STATURE ESTIMATION AND SEXUAL DIMORPHISM FROM BODY PROPORTIONS OF CHILDREN AND ADULTS IN CROSS RIVER STATE, NIGERIA

BY

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BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (PhD) DEGREE IN ANATOMY

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FEBRUARY, 2022

DECLARATION

I, KOKO OTTOH ARIKPO declare that the work in the thesis titled **''Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria''** was carried out by me in the Department of Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria. The information used for my literature review was fully acknowledged in the text and references. This thesis has not been presented in any scientific gathering, neither has it been presented for another degree or diploma at any University.

KOKO OTTOH ARIKPO _____ _____

SIGNATURE **DATE**

CERTIFICATION

This thesis entitled **''Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria''** by Koko Ottoh Arikpo meet the regulation governing the award of Doctor of Philosophy (PhD) degree in Department of Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria, under the supervision of **Prof. B. Danborno, Dr. J. A. Timbuak and Dr. M. Tanko.** It is therefore approved for the contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the Almighty God for His special grace, favour, sound health and providence. Also, to my mother Mrs. Mercy Arikpo Ottoh, and all my sisters for their love, support, encouragement, patience, care and prayers towards my academic pursuits.

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LIST OF ABBREVIATIONS

CRS: Cross River State

SSZ: Southern Senatorial Zone

CSZ: Central Senatorial Zone

NSZ: Northern Senatorial Zone

SSD: Sexual Size Dimorphism

SDI: Size Dimorphism Index

ABSTRACT

It is important to consider that biological variation among humans has biomedical, forensic, and socio-political implications. As such, the study of human variation and evolution has formed the basis of anthropological inquiry for centuries and continues to be a major source of plot and inspiration for modern scientific research. Stature prediction from body proportions and fragmented body parts of an individual plays a significant role in forensic examinations and anthropological research. It provides insight into a population, defines the ethnic variability of the population and provide significant evidence in the medico-legal investigation for the establishment of identity. The study aimed to determine the anthropometric variables, estimate stature and determine sexual dimorphism from body proportions of children and adults in the Southern, Central and Northern senatorial zones of Cross River State, in order to establish a reference data base for the relationship between body proportions, stature and sexual dimorphism in the study population as stature equations are population specific. The study sample comprised 1200 subjects (600 males and 600 females) of Cross River State parentage using systematic random sampling and self-administered proforma which were completed by the enumerators, aged 5 to 45 years who volunteered and satisfied the inclusion criteria. The study protocol was divided into four age groups, from children (5 to 11 years), adolescents (12 to 17 years), young adults (18 to 30 years) and adults (31 to 45 years). In order to examine the rate of change across age groups, male and female samples from the four age bands were considered separately. The study showed that the mean age of the subjects in the entire population was 20.35 ± 10.70 years. The average ages of the subjects from Southern, Central and Northern senatorial zones were 20.12 ± 10.38, 20.61 ± 10.77 and 20.31 ± 10.95 years, respectively. The mean height of the population was 153.09 ± 17.98 cm, with a mean height for males and females 155.88 ± 20.13 cm

and 150.29 ± 15.03 cm, respectively, indicating that the males were significantly taller in stature when compared to the females (t = 5.46, $P < 0.001$). The mean height for Southern, Central and Northern senatorial zones were 152.90 ± 17.16, 154.44 ± 18.01 and 151.92 ± 18.68 cm, respectively, indicating that the subjects from the Central senatorial zone are significantly taller in stature when compared to subjects from the Southern and Northern senatorial zones ($P < 0.001$). Girls from the Southern senatorial zone and Central senatorial zone have larger anthropometrics than the boys, except the Northern senatorial zone where boys are presented with higher anthropometrics when compared to the girls. Males are presented with higher anthropometrics in the adolescent, young adult and adult age groups when compared to their female counterparts. Also, males showed higher correlation between measured variables and stature compared to females. Linear and multiple regression models for stature estimation from anthropometric variables of each senatorial zone were generated. Demispan length had the highest precision as single prediction parameter. This study has demonstrated that stature can be predicted from body proportions, with the demispan length showing more accuracy and reliability than the other measured variables.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Human beings, when viewed in their totality, exhibit an impressive array of variation in their physical morphology, which correlates with our ability to adapt to diverse environments. One of the most notable aspects of this variation is stature, or standing height, which can range from very short individuals such as the Efe pygmies from Africa to very tall individuals such as many modern Dutch Europeans (Bogin and Varela-Silva, 2010; Baten and Blum, 2012). Our ability to observe this variation globally allows us to take it for granted, but the range of stature within regional populations in the ancient world have been understudied. Numerous studies have clearly demonstrated that skeletal characteristics vary by population and that there is a need for population specific standards for stature and sex determination. This considerable differences in body proportions have important implications for stature estimations based on body remains. To address these differences, specific formulae have been generated for certain populations (De Mendonca, 2000). The physical proportions of the human body vary not only with ethnic origin, but are also influenced by several factors, including time, genetics, nutrition, ecological context, geographical context, racial, age and gender factors (Golalipour *et al.*, 2003). All of these factors blend in unique proportions to give variations in the physical dimensions of the human body. Physical anthropology which most likely started due to interest in racial taxonomy provides the various methods by which human body dimensions can be estimated and measured (Golalipour *et al.*, 2003). Different researchers have shown the advantage of anthropometric measurement as a tool for studying the variation in human population and its importance in forensic science for crime investigation (Oladipo *et al.*, 2008). Height is one of the main criteria used in identifying human beings. This is based on the principle that an individual's height has a

defined proportional relationship with the various parts of the body (Agnihotri *et al.*, 2011). Anatomical and mathematical methods form the two main tools used in forensic anthropology for estimating height. The anatomical method consists of measuring and adding together all the skeletal elements that contribute towards an individual's height, with a correction factor for soft tissues. The mathematical model consists of derivation of formulae through linear correlations that exist between given parts of the body and height (Aragao *et al.*, 2019). For this calculation, some studies have demonstrated that regression analysis is the most reliable method (Sahni *et al.*, 2010). However, this procedure assumes equivalent linear proportions in the reference and target samples, which can be problematic given widespread temporal and geographic variation in such proportions. Alternatively, stature can be reconstructed directly through the addition of lengths or heights of skeletal elements from the foot through the skull (Auerbach and Ruff, 2010). The advantage of this approach is that body proportions are inherently incorporated. The main disadvantage is the need for relatively complete skeletons, limiting applications in many archaeological and paleontological samples. However, if a sufficiently large subsample of individuals with the necessary skeletal elements are available, it is possible to employ a "hybrid" approach in which stature is estimated anatomically in those individuals, and then used to develop sample-specific mathematical equations for estimating stature from long bone lengths in other less complete specimens. The hybrid approach has been carried out for a variety of samples, ranging from single populations or closely related populations (Raxter *et al.*, 2008; Maijanen and Niskanen, 2010; Sladek *et al.*, 2015; Mays, 2016) to geographically and temporally more extended samples (Auerbach and Ruff, 2010; Ruff *et al.*, 2012). Regression equations derived from broader samples are potentially advantageous when true population-specific equations cannot be derived, however, the extent to which they are applicable to specific samples

may be uncertain without more information on body proportions within the target samples (Ruff *et al.*, 2019).

Stature is a fundamental human body size characteristic that has often been used to assess environmental effects on morphology, both developmental and evolutionary, in living and past populations (Ruff *et al.*, 2019). Stature is the height of the person in upright posture and this parameter determine the physical identity of an individual. Before estimating stature, one must determine the race, sex, and age of the individual as stature varies with these variables. Potential stature refers to the stature of an individual who has not undergone skeletal changes associated with the aging process. These changes do not occur in most people who are 30 years of age or less at the time of death (Pungle and Munjamkar, 2017). Living stature refers to the stature of an individual who has undergone degenerative changes associated with the aging process which results in a decrease in stature. Most people who are 30 years old or older at the time of death have undergone some of these changes (Pungle and Munjamkar, 2017). Estimation of stature from long bone length to body height ratio has been shown to vary among populations, and even among individuals. Meadows and Jantz (1999) noted that such proportional changes are more pronounced in distal bones. Many anthropologists and forensic scientists use a single formula devised by Trotter and Gleser (1952, 1958) to estimate height. No detailed study has investigated whether different height calculations should be used for different stature groups (tall, medium, and short), (Duyar and Pelin, 2003). Anthropologists usually want to explain some phenomena in society (how people lived in the past, present or in the future) such as group forming, hierarchy and interaction of populations. Utilization of human bones make it possible to add further aspects to the list: demography, biological relations and health. Further it is possible to research social status, equality and the tasks of men and women in society and nutrition from biological perspective. In the analysis of any skeletal remains, the first task of a researcher is the

determination of sex, age and stature of the individuals. Whatever the ultimate research goal, this information constitutes the basic data. Moreover, in any paleo-demographic, forensic or anthropological study the reliability and accuracy of these data are of paramount importance (Tamer, 2012). Although several parts of the body can be used for sex, age and stature estimation, the poor condition of the remains in particularly severe crashes or fire as in cases of those recently dead, or of moisture and burial conditions in the case of historic subjects, make many parts of the body unusable. For these reasons, the mandible was selected for analysis for two simple reasons: firstly, there appears to be a paucity of standards utilizing this element; and secondly, this bone is often recovered largely intact (or complete enough to yield diagnostic fragments) compared to other more porous and less dense skeletal elements (e.g. humerus, radius, ulna, scapula, femur, sternum, tibia and fibular), as it is well known that the probability of a particular skeletal element surviving damaging taphonomic processes is strongly correlated with its structural density (g/cm^3) (Lyman , 1994). The most important pieces of information gathered from bone analysis is the sex, age and stature of an individual. There are several different ways to extract this information from human remains. The only method that can give a totally accurate result is the DNA technique, but in many cases for several reasons it cannot be used. Anthropological measurements of the skeleton and the comparison with existing standard data must then be applied and may help to differentiate between male and female remains noting that on an individual basis however, gender differences are not always distinctive, but taken collectively they can give a good indication in the majority of cases (Tamer, 2012). Bioanthropological research must be built upon a foundation of accurate sex, age and stature estimates. Unfortunately, there are inherent biases which guarantee a certain amount of error in the assessment of these fundamental variables, certain biases that are seemingly unavoidable using any relative standard for sex, age and stature estimation.

Regression analysis stands out as one of the statistical methods that is often put to use in physical anthropology. Its utilitarian value and availability in statistical packages are largely what makes it a preferred method. Existing studies have estimated stature from the length of diverse long bones using either multiplication factors or regression formulae (Pungle and Munjamkar, 2017). Some other researchers have also estimated stature from the perspective of body parts such as hand and foot lengths; head length and arm span (Pawar and Dadhich, 2012, Jervas *et al.*, 2014). The interest of the present study, however, was to determine the correlation between body proportions and stature, determine sexual dimorphism, and to also derive regression equations for the estimation of stature from body proportions. Even though several studies on the relationship between stature and bone measurements are available, they are mostly in relation to western populations while data available on Cross River State subjects is quite limited.

