disorder or injury to the upper or lower extremity by self-report.

The exclusion criteria were any subject with congenital deformities diseases or injuries in the hands and body parts. Any participant outside the age range was excluded from the study and also anybody who did not sign the consent form.

3.6 ANTHROPOMETRY

3.6.1 Hand measurement; the following hand dimension was measured using digital verniercaliper;

i. **Hand length:** Perpendicular distance from the tip of the middle finger to the wrist crease base line.

ii. **Hand breadth:** Distance between the radial side of metacarpal D2 (index finger) and ulnar side of metacarpal D5 (small finger).

iii. **Length of 1st digit (D1):** Perpendicular distance from the tip of the of digit 1st (D1) to ventral proximal crease

iv. **Length of 2nd digit (D2):** Perpendicular distance from the tip of the 2nd digit (D2) to ventral proximal crease

v. **Length of 3rd digit (D3):** Perpendicular distance from the tip of the 3rd digit (D3) to ventral proximal crease

vi. **Length of 4th digit (D4):** Perpendicular distance from the tip of the 4th digit (D4) to ventral proximal crease

vii. **Length of 5th digit (D5):** Perpendicular distance from the tip of the5th digit (D5) to ventral proximal crease

viii. **2D : 4D ratio:** calculated as length of 2nd digit divided by the length of 4th digit

ix. **Digit index:** calculated by the 3rd digit length divided by hand length and multiplied by 100

x. **Shape index:**calculated as hand breadth divided by hand length multiplied by 100

xi. **Palmar length:** calculated as hand length minus the 3rd digit length (that is the distance from the midpoint of the distal wrist crease to the midpoint of the proximal digit crease)

xii. **Palmar width:** same as hand breadth.

xiii. **Palmar length/width ratio:** calculated as palmar length divided by palmar width.

PlateV: Procedure for measuring third digit length

Plate VI: Procedure for measuring hand breath

3.6.2 Body Measurements

i. **Height and weight:**measured with stadiometer with functional weighing scale. The height was measured as a vertical distance between standing surface and the vertex of the head. For the weight, the participant with light clothes was asked to stand on the scale and the weight was recorded from the scale.

ii. **Waist circumference:**measuredmidway between the lowest rib and the iliac crest, with the participant in the upright position.

iii. **Hip circumferences:** measured, with the participant standing erect, feet together and on a horizontal plane at the level of the greater trochanters.

iv. **Waist to hip ratio (WHR):** calculated as waist circumferences divided by hip circumferences.

v. **Hand length to height ratio:** calculated as hand length divided by body height

vi. **Body mass index (BMI):** weight and height was used to calculate the BMI as kilograms per meter square (kg/m^2)

Plate VII: Procedure for measuring height and weight

Plate VIII: Procedure for measuring body circumference

3.6.3 Hand Grip Strength Measurement

The grip strength of right and left hands weremeasured using a standard adjustable hand grip dynamometer (Model EH101, Camry, China) at sitting position with shoulder adducted and neutrally rotated and elbow in full extension. The subjects were asked to put maximum force on the dynamometer from both dominant and non-dominant hands. The mean value will be recorded to the nearest 0.1kg.

Plate IX: Procedure for measuring grip strength.

3.7 STATISTICAL ANALYSES

Descriptive statistics (mean ± standard deviation) was determined for the directly measured variables. Comparisons between the HGS of dominant and non-dominant hands and other measured anthropometries of two sexes were carried out using Student's t-test. The Pearson's correlation was used to determine the relationship between HGS, selected hand dimensions and body variables. Linear regression analyses wasperform to predict the amount of hand grip strength for a given hand dimension and body variables. Statistical significance was declared at $p<0.05$. Data was analyzed using SPSS version 20 (IBMCorporation, NY).

CHAPTER FOUR

4.0 RESULTS

4.1 CORRELATION OF HGS WITH ANTHROPOMETRICVARIABLES, DERIVED INDICES AND RATIOS

The correlation was observed in the study variables. In Table 4.1 only right fifth digit and right palmar length have no significant correlation with both right and left hand grip strength. The left hand length, left fifth digits and left palmer length has no significance correlation with both right and left hand grip strength (Table4.2). All the body variable show significant correlation with hand grip strength with exception of hip circumferences as shown in figure Table 4.3 For the derived indices and ratios the left palmer length/ weight, left hand length/ height no significant correlation with right and left grip strength. In addition, right palmer length/ weight ratio show no correlation with right hand grip strength but correlate significantly with left hand grip strength (Table 4.1).(See Appendix IV, for Tables).

Table 4.1: Pearson's correlation between hand grip strength and right hand dimensions (n= 799)

Variables	LHGS	RHL	RD5	RD4	RD3	RD2	RD1	RPL	RPW
RHGS	0.92**	0.62**	0.05	0.54**	0.42**	0.42**	0.63**	0.66**	0.05
LHGS		0.63**	0.06	0.56**	0.42**	0.41**	0.67**	0.68**	0.05
RHL			0.01	0.80**	0.86**	0.69**	0.78**	0.93**	0.04
RD5				-0.02	-0.00	0.01	-0.01	0.01	0.01
RD4					0.74**	0.68**	0.70**	0.71**	0.02
RD3						0.69**	0.61**	0.62**	0.03
RD2							0.59**	0.58**	0.02
RD1								0.77**	0.04
RPL									0.04

RHGS; Right Hand Grip Strength, LHGS; Left Hand Grip Strength, RHL: Right Hand Length, RD5: Right Fifth Digit RD4; Right Fourth Digit: RD3 Right Third Digit RD2: Right Second Digit RD1: Right First Digit, RPL: Right Palmar Length, RPW: Right Palmar Width. * P < 0.05, ** P < 0.001

Table 4.2: Pearson's correlation between hand grip strength and left hand dimensions (n= 799)

Variables	LHGS (kg)	LHL	LD5	LD4	LD3	LD2	LD1	LPL	LPW
RHGS	0.92**	0.03	0.01	0.57**	0.40**	0.40**	0.56**	0.02	0.57**
LHGS		0.05	-0.00	0.60**	0.42**	0.41**	0.59**	0.05	0.60**
LHL			0.00	0.07	0.07	0.05	0.05	0.98**	0.05
LD5				0.02	0.04	0.06	0.05	-0.00	0.01
LD4					0.73**	0.69**	0.72**	0.05	0.60**
LD3						0.66**	0.57**	0.05	0.49**
LD2							0.60**	0.04	0.45**

LD1	0.04	0.52**
LPL		0.04

RHGS; Right Hand Grip Strength LHGS; Left Hand Grip Strength, RHL Right Hand Length: LHL; Left Hand Length, LD5; Left Fifth Digit LD4; Left Fourth Digit LD3; Left Third Digit LD2; Left Second Digit LD1; Left First Digit, Left Palmar Length RPW, * P < 0.05, ** P < 0.001

Table 4.3: Pearson's correlation between hand grip strength and body variables (n= 799)

Variables	LHGS	HT	WT	HC	WC
RHGS	0.92**	0.32**	0.34**	0.02	0.13**
LHGS		0.31**	0.33**	0.00	0.14**
HT			0.37**	0.23**	0.07*
WT				0.63**	0.60**
HC					0.61**

RHGS; Right hand grip strength, LHGS; left hand grip strength, HT; height, WT; weight, HC; hip circumference, WC; Waist Circumferences *P < 0.05 **P < 0.001

Table 4.4: Pearson's correlation between hand grip strength with body derived indices and hand ratio (n= 799)

Variables	LHGS	R2D:R4D	L2D:L4D	RPL/W	LPL/W	BMI(kg/m2)	W/H	RHL:HT	LHL:HT
RHGS	0.92**	-0.18**	-0.28**	0.05	0.01	0.09*	0.14**	0.29**	0.02
LHGS		-0.21**	-0.31**	0.08*	0.03	0.10**	0.18**	0.32**	0.05
R2D:R4D			0.44**	-0.05	-0.01	0.01	-0.00	-0.09**	-0.01
L2D:L4D				-0.03	-0.02	0.02	0.03	-0.11**	-0.02
RPL/W					0.02	-0.12**	-0.00	0.11**	0.02
LPL/W						-0.01	0.02	0.03	0.99**
BMI							0.45**	0.73**	0.03
W/H								0.33**	0.04
RHL:HT									0.07

RHGS; Right hand grip strength LHGS; Left hand grip strength, R2D: R4D; Right Second and Fourth Digits ratio: LD2: LD4; Left second and Fourth Digits ratio. RPL/W; Right palmar length to width ratio. LPL/W; left palmar length to width ratio. BMI; Body mass index W/H; waist to hip ratio. RHL: HT; Right hand length to Height ratio. LHL: HT; left hand length to height ratio.

4.2 PREDICTIVE EQUATIONS FOR HGS

From Table 4.18 the regression model predict the outcome variable (RHGS) significantly ($P < 0.05$) well with income variables (RHL, LD4, LD2, HT, WT, HC, RPL and RPW) also contributing significantly ($P < 0.05$) to the model. The constant also contribute significantly ($P < 0.05$) to the regression model only in the weight. In table 4.19 the regression model predict the outcome variable (LHGS) significantly ($P < 0.05$) well with income variables (LD5, LD4, LD3, LD2, LD1, HT, WT, HC and LPW) also contributing significantly ($P < 0.05$) to the model. Moreover, the constant significantly also contribute significantly ($P < 0.05$) to the regression model only with following predictors (LD5, WT, and LPW). For female participants the table 4.20 shows that the regression model do not predict the outcome variable (RHGS) significantly ($P > 0.05$). However, the constant significantly contribute ($P < 0.05$) to the regression model in all the variable with exception of RPL. Similar pattern was also observed in LHGS prediction model with respect to the contribution of the income variable and constant to the model.

Table 4.5: Regression equation of estimation of right hand grip strength from right hand dimensions and body variables in males of 19-20 years of age

S/N	Regression equation	R	R^2	SEE	F	P
1	RHGS = 0.225×RHL+(-4.056)	0.32	0.11	7.37	12.0	0.001
2	RHGS = 0.0001×RD5+14.061*	0.06	0.00	7.77	0.38	0.54
3	RHGS = 0.375×RD4 +12.032	0.25	0.06	7.55	6.64	0.01

4	RHGS = 0.194×RD3 + 24.508*	0.18	0.03	7.67	3.21	0.08
5	RHGS = 0.367×RD2+13.189	0.22	0.05	7.60	5.23	0.02
6	RHGS = 0.065×RD1 +35.799*	0.04	0.00	7.78	0.16	0.69
7	RHGS = 0.266×HT+(-4.741)	0.26	0.07	7.52	7.47	0.007
8	RHGS = 0.480×WT+ 13.078*	0.42	0.18	7.06	22.30	0.000
9	RHGS= 0.035×WC+37.673*	0.05	0.00	7.78	0.28	0.60
10	RHGS = 0.530×HC+(-5.956)	0.32	0.10	7.37	11.87	0.001
11	RHGS = 0.508×RPL+(-18.585)	0.40	0.16	7.15	19.08	0.000
12	RHGS = 0.415×RPW+5.337	0.31	0.10	7.40	11.05	0.001

RHGS: Right Hand Grip Strength, RHL: Right Hand Length, RD5: Right Fifth Digit RD4: Right Fourth Digit: RD3 Right Third Digit RD2: Right Second Digit RD1: Right First Digit, HT; Height WT; Weight, HC; Hip circumference, WC; waist circumference RPL: Right Palmar Length, RPW: Right, SEE: standard error of estimate,*P < 0.05

Table 4.6: Regression equation of estimation of left hand grip strength from hand left dimensions and body variables in males of 19-20 years of age.

S/N	Regression equation	R	R^2	SEE	F	P
1	LHGS = 0.095×LHL+19.852	0.17	0.03	7.59	2.86	0.09

2	LHGS = 0.243×LD5+23.906*	0.22	0.05	7.51	5.16	0.02
3	LHGS = 0.425×LD4+6.202	0.29	0.09	7.36	9.49	0.003
4	LHGS = 0.348×LD3 +9.948	0.23	0.05	7.49	5.64	0.02
5	LHGS = 0.465×LD2 + 4.318	0.28	0.08	7.38	8.93	0.004
6	LHGS = 0.334×LD1 +17.036	0.21	0.04	7.52	4.72	0.03
7	LHGS = 0.211×HT +2.860	0.21	0.04	7.52	4.70	0.03
8	LHGS = 0.445×WT +13.397*	0.40	0.16	7.06	19.13	0.000
9	LHGS = 0.008×WC + 37.942*	0.01	0.00	7.70	0.02	0.90
10	LHGS = 0.385×HC + 4.952	0.238	0.057	7.48	6.11	0.02
11	LHGS = 0.062×LPL + 31.435*	0.09	0.01	7.66	0.87	0.35
12	LHGS = 0.822×LPW +(-29.987)*	0.48	0.23	6.76	30.13	0.000

LHGS Left Hand Grip Strength, LHL: Left Hand Length, LD5: Left Fifth Digit LD4: Left Fourth Digit LD3: Left Third Digit LD2: Left Second Digit LD1: Left First Digit HT; Height, WT; Weight, LPL; Left Palmar Length LPW, Left Palmar Width, SEE: standard error of estimate, *P < 0.05.