1.2 Statement of Research Problem

It is important to develop ways of making proper identification of victims using the techniques of forensic anthropology. Since stature is one of the most important elements in the identification of an individual, there is a need to have representative anthropometric baseline equations for all populations. Predictive equations for stature estimation are been established across the global populations including Nigeria, but sex and age-group specific equations are not available in Nigerian population, especially Cross River State. Recently, the relationship between body proportions has been used to compare and highlight variations between different ethnic populations, however, there are paucity of standards utilizing these inter-relationships in children and adults' males and females who are indigenous to Cross River State. No study has been reported in the Nigerian population that used bigonial width and mandibular arch for the estimation of

stature. The use of bigonial width, mandibular arch length and other body proportions to predict stature among the Southern, Central and Northern populations of Cross River State is a step to bridge the existing gap and to stimulate further research.

1.3 Justification of the Study

Studies have been done in different regions on different ethnicity and races. However, their predictive equations formulae cannot be generalized. Many studies have been conducted in different ethnic groups to estimate stature from the length of long bones, because the long limb bones have got a definite correlation to the height of an individual (Agnihotri *et al.,* 2009; Danborno and Elukpo, 2008). This relationship between body segments has been used to compare and highlight variations between ethnic groups using somatometric measures. Recent studies have observed differential limb proportions between two sexes and among different populations. For example, Negros have relatively long arms and legs. Therefore, the formulae derived from one population cannot be applied with accuracy for others necessitating the need to evaluate various data which are both population and sex specific. This emphasizes the need for further investigation using additional parameters for accuracy and reliability. This study could provide a reference data base for the association between anthropometric variables considered in this study and stature in Cross River State populations. Comparisons made with other populations could contribute to the understanding of the relative status of Cross River State population in the context of the anthropometric variations around the world. In forensic anthropology, this study can help medico-legal cases in establishing identity of an individual when only remains or body parts such as mandible and limbs are found in mass disasters, bomb explosion, motor accidents etc., in children and adults of Cross River State.

1.4 Aim and Objectives of the Study

1.4.1 Aim of the study

The aim of this study was to determine the anthropometric variables, estimate stature and determine sexual dimorphism from body proportions of children and adults in the Southern, Central and Northern senatorial zones of Cross River State, Nigeria.

1.4.2 Objectives of the study

The objectives of this study were to:

i. determine sexual dimorphism using anthropometric parameters of children and adults that was used in stature estimation.
ii. formulate model for stature estimation and gender prediction from body proportions.
iii. formulate sex and age-group specific predictive equations for stature estimation in the study populations.
iv. determine the relationship between length of mandibular arch and bigonial width with the view of estimating stature from them.
v. determine the predictive role of hand and foot in the estimation of stature.
vi. determine the effect of multiple variables in the strength of predictive equations for stature estimation.
vii. determine if there is clinal distribution in height and predictive equations in the study population from Southern, Central to Northern Cross River State.

1.5 Scope of the Study

This study is limited to only people from the Southern, Central and Northern senatorial zones of Cross River State, Nigeria. In the Southern senatorial zone, this study covers people from Akamkpa, Odukpani and Calabar Municipal L.G.A. In the Central senatorial zone, this study covers people from Yakurr, Abi and Ikom L.G.A. In the Northern senatorial zone, this study covers people from Ogoja, Obudu and Obanliku L.G.A. The

variables collected include hand length, hand breadth, leg length, foot length, foot breadth, thigh length, neck length, wrist breadth, ankle breadth, bigonial width, mandibular arch length, demi span length, biaxillary length and sitting height of both males and females.

1.6 Research Hypotheses

In order to investigate the above listed objectives, the following working hypotheses were proposed:

i. body proportions will significantly predict stature in both males and females in the study population.

ii. predictive equations will be specific in each of the study population.

iii. there will be correlations between stature and some anthropometric length parameters of the body in the study population.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Forensic Anthropology and Anthropological Genetics

Generally, forensic science is concerned with the application of scientific principles in the investigation of crime. It is the use or application of science in courts or legal proceedings (Yadav and Singh, 2011). The term *forensic* comes from the Latin word *forensis*, meaning public. The modern definition of forensic means to be suitable for the courts, thus, forensic science is any science used for the purpose of law. When a scientist applies his/her knowledge to assist juries, judges, and attorneys in criminal and civil cases, he/she is now a forensic scientist. Forensic scientists perform chemical and physical tests on evidence submitted by police officers to resolve legal issues. In the Roman era, a criminal charge meant presenting the case before a group of public individuals in the forum. Both the accused of the crime and accuser would give speeches based on their sides of the story. The individual with the best argument and delivery would determine the outcome of the case (Yadav and Singh, (2011). Forensic anthropology is a discipline, which assists considerably in the identification of human remains (full or partially skeletonized) that have been missing for some time. It is the application of the science of physical anthropology to the legal process. The identification of skeletal, badly decomposed or otherwise unidentified human remains is important for both legal and humanitarian reasons. Forensic anthropology as sub discipline of physical anthropology looks critically into the skeletal remains with the aim

of determination of age, race, sex, and stature – the big four profiles of forensic anthropology. Recently, the range of interests of forensic anthropology is being expanded as anthropological expertise is requested in the identification and aging of living individuals (Adebisi, 2008). The focus of forensic anthropology is in obtaining information about the individual from the population (basically, the opposite goal of physical anthropology), that is, it looks into the population parameters to answer questions regarding a specific individual.

Forensic anthropology heavily applies the principles utilised in the anthropological subfields of archaeology and physical anthropology to forensic investigations. Archaeological principles are employed during the search for, recovery, and preservation of physical evidence at the outdoor scene and emphasize documentation of contextual relationship of all evidence to its depositional environment. In the other hand, physical anthropological principles are employed during the laboratory analysis of human remains and focus on reconstruction of identity and events surrounding, and subsequent to death often heavily reliant upon contextual data collected at the site (Dirkmaat and Adovasio, 1997). While interactions between biology and culture defines the field of biological anthropology, anthropological genetics is an amalgamated discipline with its origins drawn from developments in evolutionary biology, population genetics and biological anthropology (Gonder *et al.,* 2007; Omkar *et al.,* 2009). It is concerned with understanding human evolution through genetic and biological variation, from which it also provides tools for reconstructing population history (Marks, 2012). The discipline today is a dynamic one that has benefited from developments in molecular biology and the more recent field of bioinformatics (Lander *et al.,* 2001; Mardis, 2008). This has made possible the availability of a vast array of genetic markers to aid genomic analysis in contrast to the earlier approach where research in the field utilized only a limited

number of classical polymorphisms. It is reasoned that the array of genetic variation in modern humans have been influenced by the history of our ancestors (Tish-koff and Gonder, 2007). Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of human body and skeleton (Adebisi, 2003; 2008). The use of anthropometry in the field of forensic science and medicine dates back to 1882 when Alphonse Bertillon invented a system of criminal identification based on anthropometric measurements (Krishan, 2007a). His system was based on three fundamental ideas – the fixed condition of the bone system from the age of twenty till date, the extreme diversity of dimensions' present in the skeleton of one individual compared to those in another, the ease and relative precision with which certain dimensions of the bone structure of a living person can be measured using simply constructed callipers. The application of anthropometry in forensic science is referred to as forensic anthropometry (Krishan, 2007a).

2.2 Anthropological Background of Stature Estimation

The significance of forensic anthropology in medico-legal investigations has developed to be more common over time, with an increasing number of cases involving human remains (Sahar *et al.,* 2016). The establishment of identity has an important judicial and criminal significances. Mass fatalities and victims of traffic accidents deserve a special concern in identity establishment. Thus, appropriate practice and experience in identification by the collection of the available and appropriate data concerning the victims is indispensable (Knight and Saukko, 2004). Although the final and definitive identification of human remains may require DNA evidence, the forensic anthropologist provides a rapid, low-cost, and convenient way of narrowing down the focus of an investigation. The preliminary answers sought from any anthropologist include whether

studied remains are human, and what are the probable age, sex and stature of the deceased (Linda and Klepinge, 2006). Thus, constructing a biological profile from skeletal remains is one of the main aims of any forensic pathologist while other researches tend to focus on the formulation of sex estimation standards using measurements taken from long bones of the body (Braz, 2009). Stature estimation is used in a similar trend as with crime scene investigation to narrow down the possible identities of victims. Establishment of identity is paramount in forensic examination where only some parts or fragments of the body are available. This is usually seen in incidents like earthquake, bomb blast, airplane crash, mutilation by animal etc., where calculating the stature correctly can prove to be a major step forward in establishing personal identity of an individual (Krishan, 2008). Many studies have been done in the past to estimate the stature from various body parameters such as long bones, hand length, hand breadth, foot length, foot breadth, biaxillary length etc., but it has been found that cranial dimensions are more reliable in predicting the stature correctly (Pawar and Dadhich, 2012; Ekezie *et al.,* 2014). Estimation of stature is one of the most important steps in determining the identity of unknown, highly decomposed or mutilated human bodies as stature is one of the most important anthropometric parameters that determines the physical identity of an individual. Stature like other body parameters is determined by many factors such as genetics, environment and nutrition etc. (Sanli *et al.,* 2005). Stature has definite and proportional relationship with each and every part of human body and this relationship varies greatly in people of different area, race, ethnicity etc. (Ritesh *et al.,* 2018). By measuring the different body parts and stature of the healthy subjects, one can use the regression analysis method which is universally accepted to provide the best estimates for stature calculation for accurately predicting the stature in a particular population or race (Iscan, 2005). Forensic reports based on skeletal remains of adults commonly include an estimate of stature. If the remains are from a child, however, this potentially

helpful characteristic is generally omitted. Whereas long bones are commonly used for adult stature estimation, when long bones appear in a forensic case involving a child, they are more likely to be used for estimating age rather than stature (Kondo *et al.*, 2000). Contrary to abundant references for estimating adult stature from limb bone lengths, those for immature specimens are very limited. For a child, age is a critical identifying variable, and stature is less often a key factor leading toward a positive identification (Shelley, 2007). In some cases, however, such as those involving commingling of remains or victims of war or mass disasters, stature estimation will be important. For example, in the Oklahoma case with two missing girls of similar age as contained in Shelley, stature estimation based on a femoral fragment proved to be critical in the final identification of one of the girls. In a more recent case, stature estimates, based on humeral length, were also important for individual identification, along with the state of ossification centers (Shelley, 2007).