Table 4.7: Regression equation of estimation of right hand grip strength from right hand dimensions and body variables in females of 19-20 years of age

S/N	Regression equation	R	R^2	SEE	F	P
1	RHGS = 0.015×RHL+17.958*	0.03	0.00	4.80	0.13	0.72
2	RHGS = -0.041×RD5+23.142*	0.05	0.00	4.80	0.28	0.60
3	RHGS = 0.114RD4 + 13.038*	0.12	0.01	4.77	1.88	0.18
4	RHGS = -0.020 ×RD3 + 22.13*	0.02	0.00	4.80	0.06	0.80
5	RHGS = -0.007×RD2+21.09*	0.01	0.00	4.80	0.01	0.93
6	RHGS = 0.092×RD1 +15.622*	0.08	0.01	4.79	0.85	0.36
7	RHGS = -0.055×HT+29.27*	0.14	0.02	4.75	2.65	0.11
8	RHGS = -0.01×WT+21.118*	0.02	0.00	4.80	0.04	0.83
9	RHGS= -0.056×WC+24.562*	0.11	0.01	4.78	1.65	0.20
10	RHGS = -0.033×HC+23.461*	0.08	0.01	4.80	0.77	0.38
11	RHGS = 0.061×RPL+14.459	0.07	0.00	4.79	0.70	0.40
12	RHGS = 0.060×RPW+16.036*	0.08	0.01	4.80	0.71	0.40

RHGS: Right Hand Grip Strength, RHL: Right Hand Length, RD5: Right Fifth Digit RD4: Right Fourth Digit: RD3 Right Third Digit RD2: Right Second Digit RD1: Right First Digit, HT; Height WT; Weight, HC; Hip circumference, WC; waist circumference RPL: Right Palmar Length, RPW: Right, SEE: standard error of estimate, *P < 0.05

Table 4.8: Regression equation of estimation of left hand grip strength from hand dimensions and body variables in females of 19-20 years of age

S/N	Regression equation	R	R^2	F	SEE	P
1	LHG= - 0.0028×LHL + 18.973	0.01	0.00	0.00	5.41	0.96
2	LHGS=0.027×LPL+15.824	0.03	0.00	0.11	5.41	0.74
3	LHGS= -0.068×LPW+23.594	0.09	0.01	0.92	5.41	0.34
4	LHGS=0.001×LD5+18.646	0.09	0.01	0.98	5.39	0.33
5	LHGS=0.096×LD4+12.213	0.09	0.01	1.11	5.39	0.29
6	LHGS=-0.036 ×LD3+(21.273)	0.04	0.00	0.19	5.40	0.66
7	LHGS= -0.099×LD2+25.295	0.01	0.01	0.19	5.39	0.66
8	LHGS=0.044×LD1+16.110	0.03	0.00	0.15	5.41	0.70
9	LHGS=(-0.063×HT)+28.395	0.14	0.02	2.70	5.36	0.10
10	LHGS= -0.035×WT+20.358	0.06	0.00	0.45	5.40	0.50
11	LHGS= -0.052×WC+22.233	0.09	0.01	1.13	5.41	0.29
12	LHGS= (-0.028×HC)+20.993	0.06	0.01	0.46	5.41	0.50

LHGS Left Hand Grip Strength, LHL: Left Hand Length, LD5: Left Fifth Digit LD4: Left Fourth Digit LD3: Left Third Digit LD2: Left Second Digit LD1: Left First Digit HT; Height, WT; Weight, LPL; Left Palmar Length LPW, Left Palmar Width. SEE: standard error of estimate, *P < 0.05,

4.3 HAND GRIP STRENGTH OF DOMINANT AND NON-DOMINANT HAND

Fig. 4.1 and 4.2 shows the comparison of HGS of dominant and non-dominant hand among right and left handed male participants across different age groups. No statistically significant differences were observed in right and left handed participants in all the three age groups. However, statistically significant difference were observed among 17 – 18 and 19 -20 age groups in right-handed female participants (Fig.4.3) with no such differences in the left-handed female participants (Fig. 4.4). In most case the mean value of HGS tend to be higher with respect to handedness (See Appendix IV, for Table).

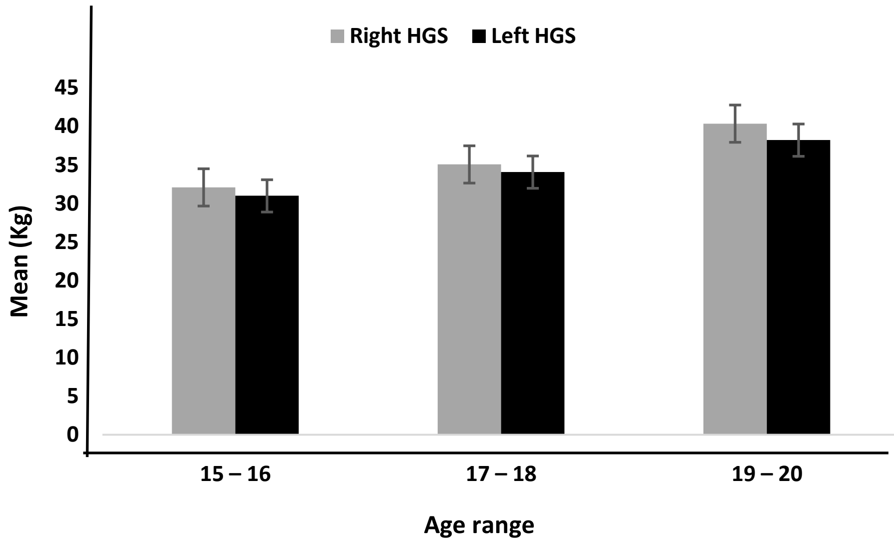

Fig. 4.1: Comparison of HGS of dominant and non-dominant hand among right handed male participants

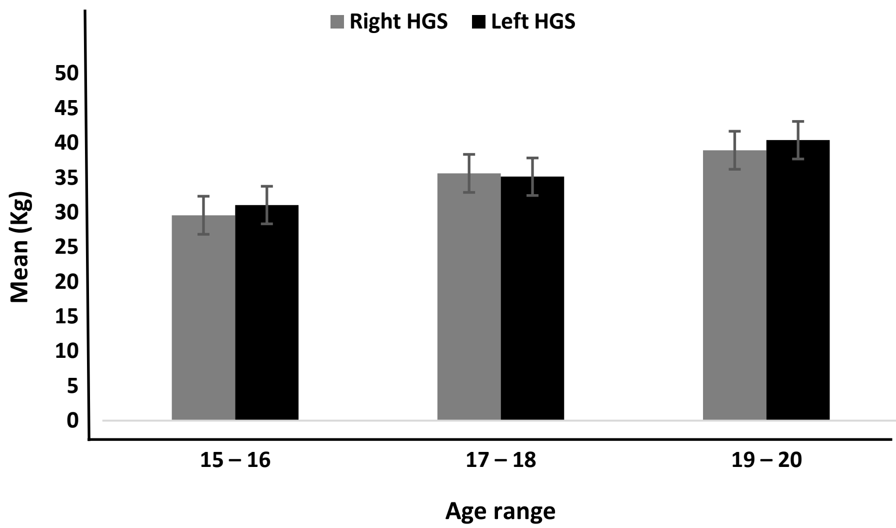

Fig. 4.2: Comparison of HGS of dominant and non-dominant hand among left handed male participants

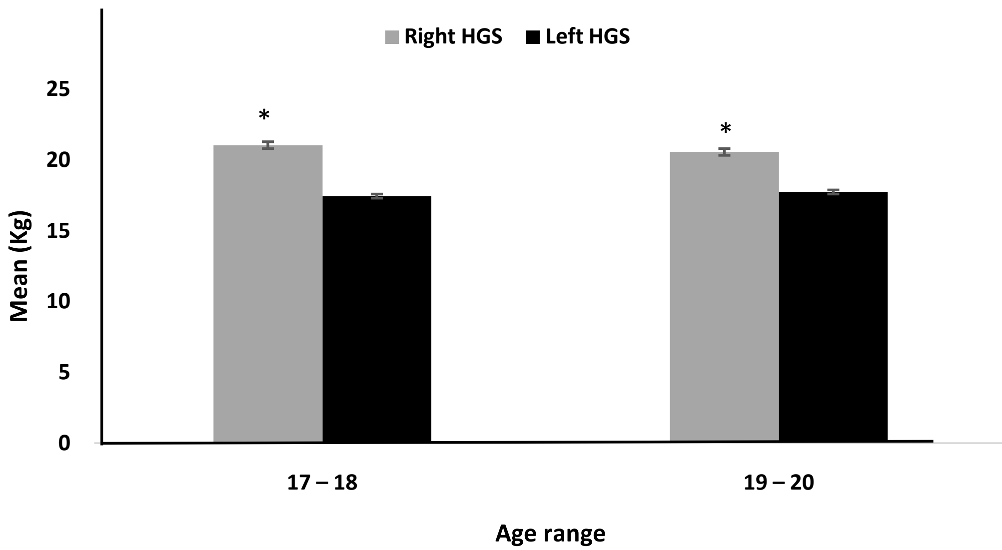

Fig. 4.3: Comparison of HGS of dominant and non-dominant hand among right handed female participants. *p< 0.001

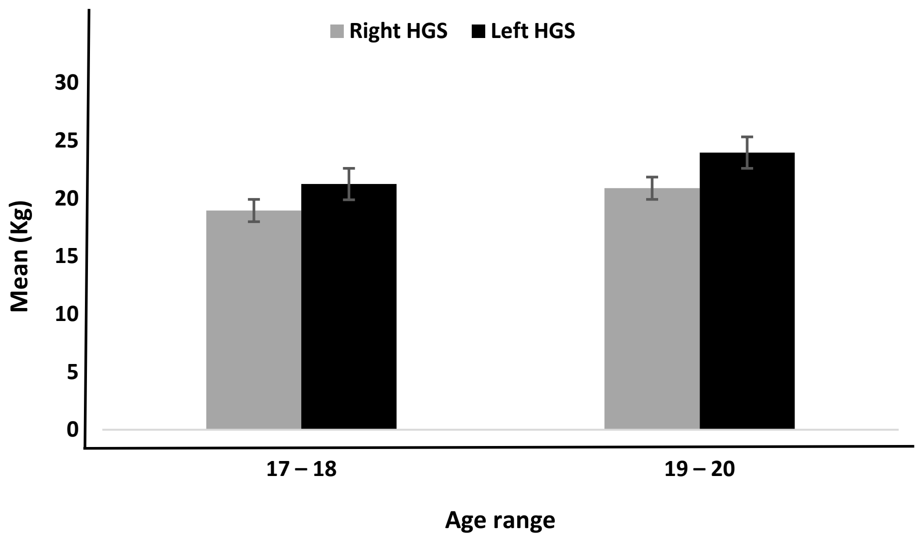

Fig. 4.4: Comparison of HGS of dominant and non-dominant hand among left handed female participants.

4.4 HAND GRIP STRENGTH

Sexual dimorphism was also observed with respect to hand grip strength. In all the three age groups male participants tend to have higher mean value ($p < 0.001$) compared to the female counter parts (Fig. 4.5) (See Appendix IV, for Table).

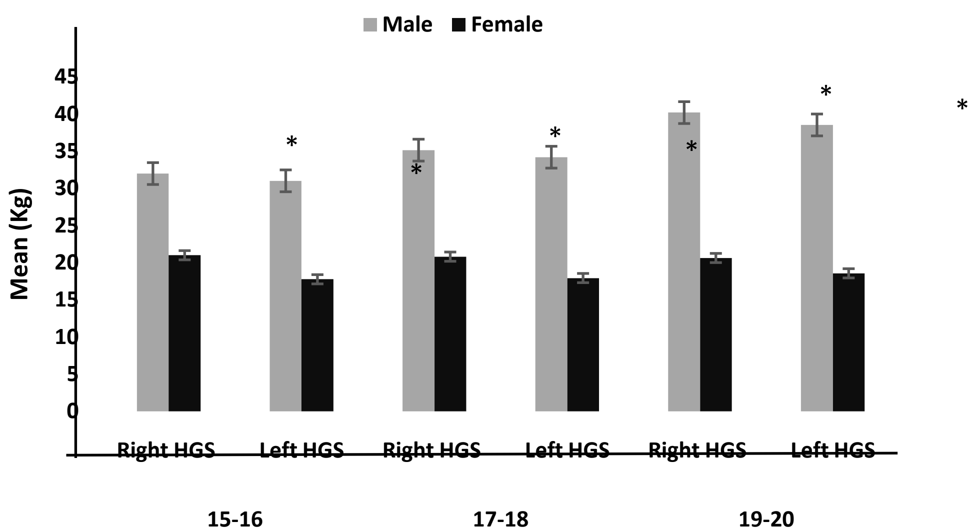

Fig. 4.5: Hand Grip Strength across different age categories *p< 0.001

4.5 HAND LENGTH, PALMAR LENGTH, PALMAR WIDTH AND DIGIT LENGTH

The sexual dimorphism of linear dimension of hand variables are considered in this study. Higher mean value ($p < 0.05$) among male participants are recorded in right and left hand variable among all three age categories in hand length (Fig. 4.6), palmar length (Fig. 4.7) and palmar width (Fig. 4.8). Similarly in the digits length (Fig. 4.9 –4.11) male participants tend to have the higher mean value ($p< 0.005$) with exception of 5^{th} digit, where female participants shown to have higher mean value ($p< 0.05$) in the right hands in all age groups and both hands in only17-18 age group (Fig. 4.10) (See Appendix IV for Tables).