Many studies have been conducted confirming that the systematic diagnosis of children's height and the regular measurement of other body proportions can yield beneficial information about children's development (Fredriks *et al.*, 2015). In essence, stature is one of the most important variables when assessing the growth of children and their nutritional status, evaluating the basic energy requirements, adjusting the measures of physical capacity and predicting appropriate drug dosage and setting standards of physiological variables (Datta Banik, 2011; Golshan *et al.*, 2003, 2007; Mohanty *et al.*, 2001; Ter Goon *et al.*, 2011), while one of the most generally known protocols for predicting children's body proportions is to derive the stature-to-sitting height ratio and calculate it with reference to age (Fredriks *et al.*, 2015). Moreover, stature cannot always be measured in the typical way, because deformities, such as scoliosis, kyphosis, fractures, amputation etc. might disrupt this process (Quanjer *et al.*, 2014). For this

reason, relative stature must be calculated from various anthropometric measures that can reliably predict the true stature. The most reliable anthropometric measures that are used as an alternative to estimate true stature are presented in the study published by Bjelica *et al.* (2012); sitting height was also one of the described anthropometric measures. In contrast, sitting height is also an important measure in many other settings. In addition to the fact that it is a reliable anthropometric measure to accurately estimate stature, it is a proxy for predicting children's body proportions. Sitting height can also be used to predict the statural growth in the cases in which the real stature cannot be measured because of lower limb deformities, such as chondrodystrophic syndromes (Fredriks *et al.,* 2015). The main characteristic of this skeletal syndrome are short limbs, while it is well-known that taller children have longer limbs and vice versa in the general population without the deformities. Furthermore, it is necessary to highlight that sitting height is gender based and a very good predictor of stature in the elderly (Fatmah, 2010). Based on different anthropometric parameters, the measurement of stature has been applied and understood since the 19th century in the field of physical anthropology. Many researchers have tried to determine the best anthropometric method for estimating the true stature. According to the accessible literature, it is quite appropriate to use arm span as the most reliable stature predictor (Mohanty *et al.,* 2001). In contrast, it is also confirmed that other anthropometric indicators, including foot length, knee height, tibial length, hand length, vertebral column length, sitting height, length of scapula, etc. can be used as reliable predictors of stature to a certain degree, in those situations in which arm span cannot be provided (Bogin *et al.,* 2002). Furthermore, it is known that certain anthropometric measurements may vary depending on racial affiliation, and from one ethnic group to another (Popovic *et al.,* 2016). It is noteworthy that researches confirming significant differences in previously mentioned anthropometric parameters between ethnically related people who live in different regions, that is, on territories with

different geographical characteristics, are more common these days (Popovic *et al.,* 2013). It is therefore impossible to use the results of research obtained in different racial and ethnic groups, different regions, with certain geographical features, and generalize the obtained results, as some other scientific claims propose, however, it is necessary to conduct individual research for each racial and ethnic group, i.e. population living in a geographically specific area for which the requirements that are the subject of this study have not been determined (Popovic, 2019). The morphology of human foot shows variations due to the combined effects of heredity, lifestyle, and climatic factors (Krishan, 2007b). It has been established previously that the dimensions of the lower extremity show greater association with the body height than those of the upper extremity (Fessler *et al.,* 2005; Ozaslan *et al.,* 2003). Stature has been estimated from various foot dimensions, such as footprints and foot outline (Fawzy and Kamal, 2010; Krishan, 2008), footstep and stride length (Jasuja, 1993; Jasuja *et al.,* 1997), and from various foot measurements such as foot length, foot breadth, malleoli, and navicular height of foot (Kanchan *et al.,* 2008; Sen and Ghosh, 2008; Zeybek *et al.,* 2008). Foot navicular height measurement was used for the first time in Zeybek's study to estimate stature and gender (Zeybek *et al.,* 2008). Some studies have focused on sex estimation from various foot dimensions and foot indices (Atamturk and Duyar, 2008; Bob-Manuel and Didia, 2009; Moudgil *et al.,* 2008), whereas others estimated stature or gender based on shoe dimensions (Ozden *et al.,* 2005).

2.3 Biological Basis of Stature

The final size and shape of an organism is thought to be the result of external stimuli acting on that organism during development (Bogin, 1999). There are two different foundations for the study of stature that should be investigated. As with the nurture versus nature debate, genetics and adaptation seem to be important in understanding how

individuals and populations grow to be of various statures. Genetics is one foundation of human growth and development. The genetic pattern of growth is regulated by proteins that are produced by genes (Bogin, 1999). The endocrine system (itself a product of one's genes) produces testosterone and estradiol in boys and girls respectively. These hormones, in conjunction with growth hormone in both sexes, cause the adolescent growth spurt (Bogin,1999; Fitzpatrick, 2012).

MascieTaylor and Bogin (1995) used quantitative genetics in researching stature in Danish communities that were involved in a process of the breakdown of reproductive isolation. During a period of nearly 900 years there was little change in stature (MascieTaylor and Bogin, 1995). Not until there was "outbreeding" between Danish communities in the nineteenth century did the population see major increases in stature. The only change in these communities was the inclusion of DNA that had not been part of the gene pool before the outbreeding. There are those who discount the importance of genetics in population studies of stature (Mascie-Taylor and Bogin, 1995).

Komlos (1994) writes that most between-group variation comes from the cumulative nutritional, hygienic, disease, and stress experience of each of the groups. This idea seems plausible when related to the research suggesting that most groups (not including Asiatic populations) may have the same potential for pre-pubertal growth (Ulijaszek, 2001). If ethnic differences in stature are decreasing, then perhaps the population differences in stature are due to the variation in environmental factors. Perhaps as nutrition levels increase and levels of stressors decrease, research would show that all populations will have relatively similar stature. With so many factors affecting stature to different degrees, it does not seem likely that this type of research is plausible. However, research on genetics such as that mentioned above cannot be ignored. If introducing new

genes into a population results in an increased stature, and the environment has not changed, there is strong evidence of genetic influence (Mascie-Taylor and Bogin, 1995). Komlos (1994) argues that genetics plays a role in the rate of stature growth of populations after discounting its role in final adult stature. It seems difficult to separate mechanisms that would control rate of growth from potential of that growth. Adaptation is another level at which stature is affected according to Mascie-Taylor and Bogin (1995). It is at this level that environmental interaction causes organisms to change in response to external stimuli. One type of adaptation, plasticity, works during the life time of an individual, and is also described by Mascie-Taylor and Bogin (1995). Bogin (1999), used the work of Franz Boas to elucidate this factor. The American-born children of immigrants had physical characteristics that were more like other American-born citizens than their parents (Bogin, 1999). It was believed that differing diets and the health care available to the children were the cause of these plastic changes (Bogin, 1999). Plastic change is the level at which most of the following factors operate. Many factors are wide-ranging and work on the population at large. Though they do not necessarily affect everyone in the exact same way or to the same degree, aspects such as nutrition, disease, and environment, will touch the lives of many, if not all, of the members of a group. In sub-optimal conditions, some of these factors act as stressors on the organisms. Income as a factor can be confounding in that it does not always have the same effect in all situations, and will be mentioned in conjunction with nutrition. Not only important to growth, nutrition is also used for body maintenance and for physical activity (Komlos, 1994). He explains that if nutritional needs are not met, then growth may be retarded or may stop completely. A number of real world and experimental studies show how nutrition affects stature. In one study begun in the 1960s, two groups of Guatemalan villagers were given either an experimental supplement or a placebo (Bogin, 1999). The findings showed that supplementing children up to the age of seven

resulted in an increase in stature compared to those that received the placebo (Bogin, 1999). Research has been done on a number of specific foods that have significant effects on stature. The impact of many generations of milk intake, or even the introduction of milk into the diet has been studied in many cultures. The introduction of milk to Japan after World War II and supplementation in Scotland produced stature increases.

African pastoralists whose diets contain a lot of milk tend to be taller than their agricultural neighbours that have diets devoid of milk. Even though a number of studies on supplementation focus on people with lower economic status, it is not possible to always equate a lack of nutrition (and short physical stature) with poverty. Joel and Cormac examined how before the great famine, the Irish, who had little more than the basics of life, were still able to flourish. The diet of potatoes, that was enhanced with the addition of fish and milk, helped to stave off disease (Komlos, 1994). The potato, being thought to cause leprosy, was initially shunned by much of Europe (Foster and Cordell, 1992). In spite of this, the potato became the staple crop of Ireland soon after its arrival in the Old World (Foster and Cordell, 1992). Relative health and adequate nutrition allowed the Irish to grow taller while eating a diet that others chose to avoid (Komlos, 1994). Similar trends are shown in a number of countries during the great depression. Jialu Wu (Komlos, 1994) found that in Pennsylvania during the great depression, people were still able to obtain nutritious food and physical well-being did not suffer substantially. Argentina, also affected by the great depression, saw a continuous increase in stature throughout the period (Salvatore, 2009). These works show that nutrition and income level need to be examined carefully in relation to stature.

Climate affects stature in a number of ways. Body size and shape is directly related to the climate in which the population lives. This is a fundamental part of mammalian

biological adaptation. In hot climates, there is a need for relatively large body surface area in order to allow for greater cooling through evaporation of sweat (Bogin, 1999). This can be achieved by having relatively long arms and legs in proportion to the trunk of the body. This trend is reversed in cold climates, with individuals having relatively larger trunks in proportion to their limbs (Bogin, 1999). Weather can have an impact on nutrition, itself a factor in stature, as mentioned above. Combining data from ice cores and tree rings, along with other sources, Steckel (1995) looks at weather change during the middle ages. During the period of about 900 to 1300 A.D. the temperatures were warmer than even modern averages. This meant warmer and longer growing seasons and allowed for a larger area available for cultivation. These factors led to increased agricultural output. Better nutrition resulting in an increase in stature led to averages not seen again until the early twentieth century (Steckel, 1995).

Disease may have a negative effect on stature. Bogin (1999) reference studies showed that intestinal parasites and malaria, in conjunction with undernutrition, have negatively affected stature in Ethiopia and Nepal. Evidence of disease is also drawn from paleopathology. Increased health, inferred by a negative correlation between the incidence of Harris lines and increased stature in a Peruvian population, is a useful example (Cohen and Armelagos, 1984).

Migration can have an effect on growth and development. There are a number of differing scenarios to migration as well. People may move from one country to another, or they may move between rural and urban areas. This means that urbanization may therefore be linked with the process of migration. Komlos (1994) used observed statures of African slaves to describe an increase in stature during the 1700s in relation to three locations. His data suggest that African born slaves did not achieve the same average

height as those born in the Caribbean (Komlos, 1994). American born slaves of African descent were taller than those born in both locations. Later, voluntary migrations to the United States also showed differences in stature. Guardsmen who were born in the United States were on average 0.84 inches taller than those who were foreign-born (Komlos, 1994). Migration to another country may also include the move to an urban area. The children of Hawaiian-born Japanese migrants were taller than their parents and Japanese people who still lived in the villages that their parents came from back in Japan. The improved diet, health care, and socioeconomic status that came with the move to an urban environment were the causes of the increase, in the view of Shapiro (Bogin, 1999). This is not to say that urbanization always results in an increase in stature. Children who lived in rural areas in the United States between 1870 and 1920 were taller than those living in urban areas (Bogin, 1999). This overlaps the period studied by Salvatore (2009) in Argentina referenced above where the opposite was the case. The gains in Argentina were attributed to urbanism in addition to a better diet (Salvatore, 2009). Gray and Wolfe (2002) explored the stress hypothesis in explaining the distribution of stature across the globe. Unlike some stressors, such as malnutrition, which would result in decreased stature, this area of research focuses on events that seem to cause an increase in adult stature (Gray and Wolfe, 2002). Some of the types of acute stress, which individuals would go through during infancy, that were identified were piercing, scarification, vaccination, circumcision, and lack of physical contact with the mother or a midwife (Gray and Wolfe, 2002). In the light of previously discussed factors, the data that are referenced are less than compelling. The data come from Yemenite children born in hospitals where they are separated from mothers and those born at home who stayed with their mothers continually (Gray and Wolfe, 2002). Those born at hospitals weighed more each of the first three years compared to those born at home (Gray and Wolfe, 2002). The data do not however include adult stature of the children in the study (Gray and Wolfe,

2002). Without data on adult stature present, this could simply be an example of an increased growth velocity not affecting final adult stature. The research also does not provide any evidence that females are affected by physical stress with increased stature, though males are influenced (Gray and Wolfe, 2002). The authors note that this result does not support those of similar increases in males and in females found in previous research (Gray and Wolfe, 2002).

Komlos (1994) also informs readers that individuals are not taken into account in anthropometrics, and the population is the unit of study. Forensic anthropologists draw their data from the population level, but most work in the field is performed if not on a single individual, then a group of individuals. If nothing else, these factors in individual stature are intriguing in how they might create outliers in the population. An individual's stature depends more on his or her parent's heights than anything else, is the view on genetics of Komlos (1994). Mascie-Taylor and Bogin (1995) includes conclusions drawn with Mascie-Taylor about a maternal effect. In general, if there are large differences between the heights of the mother and father, children's height will be more dependent on the mother's stature. The effect is opposite what may be assumed from the name of the effect, with short mothers having taller children and tall mothers having shorter children (Mascie-Taylor and Bogin, 1995). This is suggestive of stature being highly influenced by the genes of the parents. Modern medicine has provided a way for children shorter than average to attain greater adult stature. Growth hormone is used by physicians to treat idiopathic short stature (Silvers, 2010). This procedure is not something that is done very often and does not affect the whole population, but is a potential treatment for 500,000 children in the United States (Silvers, 2010). A review of a study of 80 children who received growth hormone revealed that about half gained less than 5 cm over their predicted adult stature, though others gained over 10 cm. While

some of these individuals as adults would still be close to the general trends in stature, it is possible that some individuals may deviate from the trends (Anzellini, 2016).

2.4 Human Variation in Physical Form

The human physical form is affected by environmental and genetic factors alike, but expressions of physical diversity, such as melanin production or stature, are interpreted in biological anthropology as adaptations to climate and natural access to resources (Gangestad and Scheyd, 2005; Larsen, 2010). Humans exhibit biological diversity. Since the birth of the discipline of biological anthropology, we have been interested in studying how humans vary biologically and what the sources of this variation are. There are certainly academic reasons for studying human diversity. First, is to consider the evolution of our species and how our biological variation may be similar to (or different from) that of other species of animals (e.g., other primates and apes). Such investigation can give us clues as to how unique we are as a biological organism in relation to the rest of the animal kingdom. Second, anthropologists' study modern human diversity to understand how different biological traits developed over evolutionary time. If we are able to grasp the evolutionary processes that produce and affect diversity, we can make more accurate inferences about evolution and adaptation among our hominin ancestors, complementing our study of fossil evidence and the archaeological record. Third, it is important to consider that biological variation among humans has biomedical, forensic, and sociopolitical implications (Michael, 2019). For these reasons, the study of human variation and evolution has formed the basis of anthropological inquiry for centuries and continues to be a major source of intrigue and inspiration for scientific research. Human diversity cannot be broken into discrete "races," because most physical traits vary on a continuous or "clinal" basis. One obvious example of this is how human height does not only come in three values (short, medium, and tall) but instead varies across a spectrum

of vertical heights achievable by humans all over the world. (However, this is with the only difference being the huge divergence in how factors like body size and traits such as skin color have been viewed and used socio-politically as a way of separating people throughout history.) The need to shift from typological "race" categories to a more nuanced understanding of continuously variable populations was realized by anthropologists working in the 1960s and 1970s who shifted their focus toward the study of individual traits rather than the study of groups (populations, races). Systematic evaluations of global biological variation in humans only began then, when large numbers of genetic loci for large numbers of samples were sampled from human populations distributed worldwide. It was during the 1960s that "clines" in human genetic variation were first identified (Michael, 2019).

A cline is a gradation in the frequency of an allele/trait between populations living in different geographic regions. In order to study human traits that are clinally distributed, it is often required to perform genetic testing to uncover the true frequencies of an allele or trait across a certain geographic space. One easily visible example of a clinal distribution seen worldwide is that patterning of human variation in skin color. Whether in southern Asia, sub-Saharan Africa, or Australia, dark brown skin is found. Paler skin tones are found in higher-latitude populations such as those who have lived in areas like Europe, Siberia, and Alaska for millennia. Skin color is easily observable as a phenotypic trait exhibiting continuous variation. A clinal distribution still derives from genetic inheritance, but clines often correspond to some gradually changing environmental factor. Clinal patterns arise when selective pressures in one geographic area differ from those in another as well as when people procreate and pass on genes together with their most immediate neighbors. There are several mechanisms, selective and neutral, that can lead to the clinal distribution of an allele or a biological trait. Natural selection is the

mechanism that produced a global cline of skin color, whereby darker skin color protects equatorial populations from high amounts of UV radiation; there is a transition of lessening pigmentation in individuals that reside further and further away from the tropics (Jablonski and Chaplin, 2000; Jablonski, 2004). The ability and inability to digest lactose (milk sugar) among different world communities varies according to differential practices and histories of milk and dairy product consumption (Ingram *et al.*, 2009; Gerbault *et al.*, 2011). Where malaria seems to be most prevalent as a disease stressor on human populations, a clinal gradient of increasing sickle cell anemia experience toward these regions has been studied extensively by genetic anthropologists (Luzzatto, 2012). Sometimes culturally defined mate selection based on some observable trait can lead to clinal variation between populations as well. Two neutral micro evolutionary processes that may produce a cline in a human allele or trait are gene flow and genetic drift. The ways in which neutral processes can produce clinal distributions is seen clearly when looking at clinal maps for different blood groups in the human ABO blood group system. Human variation is continuous and cannot be differentiated into geographically discrete categories. There are no "inherent" or "innate" differences between human groups, instead, variation derives from some degree of natural selection, as well as neutral processes like population bottlenecking, random mutations in the DNA, genetic drift, and gene flow through between-mate interbreeding (Michael, 2019).

Many biological adaptations to environment present in human physiology are invisible to the naked eye, such as increased lung capacity and hemoglobin counts in high altitude populations or reduced susceptibility to malaria due to heterozygous sickle cell alleles, but many others are clearly observable (Gonzales *et al.*, 2009; Beall, 2013; Gong *et al.*, 2013). Some of these apparent adaptations include melanin production and hair structure, but one of the most studied variants in human populations is adult morphology, examined

through analyses of standing height and limb length proportions (Neave and Shields, 2008; Stock, 2013; Vercellotti *et al.,* 2014). Adult standing height and limb length have become a focus for biological anthropologists due to the ease of data collection from both living and past populations, but unfortunately, few studies address all the major factors that affect stature during the interpretation of their results (Bogin and Varela-Silva, 2010; Mummert *et al.,* 2011; Becker *et al.,* 2012). In our world today, large variation in adult standing height is not unexpected since we can observe individuals from vastly different regions simultaneously. The World Health Organization (WHO) provides growth charts that include within normal variation stature ranges of 163-190 cm for males and 151-175 cm for females in adult individuals (19 years; 97% percentile interval). In ancient populations, however, stature appears to have varied less and ratios of long bones to stature have been found to be unique within a given geographic region (Zakrzewski, 2003; Raxter *et al.,* 2008; Beguelin, 2011; Mummert *et al.,* 2011; Pomeroy and Stock, 2012; Lukacs *et al.,* 2014;). This can be explained through environmental, nutritional, and genetic homogeneity as a result of minimal migration in the ancient world. Thus, population specificity requires that analyses of stature investigate differences within regional groups. Adult stature is affected during growth and development by both intrinsic and extrinsic factors (Anzellini, 2016). Some scholars have argued for effects of extrinsic factors during growth and development as being more impactful on adult stature than genetics (Bogin and Varela-Silva, 2010; Becker *et al.,* 2012; Camara, 2015). Surprisingly little data have been published on the expected range in skeletal variation within ancient regional groups (Stock and Willmore, 2003; Weinstein, 2005). In order to explore the health of a region using stature as a proxy, researchers must first understand what is expected in the skeletal morphology of the local individuals under the assumption of limited gene flow in ancient regional populations. Nutrition and pathological stress are often interpreted as the primary extrinsic mechanisms leading to reduced standing height.

Investigations of morphological differences associated with nutritional deficiencies have discovered patterns of reduced limb lengths with longer torsos (Schooling *et al.,* 2008a; Bogin and Varela-Silva, 2010). However, research on high altitude populations has demonstrated that these changes may also be associated with climate and recent migrations into high-altitude regions (Weinstein, 2005). Therefore, these factors must also be controlled when investigating differential stature and social complexity. Research by Weinstein (2005) and Pomeroy and Stock (2012) have suggested that brachial and crural indices tend to be significantly different between low-altitude, mid-altitude, and high-altitude populations. As a group increases their residential altitude, the distal appendicular bones become shorter compared to the proximal bones. Thus, tibiae are affected more significantly than femora, and will provide more reliable metrics in stature estimation if proper regression formulae are applied. However, the effects of altitude and climate on adult standing height are further complicated when populations reside in low-altitude, warm, but arid environments (Anzellini, 2016). The populations at high and mid-altitude may have greater environmental stress than populations at low-altitude, but it is also clear that the coastal populations were observably shorter on average. However, these differences are minute compared to their intraregional variation. Their variances are not significantly different from each other, suggesting either a similarity in the distribution of resources within each group, a resistance to change from mild nutritional differences, or a stable range of genetic diversity. Differences in subsistence strategy, temporal trends, and environmental pressures may also hold the key to understanding these observable differences (Anzellini, 2016).