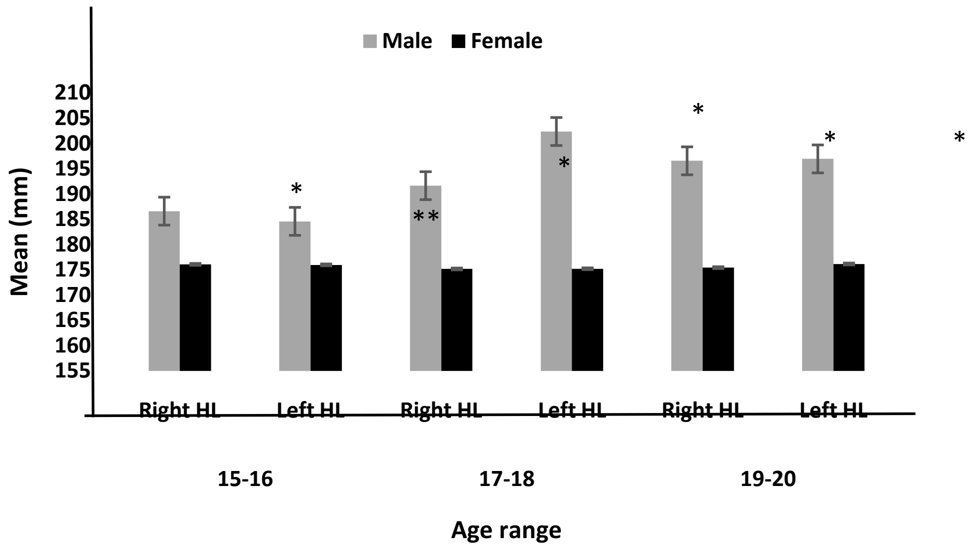

Fig. 4.6: Hand length (HL) across different age categories *p< 0.001, **p< 0.05

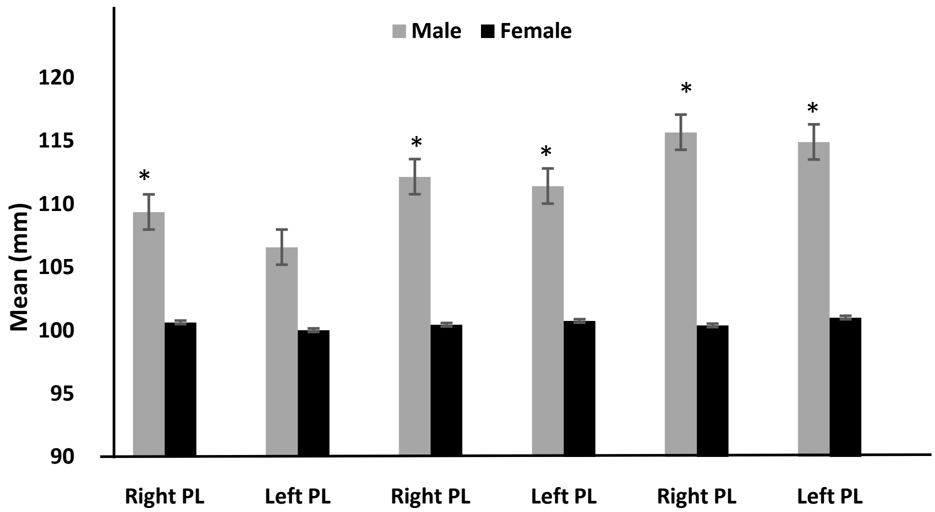

Fig. 4.7: Palmar length (PL) across different age categories *p< 0.001

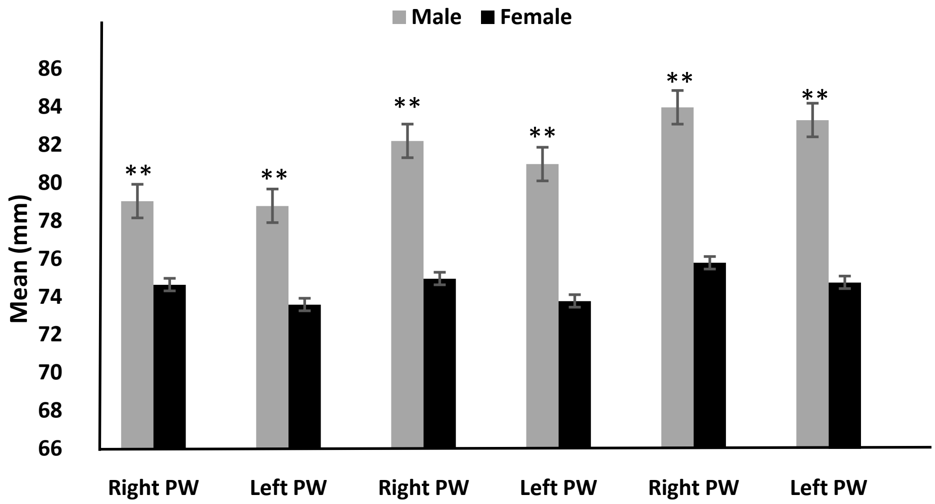

Fig. 4.8: Palmar width (PW) across different age categories, **p< 0.05

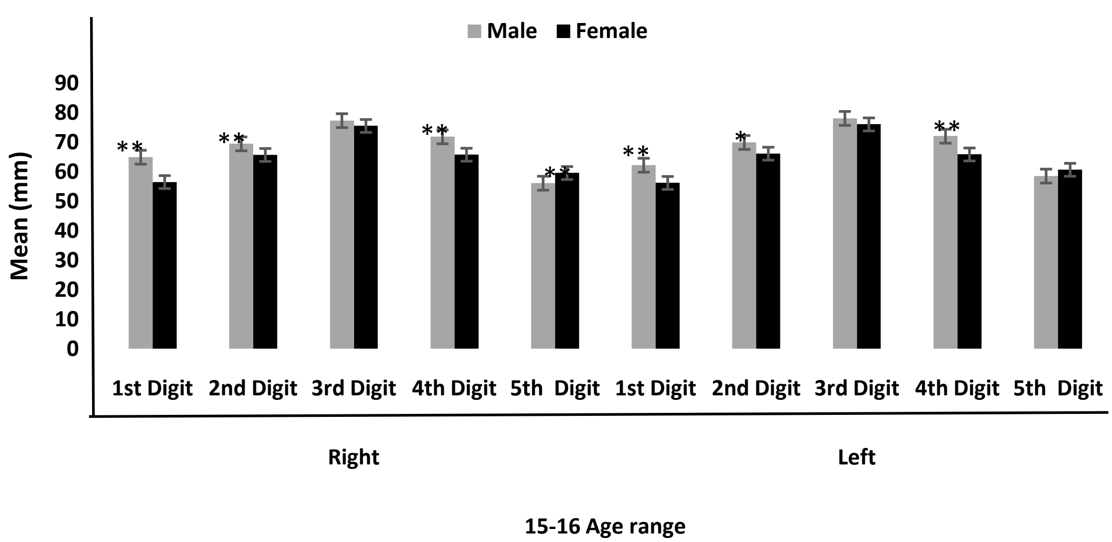

Figure 4.9: Digits length among 15-16 age categories *p< 0.001, **p< 0.05

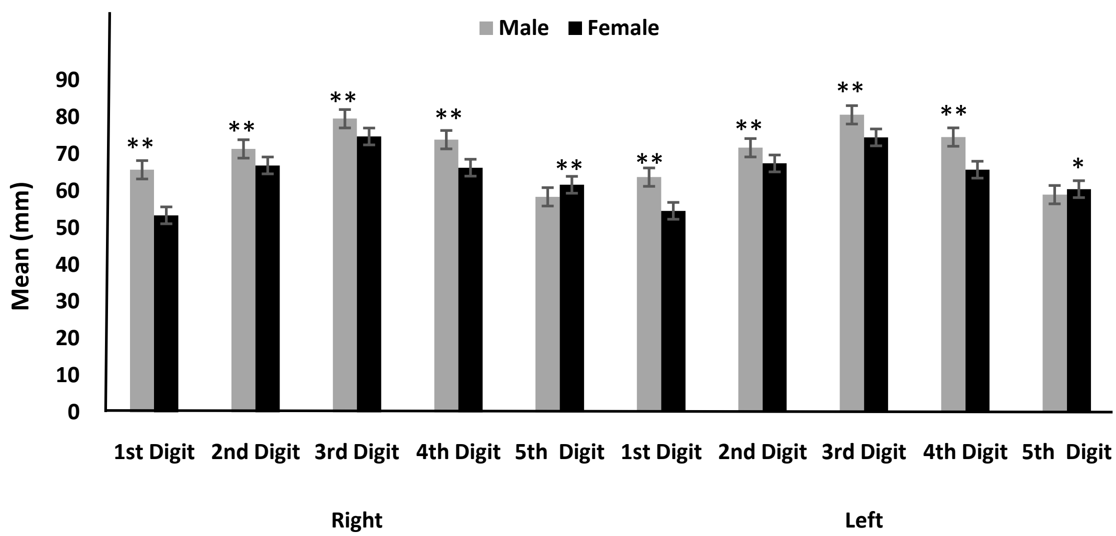

Fig. 4.10: Digits length among 17-18 age categories *p< 0.001, **p< 0.05

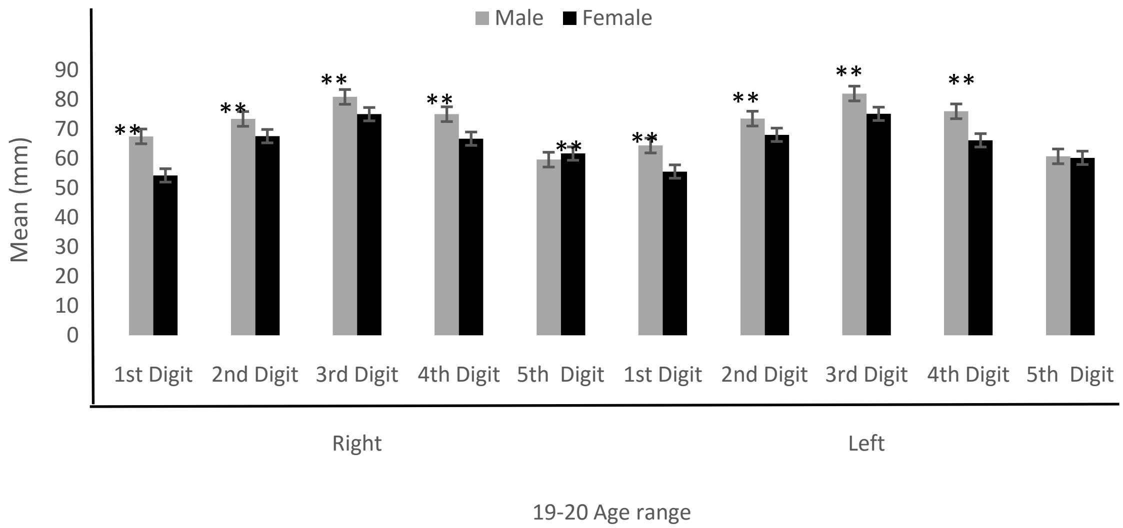

Fig. 4.11: Digits length among 19-20 age categories *p< 0.001, **p< 0.05

4.6 HAND RATIOS AND INDICES

The gender differences are noticed in hand ratios and indices. For palmar length to width ratio male tends to have higher mean value with significance (p<0.05) in all the right hand in all three age groups, except for 15-16 years of age (4.12). In 2D:4D (Fig. 4.13) female have higher mean values with statistically significant differences (p< 0.001) among 17 – 18 and 19-20 age groups in right and left hands. For digit index (Fig. 4.15) similarly, the differences (p< 0.001) is observed only in right hand among 15-16 and 17-18 age groups and in both among 19- 20 age group. In the shape index no significant differences in left and right across three age categories (Fig. 4.14). (See Appendix IV, for Tables).