The comparative samples examined in a study by Anzellini (2016), present a variety of subsistence strategies and social organizations including Late Holocene (ca. 2500 BP) hunter-gatherers from Patagonia, Early Intermediate Period (AD 200 – 600) egalitarian

agriculturalists in the mountains, a Late Intermediate Period agro-pastoral society from coastal Chile, and a Late Intermediate Period (AD 900 – 1470) chiefdom-level agricultural society from high-altitude sub-tropical forests in Chachapoyas (Sutter, 2005; Beguelin, 2011; Pomeroy and Stock, 2012). This variety in social structure and subsistence strategy provides an adequate basis for the investigation of the effect of socio-political complexity on mean and range of stature. Furthermore, the diversity in climates and geographies (i.e., mountain, coastal, plains) also provide a comparative benchmark for investigations of the effects of climates on stature. Unfortunately, genetic diversity is more difficult to control in the Americas than commonly thought (Kemp and Schurr, 2010; Cui *et al.*, 2013), but the slight variation present between these vastly distant groups and the marginal effect of genetics on adult stature provide this control (Yang *et al.*, 2010; Wells and Stock, 2011; Wood *et al.*, 2014; Roseman and Auerbach, 2015). The results of the study indicate that there are no substantial differences in the range of variation of stature across the Andes, and the differences in mean stature between groups is only slight. Using the stature as a proxy for health model, the diversity of subsistence strategies, time periods, and climates should result in significant differences between these groups. However, these results lend further support to the criticisms of this oversimplified approach. The observable differences in mean stature across these various groups can be interpreted with context. The coastal population of Azapa, a Late Intermediate Period agro-pastoralist chiefdom, is the shortest of the groups. The Andean coast is well known as an extremely arid place, and this appears to be the only environmental difference between this sample and the Chachapoya sample, suggesting that aridity directly affects stature, possibly through reduced access to dietary resources. The mid-altitude sample (SPA) and the Kuelap sample are similar, as expected, demonstrating that moderate differences in altitude (about 1000m) in a steep and rugged environment does not significantly affect average stature or range in

variation. The Patagonian sample appears to be an outlier among these groups having the tallest individuals for both males and females. Multiple factors could be contributing to their height. One of these factors is the altitude. The Patagonian sample was recovered from a site near sea level; thus, no hypoxic pressures are present in this group as would be for the mid- and high-altitude groups. When compared to the other sea-level coastal group, the Patagonians are observably much taller, but they also originate in temperate grasslands rather than a harsh desert environment (Pendall *et al.,* 2001). However, a temporal trend appears to be present as well, with the much earlier Patagonian sample being taller, and the more recent samples having become shorter. This temporal trend is also evident when comparing formative period populations to Late Intermediate Period populations from the Andean coastal region (Anzellini, 2016). This trend must be evaluated in more detail within a region while controlling for environmental, cultural, and subsistence differences. Clearly, stature is too complex to be used as a single interregional index for health. Comparisons in height between groups that differ temporally, culturally, environmentally, and genetically yield no significant results. However, within each region and culture, many of these factors can be controlled, and some interpretations are possible from the intersection of stature and material culture.

Another important aspect to consider about stature is the marked sexual dimorphism in some human populations. While humans in general are less sexually dimorphic than other primates, some differences do exist between males and females in almost every population, with males being on average 7-8% larger than females but varying depending on region and cultural practices (Bogin and Varela-Silva, 2010; Byers, 2011; Wells, 2012). Therefore, any examination of regional variation of long bone morphology must examine sexual dimorphism. These skeletal differences between the sexes are generally most visible after puberty, and thus any analysis of sexual dimorphism and juvenile

remains is inherently limited (Rosing *et al.*, 2007; Byers, 2011). All of these factors affect the study of human variation, adaptation, and health in past societies, and thus, need to be addressed.

2.4.1 Biological sources of human variation

Reproduction across the mammalian order shows similarity with that in other mammals. It results in inheritance of characteristics from parents through the shuffling of genetic materials. Within the mechanism through which this inheritance is acquired lies the source of diversity exhibited by organisms (Molnar, 1998). The deoxyribonucleic acid (DNA) is the molecule through which progenies inherit genetic information from their parents. The success of this transmission lies in the ability of the DNA to reproduce itself through a process of cell division, known as mitosis. In humans this process does not result in the production of identical cells beyond the 16-cell stage because after this stage, the cells assumed heterogeneity and commit to differentiated embryonic stem cell lines also termed cellular differentiation (Mielke *et al.,* 2011).

In the contribution of gametes by the father and mother in the production of the diploid zygote, it is required that the germ cells go through a reduction division known as meiosis, that takes them from the diploid to the haploid state. Thus, meiosis does not produce identical copies because the parental nucleus is diploid, while the daughter nuclei must be haploid. The shuffling of maternal and paternal variation leads to additional genetic variation in offspring. The source of these variations which produce different alleles at the same genetic locus is mutation. A mutation is defined as any random change in DNA sequence and it involves a range of events with different rates and different molecular mechanisms (Jobling *et al.*, 2004). Mutational events could arise as a result of insertions, replacement, deletion or inversion of genetic systems. But

genetic anthropology is mainly concerned with base substitutions, insertions and deletions.

2.4.1.1 Base substitutions

In a substitution mutation, a DNA nucleotide is replaced with another. When a purine is exchange for another purine (Adenine, A for Guanine, G and vice versa) or a pyrimidine for another pyrimidine (Cytosine, C for Thymine, T and vice versa) it is called a transition. But when a purine is replaced with a pyrimidine or vice versa, it is called a transversion. If these changes involve a coding sequence, the base substitutions may result in a change in the amino acid. Consequently, it may lead to a function change for the amino acid involved (Mielke *et al.*, 2011). Other mutations can change a nucleotide while having no effect on the coded amino acid because of redundancy in the genetic code, such mutations are referred to as "silent" mutations. Base substitutions arise from mis-incorporation of nucleotides during DNA replication and chemical modification of bases or physical damage from ionizing radiation (Jobling *et al.*, 2004). Single base-pair substitutions are among the most frequently encountered mutations in the human genome (Antonarakis *et al.*, 2005).

2.4.1.2 Insertions and deletions

Insertions and deletions popularly known as indels, refer to the addition or deletion of a single base. Together with base substitutions they are collectively known as single nucleotide polymorphisms (SNPs). Another class of indels are those made up of short variable stretches of DNA sequences that may be inserted or deleted from a locus such as the "Alu insert" on the CD4 gene (Tish-koff *et al.*, 1996). If this occurs in a coding sequence it may result in the entire sequence being mistranslated. This is also referred to

as a reading frame shift. Reading frame shift mutations are rare because they usually lead to a nonviable embryo (Mielke *et al.,* 2011).

2.5 Stature Estimation and Regional Variation

When it comes to estimating stature from the skeletal remains of past people, two main methods have been used: anatomical approximations and linear regression formulae. Anatomical approximations, such as the Fully technique, are created by taking skeletal measurements of multiple elements including of the cranium, vertebrae, sacrum, femur, tibia, talus, and calcaneus. These metrics are then input into a formula that calculates standing height and accounts for the missing soft tissue. This minimizes the error in approximation by including as many skeletal elements involved in standing height as possible (Fully and Pineau, 1960; Raxter *et al.,* 2006; Raxter *et al.,* 2007; Pomeroy and Stock, 2012). While most researchers agree that anatomical approximation is a more reliable estimate (Ousley, 1995; Pomeroy and Stock, 2012), archaeological remains rarely contain all the necessary elements or completeness of skeletal remains for the use of this method. For this reason, many attempts have been made to create regression formulae for stature estimation using single elements (Fully and Pineau, 1960; Raxter *et al.,* 2008; Beguelin, 2011; Pomeroy and Stock, 2012). However, due to a lack of complete archaeological remains and appropriate reference populations, researchers often misuse the formulae based on populations that, while relatively close in geographical proximity, might not fit the proportionality of the sample group (Fully and Pineau, 1960; Ousley, 1995; Vercellotti *et al.,* 2014). Linear regression formulae are created from a reference population (either modern cadavers or complete archaeological skeletal samples) by estimating the living stature of a number of individuals and correlating the results to the dry skeletal measurements of various long bones in order to create a formula in which to input the maximum length or physiological length metrics of

appendicular long bones (e.g., humerus, ulna, femur, tibia) and obtain a stature estimate (Trotter and Glesser, 1952; Genoves, 1967; del Angel and Cisneros, 2004; Beguelin, 2011; Pomeroy and Stock, 2012). Some regional scholars have used anatomical estimation to create new regression formulae for their specific archaeological populations (Pomeroy and Stock, 2012). In general, in the Andes, researchers have consistently used Genoves (1967), and only recently have adopted a modification to Genoves by del Angel and Cisneros (2004) (both of which reference a cadaver sample of modern native Mesoamericans) (Aufderheide *et al.*, 1993; Klaus and Tam, 2009). None has yet applied the formulae created by Pomeroy and Stock (2012), which was developed using anatomical estimates of archaeological mid-altitude Andean samples. The differences in body proportions resulting from environmental factors raise the question of appropriate estimation formulae. These distinct proportionalities suggest that stature estimations using linear regression formulae from a geographically distinct population are inappropriate (Tanner, 1987; Katzmarzyk and Leonard, 1998;). The reference populations for most regression formulae are not biologically connected to the Chachapoya, although Pomeroy and Stock (2012) use a mid-altitude Andean sample. Weinstein (2005) demonstrated that low-mid and high-altitude populations have significantly different body proportions.

2.6 Secular Trend in Stature

A secular trend is any change that takes place over successive generations. The secular change in stature is said to be linked to socioeconomic circumstances (Webb *et al.*, 2008). Affluence and health status of populations are major influences on stature (Webb *et al.*, 2008). Two studies of secular change in the United States are notable and useful to frame the research that follows. Komlos (1994) utilizes data from a number of height

studies, to show trends in stature between 1710 and 1950. Sources of data in these varied works are also drawn from regular army and city schools (Komlos, 1994). From the available data, which is limited, there is evidence that stature in the United States has seen a number of fluctuations over time (Komlos, 1994). The earliest data have a mean of 172.10 cm, only 1.10 cm shorter than that of the mean of a group born in the 1920s. Stature was steady between 172.50 and 173.50 in those born from 1780 through 1830 (Komlos, 1994). A low at 169 cm was the average reached in the late 1800s. It is after this point that the secular increase recognized in the twentieth century began (Komlos, 1994). Another aspect of stature which is often studied is leg to trunk proportions and upper to lower leg length proportions. These proportions are studied by forensic anthropologists as they are integral to the creation and use of stature estimation formulae. Jantz and Jantz (1999) examined secular change in long bone lengths in relation to stature over the period of 1880 to 1970. Though the data presented is primarily that of bone lengths, the analysis is on how long bone lengths are related to stature and how proportions of the bones have changed (Jantz and Jantz, 1999). According to Jantz and Jantz (1999), there was a secular increase in stature that is expressed in the lower limbs as a relative lengthening in relation to the trunk. Another interesting finding is that at some points there was a difference in the amount of change between men and women where the increases in male stature was about twice what it was in females (Jantz and Jantz, 1999). There are two types of change in stature that may occur, isometric and allometric (Jantz and Jantz, 1999). Isometric change is characterized by no alteration in the proportion of a body part to the overall stature (Benton and Harper, 1997). Allometric change may be categorized as either positive or negative. If positive allometry is present, the body part in question is longer than it would be if the change were isometric. If the body part is shorter than it would have been if isometric change were occurring, then the allometric change is categorized as negative (Fitzpatrick, 2012). If

there is a secular change, but the change is isometric, then previous regression formulae would still produce relatively accurate results. The slope of the regression equation would be approximately the same, but the distribution of the data points would be shifted. For example, if individuals increased in stature, and their limbs also increased at similar rates, the data points would be skewed up and to the right on a regression line, but still cluster around the line (Fitzpatrick, 2012). Any allometric change would result in regression models that are no longer accurate. If the allometric change in the population was overwhelmingly positive, then the regression formulae would predict a living stature greater than the actual stature. The opposite would occur with negative allometric change, resulting in shorter than expected estimates (Fitzpatrick, 2012). Jantz and Jantz (1999) also note that increased error may be introduced when stature estimation formulae that use multiple long bones are utilized when the rate of change between bones is not the same. Analysis of the change showed that upper limb bones are not changing at the same rate as the lower limb bones, so formulae that rely on both upper and lower limb bones are the ones that are most affected (Jantz and Jantz, 1999).