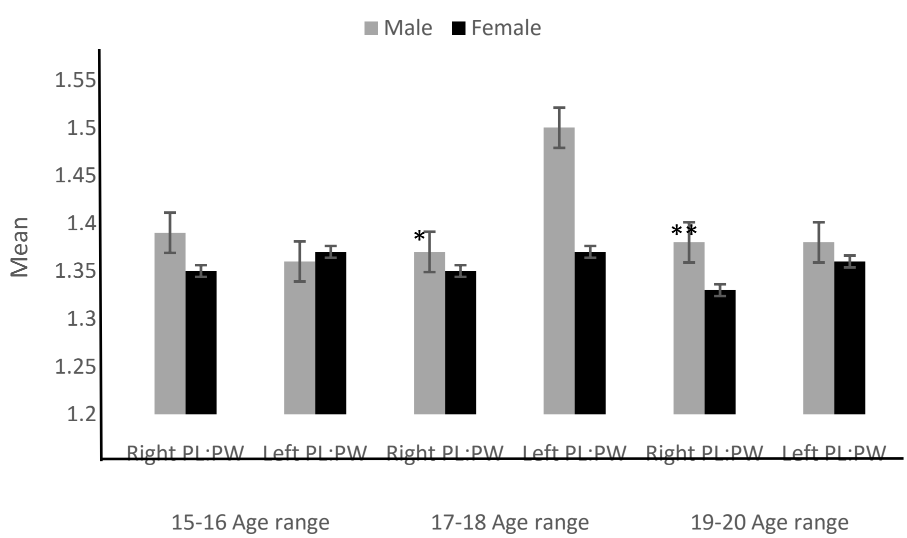

Fig. 4.12: Palmar length to width ratio (PL: W) across different age categories *p< 0.001, **p< 0.05

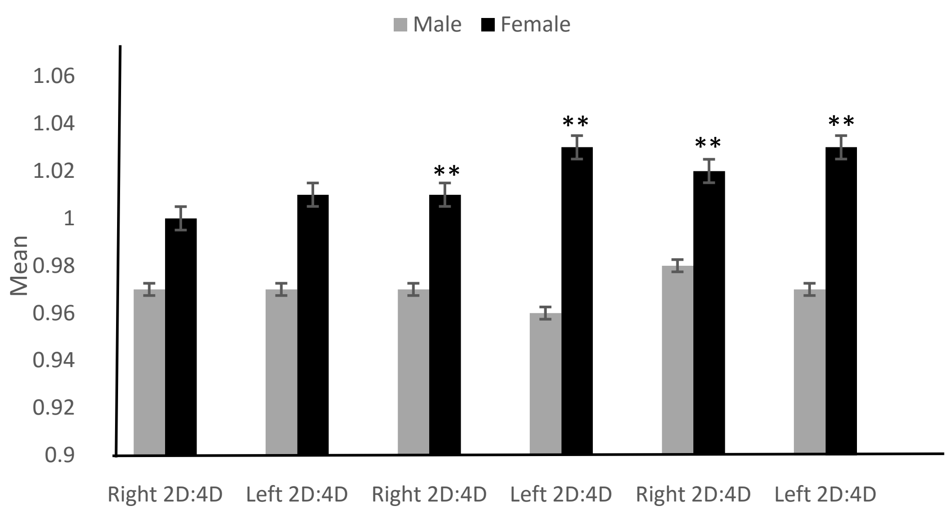

Fig. 4.13: 2D:4D digits ratio across different age categories, **p< 0.05

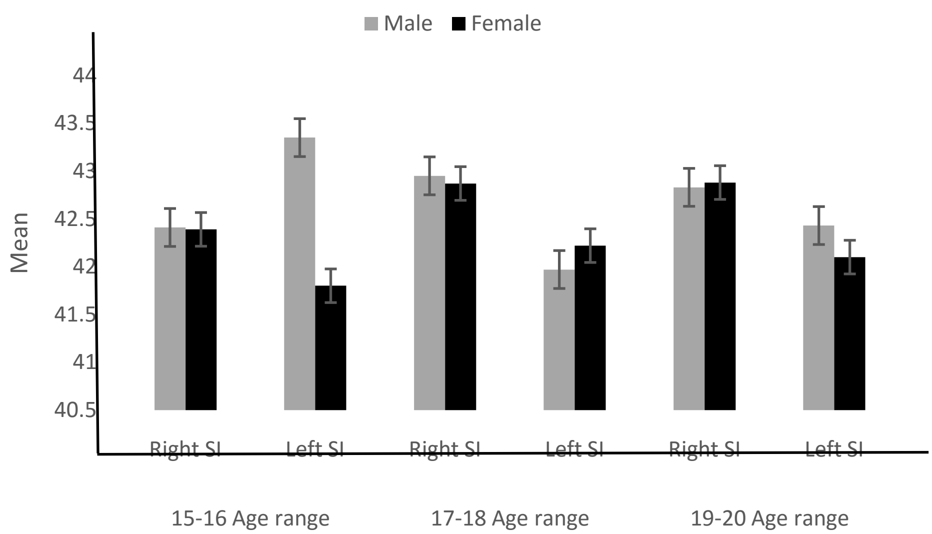

Fig. 4.14: Hand shape index (SI) across different age categories

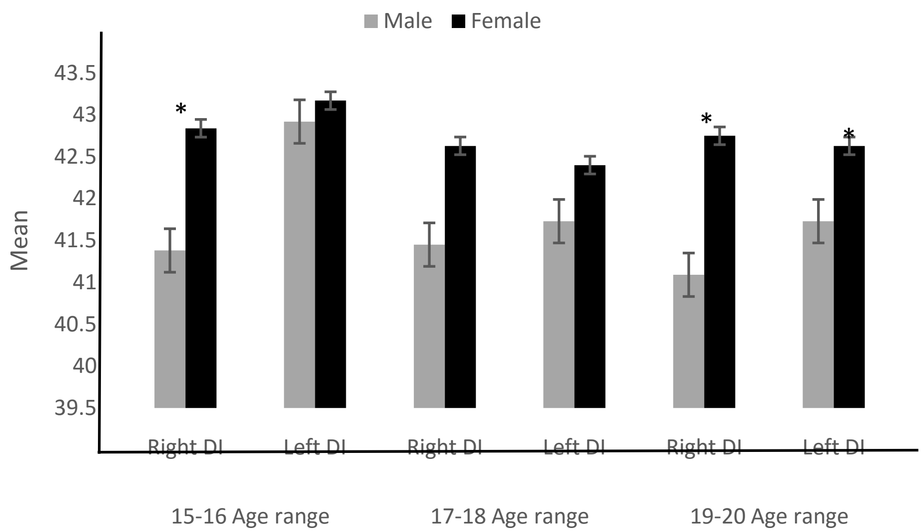

Fig. 4.15: Digit index (DI) across different age categories *p< 0.001

4.7 ANTHROPOMETRIC ANALYSES

Male participants are significantly taller ($p < 0.001$) in 17-18 and 19-20 age groups (Fig. 4.16). Similarly, the male are also heavier among 19 – 20 age groups (Fig. 4.17). However, in BMI the female have higher mean value among 17-18 age group (Fig. 4.18). For body circumferences, only hip circumferences indicate significant differences among 15-16 and 17-18 age groups (Fig. 4.19). In Fig. 4.20 W/H ratio tend to be higher in male among 17 – 18 age group. (See Appendix IV, for Tables).

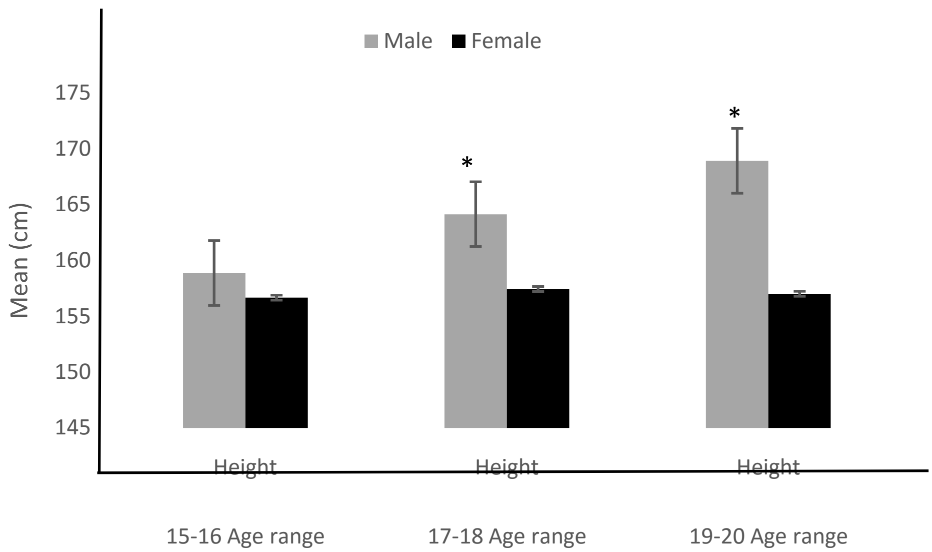

Fig. 4.16: Height across different age categories *p< 0.001, **p< 0.05

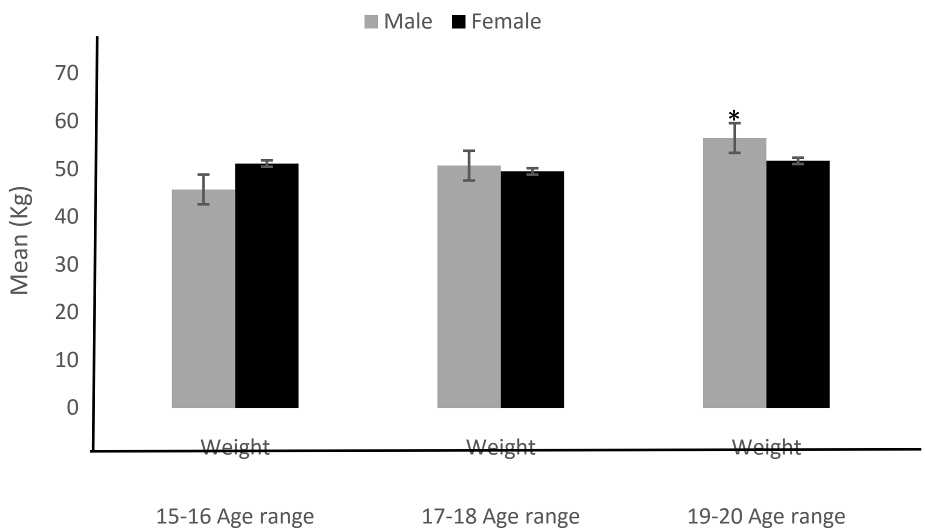

Fig. 4.17: Weight across different age categories *p< 0.001.

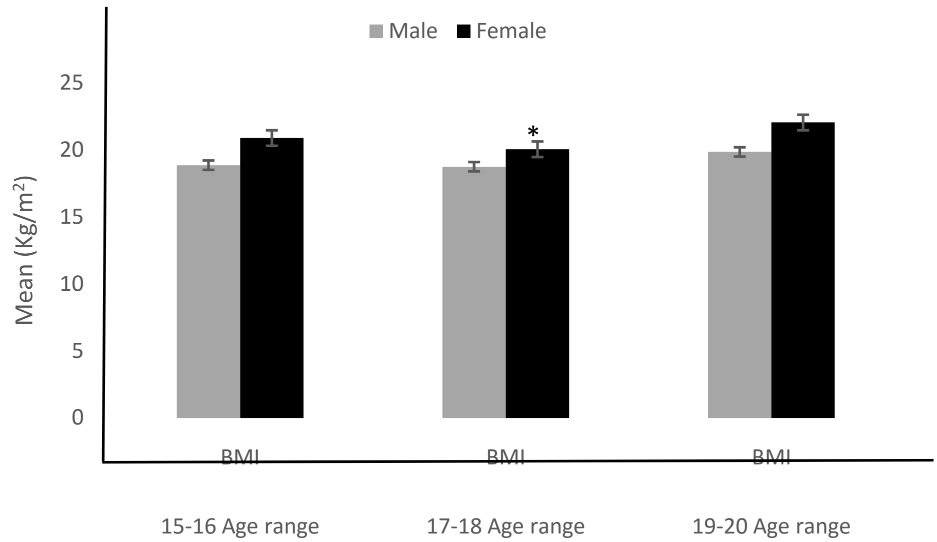

Fig.4.18: Body mass index (BMI) across different age categories *p< 0.001.

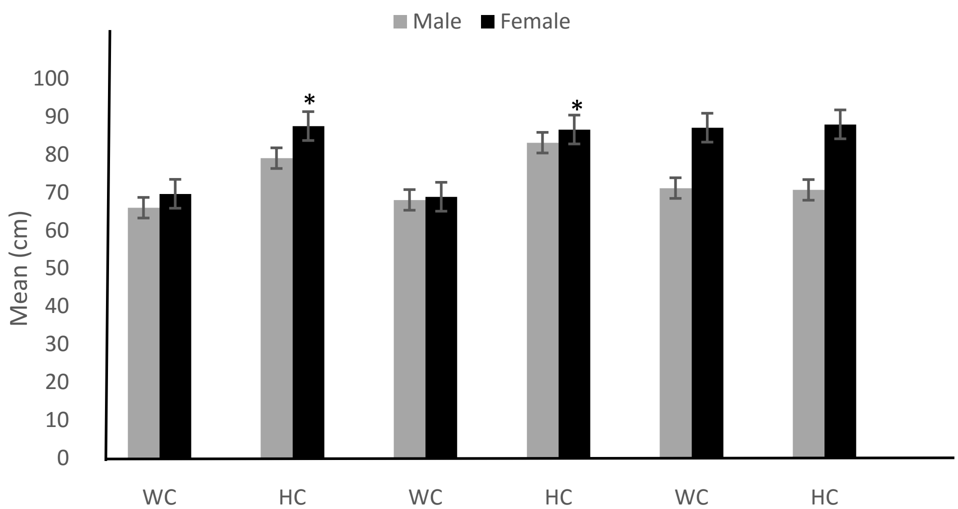

Fig. 4.19: Waist and hip circumferences (WC and HC) across different age categories *p< 0.001.