2.7 Sexual Dimorphism

It is known that sexual dimorphism is an important factor producing morphological variations in biological populations. Sexual dimorphism is the biological base for sex estimation based on the physical and behavioral differences existing between males and females (Braz, 2009). Sex differences determined in the shape, size and appearance of bones usually arise during development and are consequences of individual genetic markers and response to sex hormones during puberty. Bone development in either sex is dependent on a combination of genetic markers and hormone exposure (Franklin, 2010). The age at which these sex specific morphological changes start to appear is dependent on a number of population specific genetic and environmental factors. As the degree of

sexual dimorphism, and the age at which it occurs in males and females, varies between different populations, sex estimation standards are necessary to be population specific (Franklin *et al.,* 2012). Human sexual dimorphism is said to be an outcome of a survival strategy, a balancing of the need for high degree of biological variation within the species with the need for a narrow range of variation in the female, who is physically structured for the support of an infant prenatally and postnatally. Thus, the differences are a reflection of the ongoing processes of evolution. The genetic basis for variation has been explained by a polygenic model of inheritance. This is basis of the sexual dimorphism in the morphological and metric attributes of males and females (Bishara *et al.*, 1986). Two approaches to sex identification have been described. The first is based on a visual assessment of the shape or relative proportions of sexually dimorphic features. The second is a metric approach, which offers advantages over the visual approach as it is inherently more objective, has higher reliability, is less dependent on the previous observer experience (Mac Laughlin and Bruce, 1990).

Few studies have referred to the features of dimorphism in the Egyptian and Tunisian populations; according to Steyn and Iscan (1998), the variations in the skeletal characteristics of different populations can interfere in the diagnosis of sex. Rosing *et al.* (2007) indicate that the robusticity or thinness of the musculature, which determines some visible traits in the skeleton, depends on regional factors. Similarly, there currently appears to be no established metric mandible discriminate function standards for sex determination in Cross River State population. The pressing need for such standards is driven by the increasingly importance of sex determination either in forensic or anthropological context. On the basis of evidence in the literature, one would anticipate the mandible to be especially useful for identification of sex.

Rosing *et al.* (2007) recommended a first evaluation phase by a simple method of morphologic character before moving to the second phase of molecular analysis. In the morphologic analysis of human bones, pelvis and skull bones account for a major amount of information for sex determination. The literature attests to numerous metrical standards, each utilizing different skeletal elements, selecting an appropriate investigative technique largely depends on skeletal preservation and the efficacy of the available standards. Consideration is also accordingly given to the skeletal age of the individual, as sub-adult sexing standards are known to be less reliable. Similarly, age is one of the information that is vital in reconstructive identification of bodies where no circumstantial evidence is available and visual recognition is not possible (e.g., skeletal remains). But the role of age prediction in forensic investigations is not just limited to post-mortem reconstructive identification; in addition, age changes can also be utilized in the context of crime investigation. For example, age estimation can be vital to determine the quantum of punishment delivered to the accused wherein minority/majority status hinges on such evidence. Age estimation techniques are also useful for demonstrating substantive proof of birth records and age for immigrants (legal and otherwise) and those seeking retirement benefits. Therefore, age estimation may be necessary for the living and deceased, and may apply to children, adolescents or adult age-groups (Tamer, 2012).

The ubiquitous phenomenon of aging or age-related changes as pertaining to practically all biological organisms may be defined as the "time-independent series of cumulative, progressive, intrinsic, and deleterious functional and structural changes that usually begin to manifest themselves at reproductive maturity and eventually culminate in death" (Arking ,1998). While chronological time from a scientific perspective may be tracked or measured by the specific linear transgression of a calendrical sequence, biological 'time' is not so analogous and may be measured by "interlocking cascades of specific physical or chemical events" (Arking ,1998). This is to say that there is a definitive complex

difference between chronological age and biological age (Mitnitski *et al.*, 2002). Chronological age remains unaltered or unchanging throughout time and space but biological age may increase or decrease in tempo and/or rate depending on somatometric, physiometric, and haematological variables (metabolism) as well as lifestyle, ancestry, and the environment (Kemkes-Grottenthaler *et al.*, 2002).

Relative standards for age estimation, on a macroscopic or microscopic scale, are inherently flawed due to an interesting set of problems in human biology as well as anthropology. Some of the most important and most frequently discussed considerations include: the distinction between chronological and biological age, uniformitarian assumptions about aging through time and space, environmental and genetic differences between reference and sample populations, archaeological processes of preservation, diagenetic change and recovery, and variance between dental and skeletal age determinations (Mitnitski *et al.*, 2002). Anthropologists use the term biological age in recognition of the discrepancy between an individual's morphology and their chronological age, which is inaccessible for most skeletal populations. The discrepancy between chronological and biological age is a product of both measurable systemic reasons as well as significant idiosyncratic and seemingly random differences. There are three main sets of problems responsible for the differences between chronological and biological age: individual variation, pathological conditions, and methodological issues (Mitnitski *et al.*, 2002). The generalization (or averaging) of complex morphological changes in order to create reference standards introduces an inherent amount of inaccuracy in all relative methods of age estimation. This bias is due not only to the generalization itself, but also to observation error, scoring differences, level of experience using these discrete reference categories, and finally to the differences between the reference and the sample populations themselves. When age estimation methods are applied to archaeological populations, the number of biases is further

compounded by uniformitarian assumptions about aging across time and space. Genetic and environmental differences between reference and sample populations lead to an uncertain level of error in the application of any method (Mitnitski *et al.*, 2002).

Sexual dimorphism in humans causes visible changes during puberty that remain into adulthood (Walsh-Haney *et al.*, 1999). The differences between adult males and females can be attributed to variations in both gross morphology and functional morphology, with males being, on average, 7 - 8% larger in size (Byers, 2011). There is observable diversity in sexual dimorphism between regional populations, and some studies have attempted to understand the associated factors (Ruff, 1987; Holden and Mace, 1999; Nettle, 2002; Işcan, 2005; Wells, 2012). As with all aspects of morphological differences, behavioral and environmental factors greatly affect sexual dimorphism. This intersection of behavior and biology is studied through bio cultural approaches, which account for behavior along with external pressures in human adaptation and evolution (Dufour, 2006). With this approach, studies of sexual dimorphism have demonstrated that physical differences between males and females have been greatly affected by general patterns of cultural behavior as well as gender roles in the division of labour (Holden and Mace, 1999; Ruff, 1987). Sexual dimorphism may also be affected by patterns of sexual selection and preference, but these behaviors are more difficult to discern in the archaeological record (Nettle, 2002; Becker *et al.*, 2012; Gahtan and Mark, 2013). However, studies have also demonstrated that male and female biology react differently to environmental pressures, where in colder climates males create more lean mass and females create more adipose tissue, and environmental pressures seemingly affect males more prominently than females (Ruff, 1987; Ruff, 2002; Wells, 2012).

Plavcan (1994) stated that several different methods of estimating dimorphism have been suggested; extrapolation from coefficients of variation, division of a sample about the

mean or median into two subsamples which are then treated as males and females, and finite mixture analysis. The accuracy of none of these methods has been thoroughly investigated and compared in a controlled manner. Such analysis is necessary because the accuracy of all methods is potentially affected by fluctuations in either sample size, sex ratio, or the magnitude of intra-sexual variability. Computer modelling experiments show that the mean method is the least sensitive to fluctuations in these parameters and generally provides the best estimates of dimorphism. However, no method can accurately estimate low to moderate levels of dimorphism, particularly if intra-sexual variability is high and sex ratios are skewed.

Josephson *et al.* (1996) presented a procedure that estimates sexual dimorphism in samples of unknown sex using method-of-moments. They assume that the distribution of a metric trait is composed of two underlying normal distributions, one for males and one for females. They use three moments around the mean of the combined-sex distribution to estimate the means and the common standard deviation of the two underlying distributions. This procedure has advantages over previous methods: it is relatively simple to use, specimens need not be assigned to sex a priori, no reference to living species analogues is required, and the method provides conservative estimates of dimorphism under a variety of conditions. The method performs best when the male and female distributions overlap minimally but also works well when overlap is substantial. Simulations indicate that this relatively simple method is more accurate and reliable than previous methods for estimating dimorphism.

Ipina and Durand (2004) proposed that populations distributed as mixture models with two normal components. There do not appear to exist measures of sexual dimorphism that possess inferential properties other than some statistics used with this purpose. The use of these sample functions in such a context as well as the purported inferential

support of some other sexual dimorphism indices was discussed. A biological case study illustrates the distinct inferential conclusions that can be obtained when the indices discussed and the MI index of sexual dimorphism proposed were considered.

Ipina and Durand (2010) stated that sexual dimorphism does not appear to motivate debate. However, with the aim of measuring such dimorphism, several indexes have been proposed. They examined and compared the following measures of sexual dimorphism: the quotient of sample means, the sample range, the sample coefficient of variation, the overlapping area between two independent normal distributions, and the overlapping area between the functions making up a mixture of two normal distributions especially considering their inferential structures.

It is well known that sexual dimorphism is expressed more distinctly when there are better living conditions and health status of the given population (Lazenby, 2001). Further, socioeconomic factors (nutrition, chewing habits, occupation etc.) may contribute to expression of sexual dimorphism. Sexual dimorphism in the modern human mandible has been interpreted in the literature as being related to differences between male and female growth trajectories and musculoskeletal development (Rosas *et al.,* 2002). Humphrey *et al.* (1999) found that the condyle and ramus were generally the most dimorphic regions in the mandible and suggested that this was because these sites are associated with the greatest morphological changes in size and remodelling during growth.

Loth and Henneberg (1996) described how mandibular dimorphism is influenced by the relative development (size, strength, and angulation) of the muscles of mastication, especially the masseter, temporalis, medial, and lateral pterygoid, which have insertion points on the ramus, condyle, and coronoid process. Thus, the size and shape of the mandible is influenced by variable lifestyles, chewing habits, and also ethnic groups

(Captier *et al.,* 2006; Hu *et al.,* 2006). The expression of sexual dimorphism is likely to be influenced by the complex interaction of many biological, environmental and cultural factors. There is also good evidence showing that dietary factors can influence the expression of sexual dimorphism (Rosenberg, 1992). It has been proposed that males are more susceptible to fluctuations in nutritional quality; hence growth is reduced to a greater degree than in females, thus resulting in a more equal body size and reduced dimorphism (Stini, 1969). Basically, this means that under conditions of inadequate nutrition, males are achieving a lower percentage of their genetic growth potential than females. Further, it is also known that the nature of the division of labour and other cultural activities result in differential mechanical loading and musculoskeletal development, which can contribute to variation in the pattern and degree of sexual dimorphism in a population.