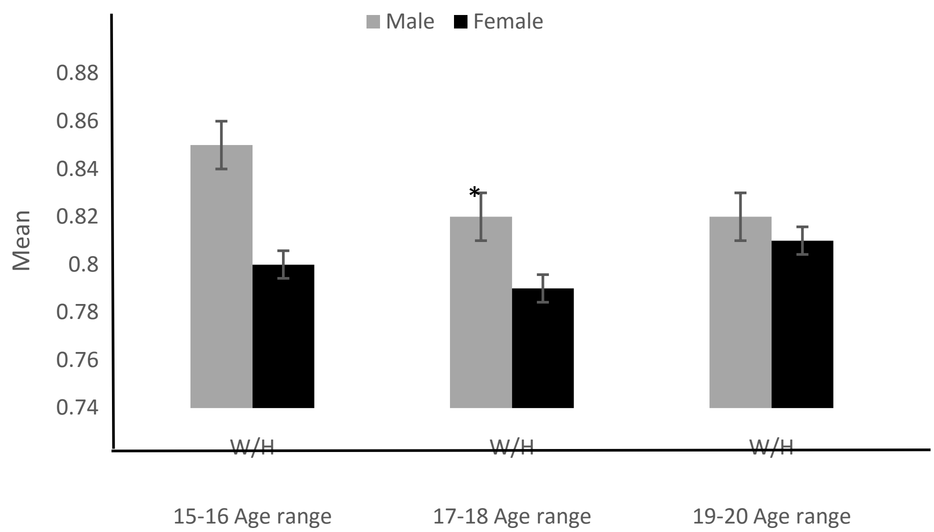

Fig. 4.20: Waist to hip (W/H) ratio across different age categories *$p < 0.001$.

4.8 HAND AND BODY VARIABLE RATIO

With regard to combine hand and body variables ratio, male tends to have significantly ($p < 0.05$) higher HL/HT ratio in right and left side across all the three age categories, except for the left side among 15 – 16 age group where no significant was observed (Fig. 4.21).(See Appendix IV, for Tables).

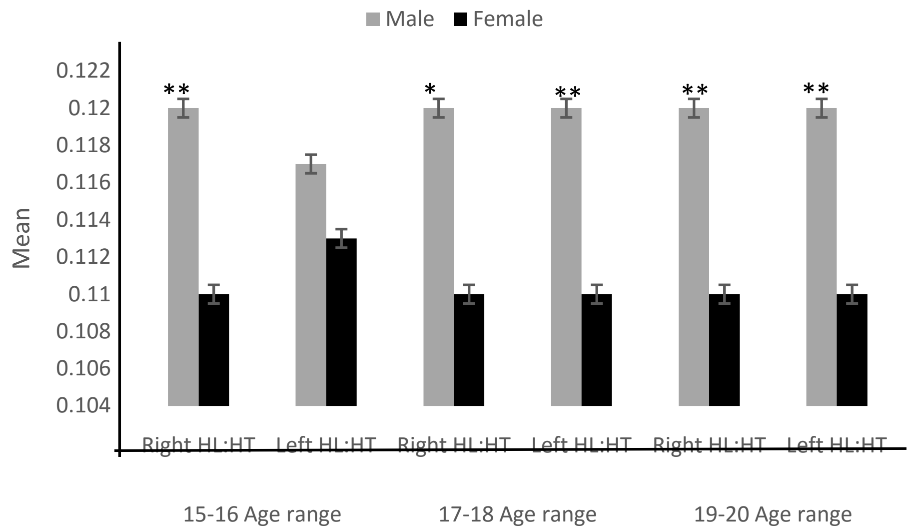

Fig. 4.21: Hand length to height ratio (HL: HT) across different age categories *p< 0.001.

CHAPTER FIVE

5.0**DISCUSSION**

Hand grip strength may be negatively affected by local disorders of the hand as well as by radiculopathy caused by degenerative changes in the cervical spine. Assessment of hand function, use of objective and reliable instruments, and knowledge about the reference values of HGSand hand morphology is lacking in our locality. Numerous authors have studied HGS in healthy individuals and several of them have reported age-and sex-specific data (Mathiowetz*et al.,* 1985; Ha¨rko¨nen*et al.,* 1993; Chong *et al.,* 1994).The data on HGS and dimension, and body variables can also be used for the designing of suitable hand tools, orthotics, and gloves among different ethnic groups including Hausas.The current study investigated the role of dominant hand in determining higher hand grip strength, the sexual dimorphism and relationship between hand grip strength, some selected hand dimensions, 2D to 4D ratio, digit index, shape index, palmer length to width ratio, Hand length to height ratio, height, weight, waist circumference, hip circumference, WHR, BMI among Hausas of Kano metropolis

With regards to hand dominancy, the present study shows that a statistically significant difference were present among 17 – 18 and 19 -20 age groups in right-handed female participants with no such differences in the left-handed female participants. However, in the previous researches it was documented that the HGS is higher in dominant hand with right handed subjects, but no such significant differences between sides could be documented for left handed people (Armstrong and Oldham, 1999, Incel*et al*., 2002). Nurgul*et al*., 2002 also notice that stronger grip and pinch strengths were obtained at dominant sides of the participants and only 14.09% of the subjects had stronger non dominant hand grips.

The variation observed in the currentfinding with respect to higher grip strength in the left handed participants among this study population may be linked to genetic influences due to differences in the ethnicity between the different study groups. Moreover, in the current results the differences in the grip strength with dominancy of hand was only observed among the female participant. This also gives another insight about the influence of genetic factor in the expression of higher grip strength with respect to dominant hand.

Although the sample size between the right and left handed participants is not proportional and this may affect conclusive statement to some extent. But despite this limitation of the sample size which was also seen in the study by Petersen *et al*., (1989) that analysed 48 left handed and 262 right handed subjects and found a significant difference between the two groups. Therefore, the issue of sample small sample size of left handed participants is unavoidable in most population, including ours. This may be linked to cultural and/ or religious influences that necessitate the use of the right hand as dominant against the left hand, hence, a left hand dominant individual will be transformed into the right handed individual.

Perhaps, in the body variables the level of sexual dimorphism was noticed only in weight and hip circumferences with higher mean value in female then the male counterpart. Derived indices and ratio also show some level of sexual dimorphism in both right and left second to fourth digit ratio, right digit index and right hand length to height ratio.For the 17 – 18 aged group participants a statistical significance difference exists between the sexes in hand grip strength and hand dimensions with higher mean value in male than female with exception of right fifth digit. Sexual dimorphism was also observed in the body variables with the exception of weight and waist circumference.

Level of sexual dimorphism was also shown in the derived indices and ratios with exception of left digit index, both shape indices and left palmar length to width ratios. In 19-20 age groups similar pattern of significant difference was notice in hand grip strength and hand dimensions, although in this group only left fifth digit has not shown a statistically significant difference not the right fifth digit as observed in the 17-18 years of age group. Sexual dimorphism was also noticed only in height and weight, and in the derived indices and ratios gender differences exist with exception of both left and right shape indices, body mass index, and waist to hip ratio and left palmar length to width ratios.

These findings were supported with previous results for example, Arden and Spector (1997) showed the heritability of HGS to be lower among females, after controlling for age, while Reed *et al.* (1991) also estimate the heritability of male HGS to be higher after adjustments of age and various anthropometric measures such as fatness, muscle mass and frame size (Mathiowetz*et al.,* 1985; Kamarul*et al.,* 2006; Vianna*et al.,* 2007). It was found that males attained greater values for hand grip strength with stature, weight, arm and calf circumferences and various subcutaneous skinfolds and also have greater hand grip strength values than their female counterparts (Benefice and Malina, 1996).

The effect of three different sports branches on the hand morphology and function was evaluated, it was revealed that there were statistically significant differences in right and left hand shape indices, right and left hand length/ height ratio values between male basketball, volleyball and handball players. Difference between basketball and handball groups was the reason of the significance.

Furthermore, the significant differences in right and left hand width, right and left hand length, right and left 3rd finger length, right and left grip strength values between female basketball, volleyball and handball players was also noticed. Handball group was the reason of the significance (Cagatey*et al*., 2008). In Humans, finger length ratio of the index and ring finger (2D:4D) is also a sexually dimorphic trait. The ratio between the length of the index and ring digit (2D:4D) may correlate with *in utero* testosterone levels (Manning *et al*., 1998; Manning and Taylor, 2001). The study of Danborno*et al.,* (2008) on Nigerians also demonstrated sexual dimorphism in 2D, 4D and 2D:4D ratio. Other research also has shown striking sex differences in HGS among adult populations, with males far outscoring females (Kamarul*et al*., 2006; Mathiowetz*et al.*, 1985; Bohannon *et al.*, 2006; Shetty *et al.,* 2012; Hemberal*et al*., 2014).

The reason of this sexual dimorphism in the study variables may be link to several factors for instance, senescence accounts for a larger percentage of the variation in HGS in men, with male HGS declining more quickly after age of 30 (Vianna *et al.*, 2007). Sex differences also observed in forebrain and cardiac sympathtic nervous responses at the onset of handgrip exercise, with smaller cardiovascular response (heart rate and mean arterial pressure) and weaker insular cortex activation observed in women. Interestingly, this may reflect both physiological and psychological sex differences when asked to provide a maximum squeeze of a dynamometer.

While greater height, weight, and muscle mass in males has been submitted as an explanation for this effect (Kamarul*et al*., 2006; Kuh, *et al*., 2006), the sexual dimorphism in androgenic hormones (i.e., testosterone) may be the responsible factor.

For instance, men with reduced testosterone levels caused by androgen deprivation have been shown to have low grip strength (Soyupek*et al.*, 2008), and supplementary increases in testosterone enhance HGS as well as lean body mass in elderly men with low serum testosterone (Page *et al*., 2005; Sih*et al.*, 1997; Wang *et al*., 2000). Moreover, somatic sex differences in mammals to date have been found to be due to either androgenic masculinization or effects of the sex chromosomes (Fink *et al*., 2006) and increased bone mineral density and muscle mass in males when compared to females as another influencing factor (Hemberal *et al*., 2014). In addition to the previous reason reported in the literature, the current research also considers the exposure of male to the more manual work than the female counterpart to be an additional environmental factor lead to sexual differences between male and female in hand grip strength and other study variables. Moreover, the more manual work exposure the higher the musculature, hence the higher the grip strength.

Age is one of the confounding variable in most of the anthropological studies a such categorization of individuals according to different age groups is always important for making some generalized conclusion. In the current study we determine the sexual dimorphism in the study variables by three age categories, 15-16, 17-18 and 19-20 years of age. The present result shows that among 15-16 years of age, there is gender differences in the hand grip strength and hand dimensions with exception of right third digit, left fifth digit and left palmar length.

According to previous report the hand grip power of females shows an age-level difference between the young and the elderly in all loads (30, 40 and 50%). However, the required time to reach peak velocity was longer in the elderly at 50%, and the time is shorter at 30% than at 40 and 50% in both young and elderly groups (Aoki and Demura, 2011). Therefore, a base line data is always needed almost for every population groups. In order to achieve that for our local community the present study categorized the data obtained base on ages and sexes. Therefore, the mean value obtained for a particular age group of a sex categories will be compared with any other population of the same sex and age categories. For instance the mean grip strength of the different age categories of our study population as in 15-16 years group their mean differences of the right hand grip strength was10.99 ± 4.44 while the mean difference in the left hand grip strength was 13.24 ± 3.54. For the 17-18 years group the mean differences in the right hand grip strength was 14.13 ± 2.71 while the mean left hand grip strength was 19.26 ± 2.81. In 19-20 years' group the mean difference of right hand grip strength was19.56 ± 2.29 while the mean left hand grip strength was 19.96± 2.27.

This indicate linear increase of hand grip strength with respect to age. Although, in the previous studies involving volunteers aged 25–64 years indicated a decrease in hand grip strength in relation to the ages

(Peolsson*et al.,* 2001; Bohannon *et al.,* 2006). The possible explanation of the contradictory findings could be dueto the influences of the age on hand grip strength. According to Ma¨lkia(1993), handgrip strength decreases by only about 0.5% a year from the age of 30 until 45–49 years of age, after which the decline accelerates to about1% a year until theage of 75, followed by an even larger decrease. Therefore, the reverse trend of increase in the hand grip strength may occur in the individual below the 30 years of age.

Another possible explanation of the increase and decrease in hand grip strength in individual below and above the 30 years of age respectively may be due to onset of muscle atrophy associated in individual above age of 30 years and normal body growth rateas well as increase in the muscle tone before age of 30 years. This explanation is in accordance with previous findings, who reported less loss of strength in frequently used muscles (Hackel *et al*., 1992; Bassey and Harris, 1993) that is to say i.e. older people in today's society have previously done heavier manual work than younger individuals. Generally, it has been well documented that in adulthood, skeletal muscle strength in general decreases with age (Larsson *et al.,* 1979). Base on the above discussion the age and sex specific data for hand grip strength were provided for our locality. Hence, the mean value of the grip strength on the above mentioned age categories may always be utilized within our Hausas population as a reference value.

The correlation was observed in all the study variables with left and right hand grip strength with the exception of fifth digit (both left and right), palmar length (both right and left), left hand length, hip circumference, palmer length/ weight ratio (both left and right), and left hand length/ height ratio. Going by previous studies, right and left hand grip strength was positively correlated with weight, height and body surface area (Chatterjee and Chaudhuri, 1991). Strong correlations between grip strength and various anthropometric traits, (weight, height, hand length) were reported by several workers (Malina *et al*., 1987; Ross and Rosblad, 2002).

The literature also reported that handgrip strength had strong correlations with various anthropometric characteristics such as, body surface area, height, weight, BMI and six hand-anthropometric variables including the shape index, digit index, 2D:4D ratio, palmar length, palmar width, palmar length/width ratio (Chatterjee and Chowdhuri, 1991; Koley and Kaur, 2009; Koley and Yadav, 2009; Koley, Kaur and Sandhu, 2009; Koley et al., 2010). The hip/waist circumferences measurements as a good marker of fat mass, bone mineral content and lean mass also strongly correlated with maximum isometric grip force (Sartorio*et al.,* 2002; Rashid and Ahmed, 2006; Foo, 2007). Among Nigerians a relationship between 2D, 4D, and 2D:4D ratio to body circumferences (chest, waist and hip) height and weight was also established (Danborno*etal.*, 2008).Based on the current and previous findings there is strong relationship between the hand grip strength, hand dimensions and body variables. This indicated that function of hand grip strength is the function of good hand dimension and body variable and vice vasa. Therefore, the prediction of the hand grip strength from the body variables and hand dimensions may be achievable within the domain of physical anthropology.

The estimation of hand grip strength is of immense importance in determining the efficacy of different treatment strategies of hand and also in hand rehabilitation. The current research generates a model of estimation of the hand grip strength (left and right) from the hand dimensions and body variables in both sexes. Considering the right hand grip strength of male, **t**he regression model predicts the outcome variable (RHGS) significantly ($P < 0.05$) well with income variables (RHL, LD4, LD2, HT, WT, HC, RPL and RPW) also contributing significantly ($P < 0.05$) to the model. For the left hand grip strength, the regression model predicts the outcome variable (LHGS) significantly ($P < 0.05$) well with income variables (LD5, LD4, LD3, LD2, LD1, HT, WT, HC and LPW) also contributing significantly ($P < 0.05$) to the model.

In female participants the regression model do not predict the outcome variable (RHGS) significantly ($P > 0.05$) in both left and right hand grip strength. This indicate that the hand dimensions and body variable as a grip strength predictors are gender selective. Therefore, these variable shown to be promising predictor in male but not in female. The differences here my give another clue in the genetic factor playing a vital role in the differences observed between the genders. In comparison with our finding the previous researches showed thatweight and height were found to be statistically significant predictors of hand grip strength after adjusted for gender, race, ever attended school and age (Moy *et al.,* 2011) in both sexes. Also according to Mohan *et al*. (2014) hand length as well as forearm circumference systematically for a step wise regression yielded positive capacity to predict hand grip strength. In addition to the variable considered in the previous study we also found that the hand length, palmar length and width, hip circumferences and length of five digit contribute significantly to the prediction of the hand grip strength using bivarient simple linear regression model. Although, for the right hand grip strength the first, third and fifth digit do not contribute significantly whereas in the left hand grip strength only left hand length and palmer length was not. This differences may be due to the effect of hand dominance which was not controlled in the generation of the model. Moreover,health status and differentlifestyle of the participant may be another factor not considered in present study. Hence, for better conclusive statement on prediction of hand grip strength several variables need to be consider for contribution in the generating prediction model as well as controlling other confounding variables that may affect the proper interpretation of the results.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

In the findings of this study a statistically significant difference were present in right-handed female participants with no such differences in the left-handed female participants. Level of sexual dimorphism was noticed in the hand grip strength, hand dimensions, derived indices and ratio height,weight, hip and waist circumferences depending on the sex of an individuals. The baseline data of the hand grip strength indicate a linear increase in the mean differences in both sexes across the different age categories. The correlation was observed in most of the study variables with left and right hand grip strength. The current research generates a model of estimation of the hand grip strength (left and right) from the hand dimensions and body variables in both sexes. The regression modelpredicts the outcome variable (HGS) significantly ($P < 0.05$) well among the male participants then the female counter part.

6.2RECOMMONDATIONS

i. Different ethnic and age groupshould be used in another study like this on the same ethnic group for more generalized data.

ii. More anthropometric variables on hand dimensions like hand circumference and other body variables should be added for representative information among Hausa ethnic group.

iii. Similar study on other population or different ethnic group should be carry out in order to establish and give detailed explanation of hand grip strength, hand dimensions and body variables in Nigeria.

iv. Study with control of other variables like height, weight and other body variables should be carry out in the same population with the same sample size.

v. The data generated on hand grip strength should be used as baseline data or reference values among Hausas within the studied age group.

vi. Many researches have reported some differences in hand grip strength with different dynamometers, so another study can be done with different type and model of dynamometer

vii. The study can also be done with higher age groups participants to establish more generalized data on hand grip strength among Hausas.

6.3 CONTRIBUTION TO KNOWLEDGE

Sexual dimorphism was also observed with respect to hand grip strength. In all the three age groups male participants tend to have higher mean value ($p < 0.001$) compared to the female counter parts

Hand Grip Strength is negatively correlated with 2D:4D especially on the left hand (right hand r=-0.18, -0.21, left hand r= -0.28, -0.31, P<0.001). Right and left digit ratio negatively correlated with right hand length: height ratio (r-0.10 and r=-0.11 at P<0.001) respectively.

The current research generates a model of estimation of the hand grip strength (left and right) from the hand dimensions and body variables in both sexes. Considering the right hand grip strength of male, **t**he regression model predicts the outcome variable (RHGS) significantly ($P < 0.05$) well with income variables (RHL, LD4, LD2, HT, WT, HC, RPL and RPW) also contributing significantly ($P < 0.05$) to the model. For the left hand grip strength, the regression model predict the outcome variable (LHGS) significantly ($P < 0.05$) well with income variables (LD5, LD4, LD3, LD2, LD1, HT, WT, HC and LPW) also contributing significantly ($P < 0.05$) to the model.

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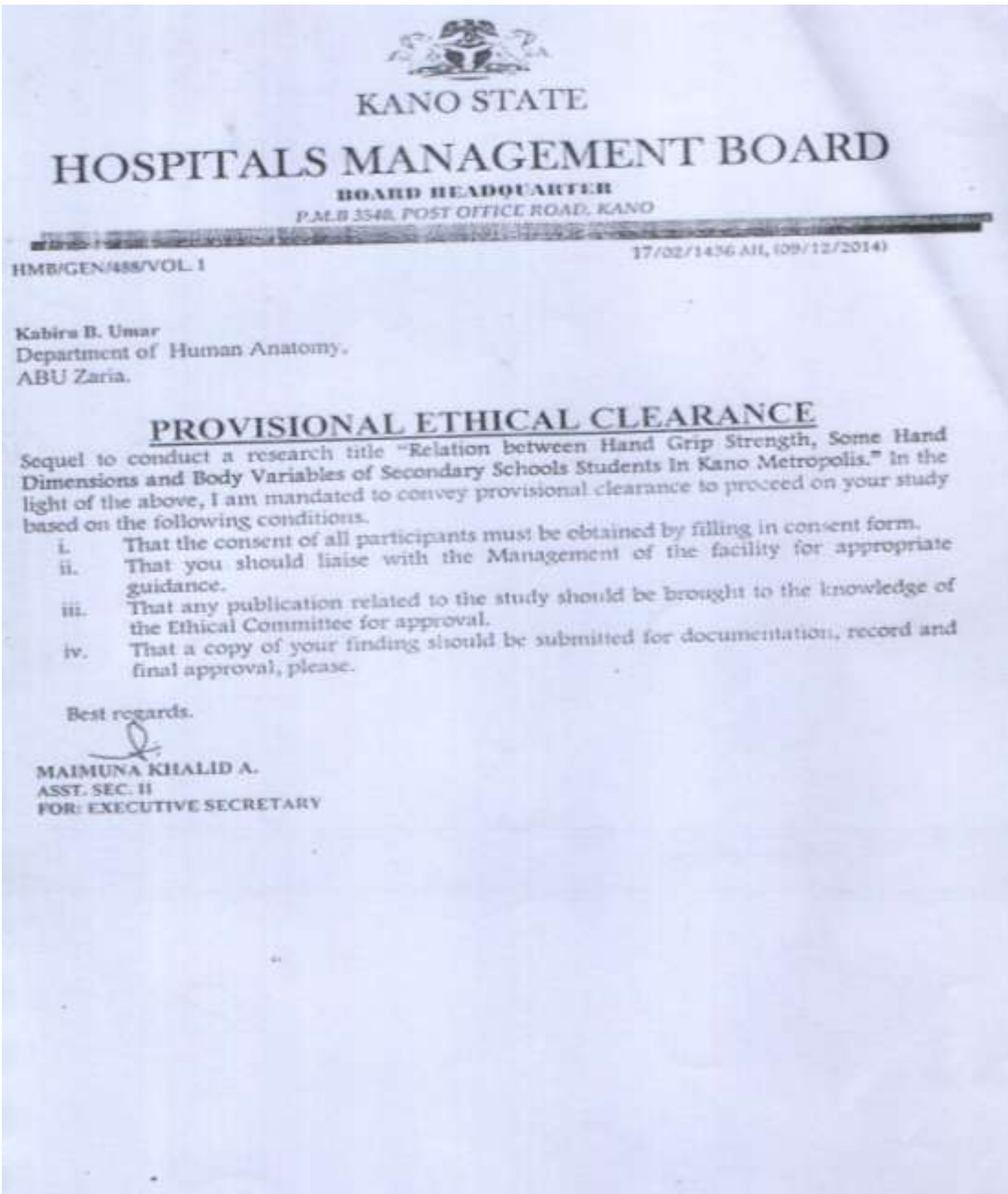
APPENDIX I

LETTER OF APPROVAL FROM THE COMMITTEE ON ETHICS FROM KANO STATE HOSPITAL MANAGEMENT BOARD



KANO STATE

HOSPITALS MANAGEMENT BOARD

BOARD HEADQUARTER

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HMB/GEN/488/VOL. 1

17/02/1436 AH, (09/12/2014)

Kabiru B. Umar
Department of Human Anatomy,
ABU Zaria.

PROVISIONAL ETHICAL CLEARANCE

Sequel to conduct a research title "**Relation between Hand Grip Strength, Some Hand Dimensions and Body Variables of Secondary Schools Students In Kano Metropolis.**" In the light of the above, I am mandated to convey provisional clearance to proceed on your study based on the following conditions.

i. That the consent of all participants must be obtained by filling in consent form.
ii. That you should liaise with the Management of the facility for appropriate guidance.
iii. That any publication related to the study should be brought to the knowledge of the Ethical Committee for approval.
iv. That a copy of your finding should be submitted for documentation, record and final approval, please.

Best regards.

MAIMUNA KHALID A.
ASST. SEC. II
FOR: EXECUTIVE SECRETARY

APPENDIX II

Questionnaire of study on relationship of hand grip strength, some selected hand dimensions and body variables in secondary schools students in Kano metropolis, Nigeria.

Bio Data

1. ID ……… DATE OF BIRTH (DAY/MONTH/YEAR)………………………..………
2. Place of birth …………………… 4. SEX…………………………………
3. Tribe (a) Father…………………… (b) Mother ………………………………

   (c) Grand father……………… (d) Grand mother………………………
4. Handedness ……………………………………

Anthropometry

Hand variables	**Right hand(mm)**	**Left hand(mm)**
1. Hand length;		
2. Hand breadth;		
3. Length of 1st digit;		
4. Length of 2nd digit;		
5. Length of 3rd digit;		
6. Length of 4th digit		
7. Length of 5th digit		
8. 2D:4D ratio		

9. Digit index		
10. Shape index		
11. Palmar length		
12. Palmar width		
13. Palmar length/width ratio		

Body variables	
1. Height (cm)	
2. Weight (Kg)	
3. Waist circumferences (cm)	
4. Hip circumferences (cm)	
5. Waist to hip ratio (cm)	
6. Right hand length to height ratio	
7. Left hand length to height ratio	
8. Body mass index (Kg/m^2)	

	Right hand(kg)	**Left hand(kg)**
Hand grip strength		

APPENDIX III

INTRODUCTORY LETTER

Dear respondent

I am KABIRU B. UMAR, a Master's student of Department of Human Anatomy, Ahmad Bello University, Zaria, conducting a research study on relationship of hand grip strength and some selected hand parameters in secondary school students in Kano metropolis, Nigeria.

Participation is voluntary. It involves collection of some hand dimensions and body variables, grip strength and certain information about you.

The variables and information collected will only be used for above objectives and scientific publication. I assure you that your grip strength and other information will be kept in strict confidence.