2.7.1 Sexual Size Dimorphism (SSD) and Size Dimorphism Index (SDI)

Dimorphism is a widespread occurrence across animal taxa, and believed to have evolved in response to selection pressures favouring particular phenotypes. Sexual size dimorphism is the morphological difference between males and females of the same species (Shine, 1989). SSD has been the subject of intense study and controversy. Several reviews have been published for a diverse array of taxa including invertebrate (Fairbairn, 1990), reptiles (Gibbons and Lovich, 1990) and mammals (Bondrup-Nielson and Ims, 1990; Clutton-Brock *et al.,* 1977). Despite the biological significance of SSD and the importance of comparisons across phylogenetic groups, a general approach for defining the degree of difference between the sexes has not been developed. While some debate surrounds the evolutionary process, three principle hypotheses have been proposed to explain the cause of sexual size dimorphism.

The first been **the division of labour hypothesis;** which relates to males and females within a breeding pair investing their effort into different roles. This implies that SSD is a result of ecological forces or natural selection, due to differential interactions of each sex with its environment (Camilleri and Shine, 1990)

The second been **the sexual selection hypothesis** which focuses on male-male competition for mating opportunities and territorial defence, ultimately favouring larger body size in males (Hedrick and Temeles, 1989). This implies that size differences between sexes are the result of selective factors not directly related to the environment (Darwin, 1871; Arnold, 1983), and as such, sexual selection can result from (a) intrasexual competition for mates, usually in the form of male combat, or (b) epigamic selection in which females choose among males (Trivers, 1972).

The third been **the food competition hypothesis** which relates to ecological causation, whereby differences in body size reduce competition for resources through segregation of prey and habitat use (Shine, 1989). Many studies have proposed sexual selection as a primary cause, while niche segregation is a consequence and maintainer of dimorphism (Navarro *et al.*, 2009).

In species where differences in dimorphism between the sexes is not immediately apparent, many studies determine sex based on morphometrics using discriminant function analyses (Amat *et al.*, 1993; Bosch, 1996; Coulson, 2009). These functions incorporate body mass and other structural measurements to accurately predict sex from calibrations of known sex individuals (Dechaume-Moncharmon *et al.*, 2011). While these functions can differ between species and populations (Evans *et al.*, 1993), they also can be reliable, inexpensive and non-invasive. Variation in body mass between the sexes may reflect differences in structural size and/or differences in body composition due to relative contribution of fat and lean mass (Schulte-Hostedde *et al.*, 2001). Body condition

can represent energy reserves and, hence, is an indication of an individual's health and nutritional state (Viblanc *et al.,* 2012). Furthermore, determining body condition is a valuable tool as it can be used to indicate how individuals are managing natural environmental variation and stressors (Mata *et al.,* 2006). Fairbairn and Shine (1993) proposed male biased dimorphism occurs in species with a large average body mass and in conditions where primary productivity is high. The degree of dimorphism can vary greatly, geographically within and between closely related species (Fairbairn, 1997), such differences in the degree of dimorphism may be due to food availability or inter-population growth patterns (Lovich and Gibbons, 1992). Alternatively, sexual selection may be driving the greater divergence in dimorphism (Einoder *et al.,* 2008). Discriminant function was developed to assess whether the degree of sexual size dimorphism was sufficient to accurately determine sex from morphometric measurements. Alternatively, discriminant functions have been widely used to determine the sex of individuals in the field from morphometric measurements with an accuracy > 90% (Amat *et al.,* 1993; Bosch, 1996; Hull, 1996). However, the applicability of a discriminant function across a species is not always possible and can depend on the degree of variation in morphometrics between population (Arnould *et al.,* 2004).

Size dimorphism index (SDI) indicates percentage of difference between sexes. Following the methods of Lovich and Gibbons, a size dimorphism index (SDI) can be calculated from the mean measurements of males and females, where the extent of dimorphism (percent difference) can be calculated as:

$$SDI = \left|-\left(\frac{Mean\ male}{Mean\ female}\right) + 1\right| \times 100$$

Alternatively, SDI formulation is based on the simple ratio of size of the larger sex divided by size of the smaller sex, with the result arbitrarily defined as positive when

females are larger than males and negative in the converse situation (Gibbons and Lovich, 1990). One approach for the identification of the general phylogenetic patterns of SSD within a group of individuals is to establish which sex is larger among a large number of taxa (Greenwood and Wheeler, 1985). The procedure of rating species on the basis of the direction of SSD has the advantage of permitting broad phylogenetic comparisons but the disadvantage of not permitting the ranking of species on the basis of degree of dimorphism. Also, it does not allow quantitative comparison of populations that can demonstrate levels of variability within a species. The use of a size dimorphism index (SDI) has been proposed by numerous authors to quantify the degree of SSD exhibited by a species or population. However, the variation in methods of calculating the SDI has been extensive, and the diversity of methods has, in some instances, hampered comparisons among phylogenetic groups. Methods for calculating an SDI are roughly divisible into two broad classes: those based on a ratio, and those based on a difference. A useful SDI should meet four criteria:

i. First, it should exhibit proper scaling. For instance, the mean body size of one sex is two times greater than mean body size of the opposite sex and the SDI equal X. If the mean body size of the larger sex is four times greater than mean size of the opposite sex, then the calculated SDI must equal 2X, if the SDI is properly scaled.
ii. Second, the SDI should produce measures that have high intuitive value. This implies that a reader would be able to look at an SDI and determine the actual degree of SSD exhibited without referring to the formula used to calculate it.
iii. Third, a useful SDI should exhibit directionality. This implies that situations where one sex is larger than the other would have SDI's preceded by a positive sign (+), whereas in the converse situation the sign would be negative (-), thus providing the reader with information concerning the directionality of SSD.

iv. Lastly, a useful SDI should possess a characteristic symmetry around a central value, preferably zero, where the sexes exhibit equal mean body size. For instance, in a case where females are N times larger than males the SDI must = X. And in the case where males are N times larger than females the SDI must = -X to be symmetric. Thus, this criterion is directly related to the directionality criterion.

2.8 Sexual Dimorphism and Sex Estimation

It is essential to have parameters that allow the detection of sexual dimorphism. The difficulty in determining sex of skeletal remains is a known problem that limits anthropological research and forensic practice. There have been developed numerous methods to carry out the determination of sex; they can be divided into morphological and molecular methods; the evaluation of gender from qualitative indicators must be contextualized to the population (Rosing *et al.,* 2007). In forensic medicine, the diagnosis of sex is the first step in the identification of complete or incomplete human skulls (Suazo *et al.,* 2008a). A first approximation is made through the qualitative analysis of a series of morphological indicators of sexual dimorphism. Skeletal remains in good condition allow the observation of morphological sexual dimorphism with a 95% accuracy (Kimmerle *et al.,* 2008; Suazo *et al.,* 2008a). There are factors that influence the growth and development of skeletal dimensions, such as ecological, racial, age, sex and genetics. At birth men have specific forms of their bones, however, differences between sexes decrease rapidly, leading to an almost total reduction in sexual dimorphism between the ages 4-14 years. From puberty to adulthood, males are characterized by changes in allometric shape, while the shape of the female continues even after changing size and ceasing to increase (Martinez, 2018). The determination of sex is more accurate in adults than in puberty, as a result of the effect of sex hormones, estrogen and

progesterone in the development of morphological differences. Hormones control the development and growth of bones, women complete their development earlier than men, which modify their appearance drastically during puberty. Skeletal growth and development processes are influenced by a wide range of mechanisms, especially genetic, endocrine, functional and environmental (Martinez, 2018). Although several statistical models have been developed to carry out a quantitative analysis of the morphological indicators of dimorphism, which determine sex by visual inspection, the problem is that skeletal characteristics vary in different populations. Anthropometric measurements of bones are useful in determining gender. The length, width and height of bones can be used when the entire skeleton is not available. Anthropologists have established scientific methods of identification of corpses reduced to the skeletal state, based on the fundamental pillars of the identification, such as the determination of individual race, sex, age and stature estimation (Martinez, 2018).

The effects of sexual dimorphism on stature need to be controlled when using stature as a proxy for health (Holden and Mace, 1999; Nettle, 2002; Wells, 2012). When the skeletal remains being studied are commingled, sexing individuals from isolated elements becomes problematic. Since stature demographics for a commingled context are generally calculated from appendicular long bones with no associated cranium or os coxae, sex estimates of isolated elements are confounded (Buikstra and Konigsberg, 1985; Byrd and Adams, 2009). In general, the use of postcranial remains to estimate sex has been unreliable due to major overlap in sizes between the sexes, the use of rough boundaries for metric determination of sex, and inability to account for differences in sexual dimorphism across various regional populations (Bass, 1995; Byers, 2011). The lower end (epiphysis) of radius and ulna fuses with their respective diaphysis in the age group of 16-20 years. Standards used to analyze morphometric data are most precise

when applied to the population from which they were derived (Lazenby, 2002). For instance, the radius and ulna may be smaller and more fragile than other long bones as the femur; however, estimating their power to differentiate between the sexes will provide alternative markers for sex identification when more accurate bones such as the pelvis or femur are absent or damaged (Burrows *et al.*, 2003).

Recent studies have tried to mitigate these issues of sex determination from appendicular elements through the use of discriminant analyses. Spradley and Jantz (2011) have suggested that multivariate analyses of long bone metrics may provide estimations of sex with an accuracy of up to 95%. Multivariate analyses are difficult in the field due to the necessity of dedicated software, thus logistic regression formulae to determine sex from isolated long bone metrics is a more manageable solution when the demography of the site must be completed without the aid of such software. This method of logistic regression has proved useful in sex determination of forensic cases using the cranium but has yet to be used with postcranial remains, and due to constraints of reference populations has never been used in this region (Walker, 2008; Dabbs and Moore, 2010; Klales *et al.*, 2012). Sex determination of human skeletal remains is considered an initial step in its identification and is crucial for further analysis, because estimation of age at death and stature follows markedly different pattern in males and females (Ozer *et al.*, 2006). A number of literatures have shown sexual dimorphism in almost every bone of human skeleton. As evident from the past studies, skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing accuracy up to 92% (Cox and Mays, 2000; Kemkes-Grottenthler *et al.*, 2002). But in cases where intact skull is not found, mandible may play a vital role in sex determination as it is the most dimorphic bone of skull (Duric *et al.*, 2005). Dimorphism of the adult modern human facial skeleton and the

mandible has been noted in diverse populations (Rosas and Bastir, 2002; Thayer and Dobson, 2010).

Ongkana and Sudwan (2010) investigated the non-metric features of mandibles, which can be used consequently as the standard for sex determination in the Thai population. Eighty-eight mandibles, 64 males and 24 females, were examined for the shape of the chin, presence of the antegonial notch, appearance of the gonial angle and presence of the posterior ramus flexure. The study showed that MRPF could not identify the particular sex of Thai skeletons. Thus, the reproducibility of this technique was doubtful, and should be used cautiously.