Yours faithfully

Kabiru B. Umar

Department of Human Anatomy,

Faculty of Medicine,

Ahmadu Bello University, Zaria

Tel: 08135874401

APPENDIX IV

CONSENT FORM

CONSENT TO PARTICIPATE IN THE RESEARCH

Study on relationship of hand grip strength, some selected hand dimensions and body variables in secondary schools students in Kano metropolis,

You are asked to participate in a research study conducted by KABIRU B. UMAR, from the Department of Human Anatomy, Faculty of Medicine, ABU, Zaria,

If you have any question or concerns about the research, please feel free to contact KABIRU B. UMAR, Department of Human Anatomy, Faculty of Medicine, ABU, Zaria, 08135874401

PURPOSE OF THE STUDY

The study will assess the relationship of hand grip strength, some selected hand dimensions and body variables in secondary schools' students in Kano metropolis

PROCEDURES

The data collection will involve distribution of questionnaire divided into two section as follows;

Section.A (Bio data); here the participant will be ask to fill in some information relevant to his bio data. This can be done in less than 1minute

Section B (Anthropometry that is measurement of body parameters); here the investigator will measure the hand grip strength, then hand dimensions like Hand length, Circumferences and breadth, Length of 1st digit to 5th digit (D5), then body variables Height, Weight, Waist and Hip circumferences, these can be achieved within 3-5 minutes

POTENTIAL RISK AND DISCOMFORT

There is no associated risk with this procedure and the only discomfort may be the time you will sacrifice while taken the measurement.

POTENTIAL BENEFITS TO PARTICIPANT AND/OR TO SOCIETY

This research may be of potential benefit to the participant and/or society in the following ways;

1. Opportunity to know your grip strength, some hand dimension and other important body parameters such as Height, Weight, Body Mass Index, Waist and Hip circumferences among others.
2. The participant may have an opportunity to come in contact with the equipment used in the study as well as gaining knowledge about the names and uses of such equipment
3. For the society in general estimation of hand grip strength is of immense importance in determining the efficacy of different treatment strategies of hand and also in hand rehabilitation.
4. The data on hand dimension may be used to assess grip strength of individuals in the society

PAYMENT FOR PARTICIPATION

Incentive and refreshment will be offered to the participant after participation

CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identify information that is obtained in connection with this study. The variables and information collected will only be used for the aims and objectives of the study as well as scientific publications. I assure you that your grip strength and other information will be kept in strict confidence.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you 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 don't want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise that warrant doing so.

RIGHT OF RESEARCH PARTICIPANTS

You may withdraw you consent at any time and discontinuous participation without penalty. You are waiving any legal claims, right or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through Committee on ethics from Kano State Hospital Management Board. If you have questions regarding your right as a research participant contact; Committee on ethics, Kano State Hospital Management Board.

SIGNATURE OF RESEARCH PARTICIPANTS/ LEGAL REPRESENTATIVE

I have read the information provided for the study titled. Study on relationship of hand grip strength, some selected hand dimensions and body variables in secondary schools students in Kano metropolis, as describe herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form

____

Name of the participant

_______________________________________ _____________________

Signature of the participant Date

SIGNATURE OF THE WITHNESS

____

Name of the witness

______________________________________ _____________________

Signature of the witness Date

APPENDIX IV

TABLES FOR THE CHARTS IN THE RESULT SECTION

Table 1: Comparison of hand grip strength (left and right) between dominant and non-dominant hands across different age groups and sexes

				Mean ± SD			
Age	Handedness	Sex	n	Right HGS	Left HGS	t-value	p- value
15-16	Right Handed	Male	78	32.09 ± 10.08	30.99 ± 9.54	0.702	0.48
	Left Handed	Male	4	29.58 ± 12.04	31.05± 10.83	-0.18	0.86
17-18	Right Handed	Male	140	35.07 ± 7.67	34.07 ± 7.93	1.07	0.29
	Left Handed	Male	14	35.61 ± 8.14	35.13 ± 8.23	0.16	0.88
	Right Handed	Female	185	21.05 ± 4.10	17.45 ± 4.95	6.97	<0.001
	Left Handed	Female	26	18.96 ± 4.58	21.25 ± 4.92	-1.73	0.09
19-20	Right Handed	Male	90	40.36 ± 7.64	38.22 ± 7.52	1.89	0.06
	Left Handed	Male	14	38.94 ± 8.62	40.39 ± 8.54	-0.45	0.66
	Right Handed	Female	113	20.57 ± 4.58	17.74 ± 4.86	4.51	<0.001

Left Handed	Female	17	20.89 ± 6.12	23.97 ± 5.79	-1.50	0.14

SD; standard deviation, HGS; Hand grip strength

Table 2: Sexual dimorphism in right hand grip strength and right hand dimensions among 15 -16 aged group participants

	Male (n= 82)	Female (n= 29)		
Variables	Mean ± SD	Mean ± SD	t	P
RHGS	31.97 ± 10.12	20.98 ± 5.68	5.54	0.000
RHL	186.60 ± 11.48	176.07 ± 10.58	4.34	0.000
RD5	56.05 ± 5.19	59.49 ± 5.09	-3.09	0.003
RD4	71.76 ± 5.41	65.70 ± 5.31	0.52	0.000
RD3	77.23 ± 5.57	75.42 ± 5.61	1.49	0.14
RD2	69.37 ± 5.30	65.61 ± 5.07	3.33	0.001
RD1	64.85 ± 5.50	56.43 ± 6.71	6.69	0.000
RPL	109.37 ± 6.95	100.64 ± 6.71	5.88	0.000
RPW	79.04 ± 6.50	74.64 ± 5.73	3.23	0.002

RHGS; Right Hand Grip Strength, RHL Right Hand Length, RD5; Right Fifth Digit RD4; Right FourthDigit; RD3 Right Third Digit RD2; Right Second Digit RD1; Right First Digit, RPL; Right Palmar Length, RPW; Right Palmar Width. SD; standard deviation.

Table3: Sexual dimorphism in left hand grip strength and left hand dimensions among 15 -16 aged group participants

	Male (n= 82)	Female (n= 29)		
Variables	Mean ± SD	Mean ± SD	t	P
LHGS	30.99 ± 9.53	17.75 ± 5.99	7.00	0.000
LHL	184.58 ± 22.23	175.97 ± 10.41	2.01	0.047
LD5	58.46 ± 5.35	60.59 ± 5.73	-1.81	0.07
LD4	71.95 ± 5.22	65.78 ± 6.26	5.20	0.000
LD3	77.99 ± 5.94	75.96 ± 5.39	1.63	0.11
LD2	69.85 ± 6.39	66.04 ± 5.59	2.85	0.005
LD1	62.14 ± 5.31	56.14 ± 4.76	5.38	0.000
LPL	106.59 ± 20.42	100.02 ± 6.78	1.70	0.09
LPW	78.79 ± 6.47	73.59 ± 7.02	3.65	0.000

LHGS: Left Hand Grip Strength: LHL: Left Hand Length LD5: Left Fifth Digit LD4: Left Fourth Digit LD3: Left Third Digit LD2: Left Second Digit LD1: Left First Digit. LPL: Left Palmar Length LPW: Left Palmar Width SD: standard deviation.

Table 4: Sexual dimorphism in hand grip strength and body variables among 15 -16 aged group participants.

	Male (n = 83)	Female (n =29)		
Variables	Mean ± SD	Mean ± SD	t	P
Height (cm)	158.87 ± 11.37	156.66 ± 9.37	0.94	0.35
Weight (kg)	45.72 ± 8.90	51.14 ± 8.99	-2.81	0.006
Waist circumferences (cm)	65.99 ± 11.48	69.66 ± 9.68	-1.54	0.13
Hip Circumferences (cm)	79.06 ± 7.28	87.52 ±10.10	-4.85	0.000

SD; standard deviation

Table 5: Sexual dimorphism in derived ratios among 15 -16 aged group participants

Male (n = 83)	Female (n =29)

Variables	Mean ± SD	Mean ± SD	t	P
R2D:R4D	0.97 ± 0.05	1.00 ± 0.07	-2.83	0.006
L2D:L4D	0.97± 0.07	1.01 ± 0.09	-2.36	0.02
RPL/W	1.39 ± 0.11	1.35 ± 0.07	1.80	0.07
LPL/W	1.36 ± 0.25	1.37 ± 0.09	-0.20	0.84
W/H	0.85 ± 0.28	0.8S0 ± 0.05	1.03	0.31
RHL:HT	0.12 ± 0.01	0.11± 0.01	2.27	0.03
LHL:HT	0.117 ± 0.02	0.113 ± 0.01	1.28	0.20

R2D: R4D; Right Second and Fourth Digits ratio, LD2: LD4; Left Second and Fourth Digits ratio. RPL/W; Right Palmar Length to Width ratio, LPL/W; left Palmar length to width ratio. BMI; Body Mass Index, W/H; Waist to Hip ratio. RHL: HT; Right Hand Length to Height ratio. LHL: HT; Left Hand Length to Height ratio.

Table 6: Sexual dimorphism in derived indices among 15 -16 aged group participants

	Male (n = 83)	Female (n =29)

Variables	Mean ± SD	Mean ± SD	t	P
RDI	41.38 ± 1.34	42.84 ± 1.87	-4.53	0.000
LDI	42.92 ± 7.50	43.17 ± 1.85	-1.17	0. 86
RSI	42.41 ± 3.25	42.39 ± 1.98	0.04	0.97
LSI	43.35 ± 7.23	41.80 ± 2.93	1.12	0.27
BMI(kg/m2)	18.86 ± 11.47	20.89 ± 3.49	-0.94	0.35

RDI; Right Digit Index, LDI; Left Digit Index, RSI; Right Shape Index, LSI: Left Shape Index, BMI; Body Mass index

Table7: Sexual dimorphism in right hand grip strength and right hand dimensions among 17-18 aged group participants

	Male (n= 154)	Female (n = 211)		
Variables	Mean ± SD	Mean ± SD	t	P

RHGS	35.12 ± 7.69	20.79 ± 4.98	21.56	0.000
RHL	191.64 ± 9.29	175.16 ± 10.01	16.02	0.000
RD5	58.35 ± 5.15	61.61 ± 5.74	-5.60	0.000
RD4	73.82 ± 5.71	66.24 ± 5.27	13.11	0.000
RD3	79.49 ± 5.64	74.69 ± 5.47	8.15	0.000
RD2	71.32 ± 5.96	66.85 ± 5.41	7.47	0.000
RD1	65.67 ± 5.73	53.34 ± 4.99	21.88	0.000
RPL	112.16 ± 5.52	100.45 ± 5.99	19.02	0.000
RPW	82.21 ± 5.79	74.96 ± 6.02	11.55	0.000

RHGS; Right Hand Grip Strength, RHL Right Hand Length, RD5; Right Fifth Digit RD4; Right Fourth Digit; RD3 Right Third Digit RD2; Right Second Digit RD1; Right First Digit, RPL; Right Palmar Length, RPW; Right Palmar Width. SD; standard deviation

Table8: Sexual dimorphism in left hand grip strength and left hand dimensions among 17-18 aged group participants.

	Male (n= 154)	Female (n = 211)		
Variables	Mean ± SD	Mean ± SD	t	P
LHGS	34.17± 7.93	17.91 ± 5.09	23.80	0.000

LHL	202.36 ± 91.18	175.20 ± 11.60	4.28	0.000
LD5	58.94 ± 4.87	60.43 ± 5.12	-2.80	0.005
LD4	74.53 ± 5.41	65.70 ± 5.14	15.85	0.000
LD3	80.55 ±5.51	74.44 ± 7.67	8.42	0.000
LD2	71.64 ± 5.14	67.39 ± 5.85	7.20	0.000
LD1	63.68 ± 5.96	54.56 ± 5.20	15.57	0.000
LPL	111.42 ± 12.93	100.75 ± 6.14	10.47	0.000
LPW	80.99 ± 5.06	73.78 ± 6.10	12.00	0.000

LHGS: Left Hand Grip Strength: LHL: Left Hand Length LD5: Left Fifth Digit LD4: Left Fourth Digit LD3: Left Third Digit LD2: Left Second Digit LD1: Left First Digit. LPL: Left Palmar Length LPW: Left Palmar Width. SD; Standard deviation.

Table9: Sexual dimorphism in body variables among 17-18 aged group participants.

	Male (n= 154)	Female (n = 211)		
Variables	Mean ± SD	Mean ± SD	T	P
Height (cm)	164.14 ± 6.81	157.44 ± 9.29	7.59	0.000

Weight (kg)	50.70 ± 7.99	49.49 ± 7.49	1.47	0.14
Waist circumference (cm)	68.05 ± 5.41	68.88 ± 8.17	-0.99	0.32
Hip circumferences (cm)	83.14± 6.50	86.61 ± 8.41	-4.28	0.000

SD: standard deviation.

Table10: Sexual dimorphism in derived indices and ratios among 17-18 aged group participants.

	Male (n=154)	Female (n= 211)		
Variables	Mean ± SD	Mean ± SD	t	P
R2D:R4D	0.97 ± 0.08	1.01 ± 0.07	-5.41	0.000

L2D:L4D	0.96 ± 0.07	1.03 ± 0.07	-8.73	0.000
RPL/W	1.37 ± 0.09	1.35 ± 0.10	2.19	0.03
LPL/W	1.50 ± 1.11	1.37 ± 0.10	1.72	0.09
W/H	0.82 ± 0.06	0.79 ± 0.07	3.37	0.001
RHL:HT	0.12 ± 0.01	0.11 ± 0.01	8.91	0.000
LHL:HT	0.12 ± 0.06	0.11 ± 0.01	2.97	0.003

R2D; R4D; Right Second and Fourth Digits ratio: LD2: LD4; Left Second and Fourth Digits ratio. RPL/W; Right palmar length to width ratio. LPL/W; left palmar length to width ratio. W/H; Waist to Hip ratio. RHL: HT; Right hand length to Height ratio. LHL: HT; left hand length to height ratio.

Table11: Sexual dimorphism in derived indices and ratios among 17-18 aged group participants.

	Male (n= 154)	Female (n=211)		
Variables	Mean ± SD	Mean ± SD	t	P

RDI	41.45 ± 1.77	42.63 ± 1.67	-6.50	0.000
LDI	41.73 ± 5.83	42.4 ± 3.10	-1.42	0.16
RSI	42.95 ± 3.05	42.87± 3.47	0.26	0.80
LSI	41.97 ± 6.14	42.22 ± 4.01	-4.75	0.64
BMI(kg/m^2)	18.75 ± 2.31	20.05 ± 3.12	-4.37	0.000

RDI; Right digit Index, LDI: Left Digit Index, RSI; Right Shape Index, LSI: Left Shape Index BMI; Body mass

Table12: Sexual dimorphism in right hand grip strength and right hand dimensions among 19-20 aged group participants.

	Male (n= 104)	Female (n= 130)

Variables	Mean ± SD	Mean ± SD	t	p
RHGS	40.17 ± 7.75	20.61 ± 4.78	23.68	0.000
RHL	196.56 ± 11.18	175.42 ± 9.86	15.35	0.000
RD5	59.60 ± 4.07	61.65 ± 5.41	-3.21	0.002
RD4	75.02 ± 5.11	66.71 ± 5.04	12.46	0.000
RD3	80.88 ± 6.99	75.02 ± 5.27	7.31	0.000
RD2	73.42 ± 4.66	67.57 ± 5.10	9.05	0.000
RD1	67.49 ± 4.80	54.25±4.22	22.44	0.000
RPL	115.68 ± 6.06	100.40±5.76	19.70	0.000
RPW	83.98 ± 5.84	75.79 ± 5.96	10.54	0.000

RHGS: Right Hand Grip Strength, RHL Right Hand Length, RD5: Right Fifth Digit RD4: Right Fourth Digit: RD3 Right Third Digit RD2: Right Second Digit RD1: Right First Digit, RPL: Right Palmar Length, RPW: Right Palmar Width. LPW, SD: standard deviation.

Table13: Sexual dimorphism in left hand grip strength and left hand dimensions among 19-20 aged group participants

	Male (n= 104)	Female (n= 129)		

Variables	Mean ± SD	Mean ± SD	T	P
LHGS	38.51 ± 7.66	18.55 ± 5.39	23.35	0.000
LHL	196.94 ± 13.34	176.15 ± 10.39	13.40	0.000
LD5	60.71± 4.42	60.22 ± 4.57	0.83	0.41
LD4	75.99 ± 5.26	66.16 ± 5.22	14.26	0.000
LD3	82.03 ± 5.04	75.14 ± 5.75	9.62	0.000
LD2	73.52 ± 4.67	68.03 ± 5.29	8.30	0.000
LD1	64.38 ± 4.83	55.56 ± 4.12	15.07	0.000
LPL	114.91 ± 11.43	101.02 ± 5.89	12.01	0.000
LPW	83.31 ± 4.45	74.76 ± 6.76	11.10	0.000

LHGS: Left Hand Grip Strength: LHL: Left Hand Length LD5: Left Fifth Digit LD4: Left Fourth Digit LD3: Left Third Digit LD2: Left Second Digit LD1: Left First Digit. LPL: Left Palmar Length LPW: Left Palmar Width SD: standard deviation.

Table 14: Sexual dimorphism in body variables among 19-20 aged group participants

	Male (n= 104)	Female (n= 129)		
	Mean ± SD	Mean ± SD	t	P

Height	168.92 ± 7.61	157.01 ± 12.36	8.60	0.000
Weight	56.48 ± 6.84	51.70 ± 9.19	4.42	0.000
Waist circumference	71.17 ± 11.51	70.69 ± 9.69	0.34	0.73
Hip circumferences	87.09 ± 4.72	87.97 ± 11.56	-0.73	0.47

SD; standard deviation, SEM; standard error of mean.

Table15: Sexual dimorphism in derived indices and ratios among 19-20 aged group participants

	Male n= (104)	Female (n= 129)		
Variables	Mean ± SD	Mean ± SD	t	P

R2D: R4D	0.98 ± 0.07	1.02 ± 0.07	-3.93	0.000
LD2: LD4	0.97 ± 0.055	1.03 ± 0.07	-7.27	0.000
RPL/W	1.38 ± 0.10	1.33 ± 0.09	4.16	0.000
LPL/W	1.38 ± 0.14	1.36 ± 0.09	1.43	0.16
W/H	0.82 ± 0.10	0.81 ± 0.09	0.51	0.61
RHL:HT	0.12 ± 0.01	0.11 ± 0.01	2.94	0.004
LHL:HT	0.117 ± 0.10	0.11 ± 0.01	2.65	0.009

R2D: R4D; Right Second and Fourth Digits ratio: LD2: LD4; Left Second and fourth Digits ratio. RPL/W Right palmar length to width ratio. LPL/W; left palmar length to width ratio, W/H; waist to hip ratio. RHL: HT; Right hand length to Height ratio. LHL: HT; left hand length to height ratio.

Table16: Sexual dimorphism in derived indices among 19-20 aged group participants

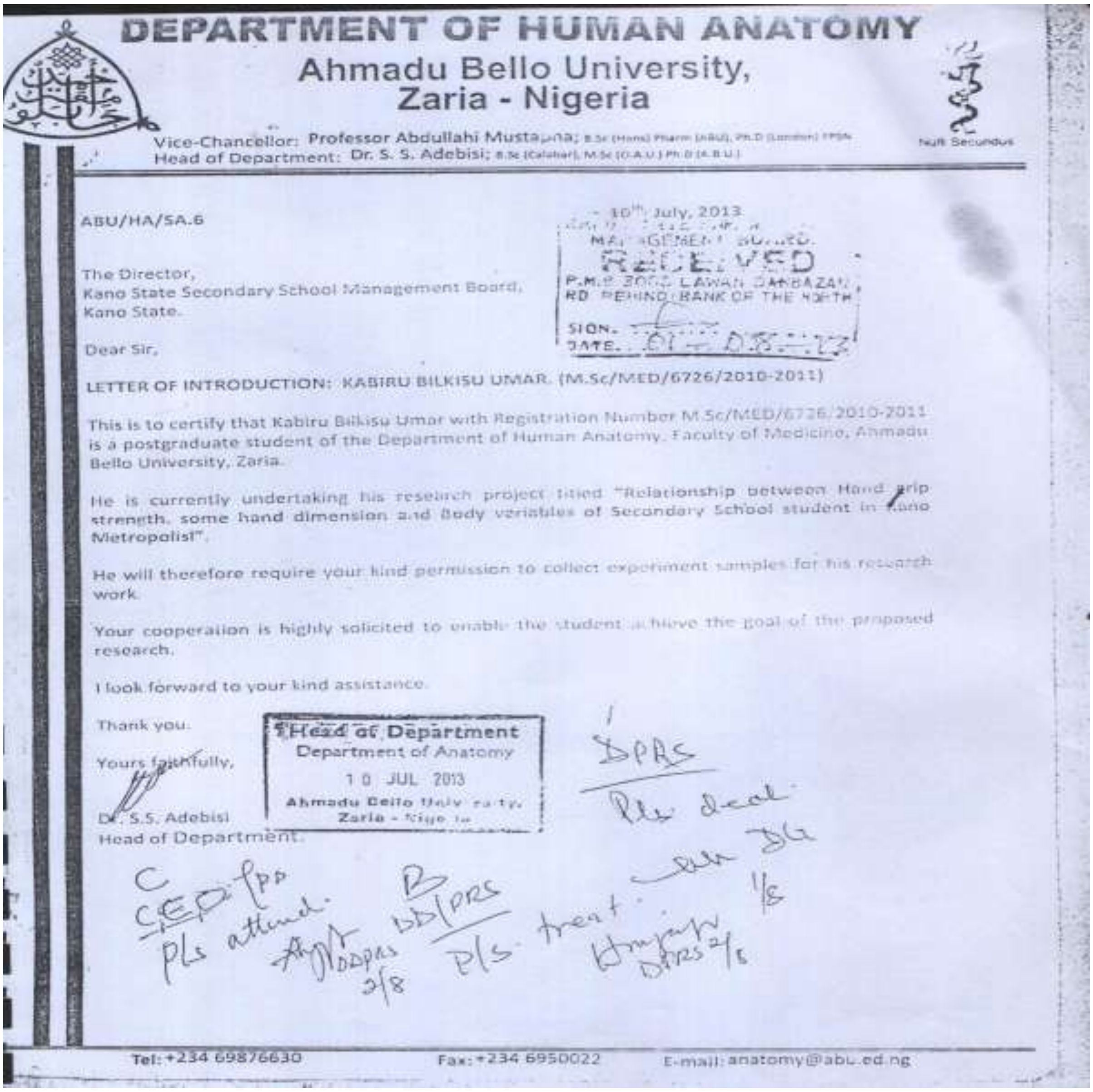
	Male, (n= 104)	Female(n= 129)		
Variables	Mean ± SD	Mean ± SD	t	p

RDI	41.09 ± 2.24	42.75 ± 1.42	-6.91	0.000
LDI	41.73 ± 2.23	42.63 ± 1.54	-3.64	0.000
RSI	42.83 ± 3.60	42.88 ± 4.92	-0.09	0.93
LSI	42.43 ± 2.91	42.10 ± 4.90	0.62	0.54
BMI	19.85 ± 2.67	22.05 ± 15.86	-1.40	0.16

RDI; Right Digit Index, LDI: Left Digit Index, RSI; Right Shape Index, LSI; Left Shape Index, BMI; Body mass index

APPENDIX VI

LETTER OF INTRODUCTION FROM DEPARTMENT OF HUMAN ANATOMY, FACULTY OF MEDICINE, ABU ZARIA



DEPARTMENT OF HUMAN ANATOMY

Ahmadu Bello University, Zaria - Nigeria

Vice-Chancellor: Professor Abdullahi Mustapha; B.Sc (Hons) Pharm (ABU), Ph.D (London) FPSN
Head of Department: Dr. S. S. Adebisi; B.Sc (Calabar), M.Sc (O.A.U.) Ph.D (A.B.U.)

Nulli Secundus

ABU/HA/SA.6

10th July, 2013

MANAGEMENT BOARD
RECEIVED
P.M.B. 3003, LAWAN DANBAZAU RD. BEHIND BANK OF THE NORTH
SIGN.
DATE. 01-08-13

The Director,
Kano State Secondary School Management Board,
Kano State.

Dear Sir,

LETTER OF INTRODUCTION: KABIRU BILKISU UMAR. (M.Sc/MED/6726/2010-2011)

This is to certify that Kabiru Bilkisu Umar with Registration Number M.Sc/MED/6726/2010-2011 is a postgraduate student of the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria.

He is currently undertaking his research project titled "Relationship between Hand grip strength, some hand dimension and Body variables of Secondary School student in Kano Metropolis".

He will therefore require your kind permission to collect experiment samples for his research work.

Your cooperation is highly solicited to enable the student achieve the goal of the proposed research.

I look forward to your kind assistance.

Thank you.

Yours faithfully,

Dr. S.S. Adebisi
Head of Department

Head of Department
Department of Anatomy
10 JUL 2013
Ahmadu Bello University,
Zaria - Nigeria

DPRS
Pls deal
DG 1/8

CEP/PP
Pls attend.
DD/PRS 2/8
P/s treat
DPRS 2/8

Tel: +234 69876630 Fax: +234 6950022 E-mail: anatomy@abu.ed.ng

APPENDIX VII

LETTER OF INTRODUCTION FROM KANO STATE SENIOR SECONDARY SCHOOL MANAGEMENT BOARD

KANO STATE SENIOR SECONDARY SCHOOLS MANAGEMENT BOARD
GIDAN MALAMAI
No. 1 Lawan Danbazau Link behind Bank of the North Headquarters, Kano.
Tel: 064-318855, 665420, 661948, 667884, 667169

Our Ref: ______ Your Ref: ______ Date: 12th August, 20[illegible]

The Zonal Education Officer ______
Dala, Municipal and Nassarawa Zonal Education Officers Kano.

Dear Sir,

INTRODUCTION LETTER

I am directed to introduce Umar Kabir [illegible]
a researcher from Ahmadu Bello University Zaria.
He/She is conducting a research on Relationship between hand grip strength, some hand dimensions and body variables of Secondary Schools Students in Kano metropolis.
in your zone. The Board expects you to give him/her all the necessary assistance during the research. Your usual cooperation is highly appreciated by the Board.

Best regards,

[signature]

SHUAIBU KASSIM ABUBAKAR,
C.E.O PUBLICATION/DOCUMENTAION,
FOR: DIRECTOR GENERAL