Saini *et al.* (2011) tested the reliability of MRPF in Indian population. A total number of 112 adult mandibles (88 males and 24 females) were studied. The mandibles were scored according to the original method by two observers in three different sessions. The result showed that MRPF can be used to diagnose sex with an average accuracy of up to 82%. Though, inter and intra-observer errors were present but could be minimized with extended practice. Thus, it was concluded that, MRPF has the potential to be relied upon as a single morphological trait for determination of sex in Indian population.

Tamer (2012) stated clearly that the accuracy in determining sex using mandibular ramus flexure is very different from the excellent results reported by Loth and Henneberg (1996) in their original article, which interacts with the radiographic image distortion, inherent to the technique, different ethnic background and the equipment used, but in any case agrees with numerous articles that have questioned the accuracy of the method. The results show that there is significant difference in the shape of male and female mandibles ($P < 0.001$). The trait can correctly diagnose 84.7-90% males and 70-82% females. The overall predictive accuracy was 80-83.23% which is much lower than

claimed by Loth and Henneberg (1996), males were identified more accurately by observing posterior ramus flexure.

Traditionally, subjective visual assessments of sexually dimorphic features of the skull and pelvis are resorted to for sex identity. Morphological methods are not population specific, with suits application to fragmentary archaeological and forensic materials. Moreover, the method encapsulates morphological information that is difficult to quantify using standard anthropometric techniques (Walker, 2008). It has been stated that descriptive traits are more influential in sex determination from skulls than metric assessment of size and proportions (Celbis *et al.,* 2001). Mandible is one of the most durable and dimorphic bone of the skull and important for sex identification. Several studies evaluated the utility of sexually dimorphic human mandible using metric and morphological features (Humphrey *et al.,* 1999; Hu *et al.,* 2006). It was found that dimorphism is generally more marked in mandibular ramus than in the mandibular body. Mandibular ramus can differentiate between sexes as the process of mandibular development and masticatory forces are different for males and females which influence the shape of the ramus (Franklin *et al.,* 2006). The sexual variations in mandibles may bear genetic, hormonal or environmental influences (Vodanovic *et al.,* 2006). Since mandible is the last skull bone to cease growth, it is sensitive to adolescent growth spurt. Due to the effect of oestrogen, epiphyseal maturation and skeletal mineralization, mandibular growth becomes stable in females at the age of around 14, while it continues for two more years in males, making the flexure more obvious. Relatively, weaker muscle forces during mastication, may also contribute to small sized mandibles in females (Lazenby, 2001; Rosas *et al.,* 2002). Some Authors argued that the morphological marks are more subjective and sex determination depends on experience

of the investigator, and that visual methods of sexing skull are likely to be inaccurate when performed by an inexperienced worker (Walrath *et al.,* 2004). Sex determination in unidentified skeletons may be extremely complicated in cases of explosions, warfare and other mass disasters because of skeletal fragmentation. Identification of skeletal remains holds a prime importance in forensic medicine and anthropology especially in criminal investigations. Main attributes of biological identity include sex, age, stature, and ethnic background of individual which are called 'Big Four' in forensic context (Jambunath *et al.,* 2016). The mandible and its variations in age, sex and race will help physicians, surgeons, medico-legal authorities and anthropologists to give correct interpretations for the results of diagnostic procedures in living (Williams *et al.,* 2000). Skeletal components most often investigated for gender determination are pelvis and skull with mandible being a practical element to analyse sexual dimorphism in fragmented bones (Indira *et al.,* 2012). Mandible is the largest, strongest and movable part of skull and its identification is important in medico-legal cases and anthropological work (Kumar and Lokanadham, 2013). The skeletal components most often investigated for sex determination are the pelvis, skull and mandible. In human remains, next to pelvis, mandible is used to estimate age, sex, and race. Mandibular ramus and gonial angle can be used to determine sex. Studies have shown that mandibular ramus can differentiate between sexes, as the stages of mandibular development, growth rates, and duration are distinctly different in both sexes (Jambunath *et al.,* 2016).

In a study conducted by Vineet *et al*. (2011) showed significant sexual dimorphism with an accuracy of 80.2% using mandibular ramus and also reported that the varying result could be due to difference in the sample size selected, and that, usually, the sex can be accurately identified after puberty.

Jambunath *et al.* (2016) conducted a preliminary study on pre-pubertal age group and comparison was made between the ramal and gonial dimensions to ascertain an accurate method for sexual dimorphism. In their study condylar, coronoid and projection height of the ramus was significant in males ($P < 0.001$) and gonial angle was significant in the females ($P < 0.001$). Thus, reported that the gonial angle was larger in females and bigonial width was not significantly different in males and females. Their findings were in accordance with the studies conducted by Rajalakshmi *et al.* (2007) but these findings are in contrast with the study conducted by Kharoshah *et al*. (2010). The varying results was reported to be due to differences in the age group and population selected, and that the accuracy of classification for sexual dimorphism was found to be 72% in ramus dimensions or method and 66% in gonial angle or method which indicates that the ramus method proved to be more accurate than the gonial method, and concluded that mandibular ramus and gonial angle can be used as aids for sex determination, even though ramus method was found to be more accurate than the other.

2.9 Sexual Dimorphism and Age Estimation

Forensics is one of the areas that use information on age-related growth and development parameters. Today, Nigeria has great potential for man-made disasters, such as accidents on the land, on sea, and in the air, as well as fires, bombings, and unrest that cause damage, loss of property, and relatively heavy human casualties, including injury or death (Suwandono, 2010; Rachmadiani *et al.*, 2017). In some instances, it is possible to determine the identities of the death casualties, while other times it is not; therefore, identification procedures are required. In such cases, age estimation can be a useful tool, due to the increasing physical growth and development of the human body; any changes can be attributed to an individual's age. In addition to using age estimation to identify

individuals that have died, it can also be used to determine the age of individuals who are still alive in order to know whether a person is a child or an adult, if the judicial process requires such information and/or a person's birth certificate is not available or its authenticity is doubtful (Putri *et al.,* 2013). The mandible has a role in the estimation of age because it is the largest and strongest bone in the skull and it often remains intact, even after death. The compact bone in the mandible helps it maintains its shape, and it retains that shape more often than other bones (Muskaan and Sarkar (2015). In adolescence, the growth of the jaw bone is related to puberty (Proffit *et al.,* 2007). Until the third decade of life, morphology and dental changes can contribute to estimating a person's age; however, after the third decade, changes related to age are nearly imperceptible. The average value of the measurement parameters of the mandible vary in different populations. This makes it possible to determine the variations between the average values of the existing measurements with the average value of the measurement parameters of the mandible in an Indonesia population (Muskaan and Sarkar (2015). In old age, changes in the mandible occur, especially with tooth loss, and when the alveolar bone is absorbed resulting in decreasing bone height (Singh, 2014). The measurement of the mandible parameters as the principle method for age estimation is used in forensic identification as well as in a variety of fields of dentistry. In orthodontics, mandibular parameter measurements can play a role in monitoring the growth patterns of individuals for orthodontic assessment (Leversha *et al.,* 2015). The average value of the measurement parameters of the mandible vary in different populations. This makes it possible to determine the variations between the average values of the existing measurements with the average value of the measurement parameters of the mandible in a Nigerian population.

2.10 Methods of Stature Estimation

Research has been completed on a number of methods for estimating stature. Stewart (1979) provides a detailed history of stature estimation, from which I will mention a few of the highlights. This history begins with Thomas Dwight in 1894 stating that there is no rule of proportion for estimating stature from the long bones of the legs because some people have short legs and some people have long legs (Stewart, 1979). Dwight suggested that the anatomical method (measuring all bones that make up stature) should be used unless there was no other choice (Stewart, 1979). Next, in 1888, Paul Topinard published on the use of ratios to estimate the stature of the skeleton from the maximum lengths of long bones, to which the constant of 35 mm was added for the living stature (Stewart, 1979). Rollet also, published his doctoral thesis, and he included tables of his data displaying bone lengths and their corresponding stature. Manouvrier did not like the layout of Rollet's tables, as he was the head of the anthropology society of Paris at the time, when he published his own version of Rollet's data, his work became the one that was most utilized (Stewart, 1979). Karl Pearson was the first to use regression theory in 1899, analyzing the data collected by Rollet. Pearson, diverging from the practice of using bicondylar length by Manouvrier, used solely maximum length of the femur (Stewart, 1979). Trotter and Glesser (1952) cite a number of early stature estimation examples that are precursors to their own work. Many reference books, including laboratory and field manuals, even those published recently, include the formulae or stature tables created by Trotter and Glesser (Buikstra and Ubelaker, 1994; Bass, 1995; Burns, 1999). Trotter and Gleser (1952) collected data from the Terry collection, and from U.S. war dead. They created regression formulae based on upper and lower long bone lengths of men and women which were divided by socially attributed racial categories.

Georges Fully, whose most memorable work is likely the "Fully" anatomical method of stature estimation, had created estimation formula from long bones in 1956 (Raxter *et al.*,

2006). Unfortunately, Fully, did not give explicit directions on how to take the measurements needed, but recent work has been completed based on the original method, with results that correlate to stature at 0.96 (Raxter *et al.,* 2006).

Other methods of stature reconstruction have been researched that do not require the use of long bones, and have been tested again on and off. Giroux and Westcott (2008) tested the correlation between stature and sacral height, hip height, and femoral head diameter, obtaining data from 247 individuals in the FDB at the University of Tennessee. These measurements do seem to correlate significantly with stature. Only sacral height in white females had a p value of greater than 0.05. The authors do find that the confidence interval based on the mean and standard deviation falls outside of the 95% confidence interval, suggesting that there is not enough accuracy for use in identifying individuals (Giroux and Wescott, 2008). Giroux and Westcott (2008) also note the ability to use metacarpals, metatarsals, and ankle bones in stature estimation, all of which end up being more accurate than sacral height. Another aspect of Thomas Dwight's work around the turn of the 20th century used the sternum and the spine for respective stature estimation formulae. The sternal method was found to be useless, because sternum length was so variable compared to stature (Stewart, 1979). One recent study supports those results with a correlation of only 0.33 (Marinho *et al.,* 2012). Yet another study found the correlation in their samples to be quite high at 0.66, so the measurement is likely to be studied further (Menezes *et al.,* 2011). Dwight had more success with the spinal method, though a large proportion of his sample was over the age of 60 and he did not document how he measured the "body length" with which he correlated the length of the spine (Stewart, 1979). The Steele method, developed by Steele (1970), can be used when intact long bones are not discovered. Once measurements have been made, they can be translated into stature estimates indirectly or directly. In Steele's indirect method,

measurements of landmarks on fragmentary long bones are used to estimate their maximum length, which are then be put into the regression formulae for stature. Steele's direct method derived estimates from the fragments themselves, bypassing the extra step of using the Trotter and Gleser equations. Stature estimation from fragmentary remains through Steele's method has been reviewed by a number of scientists as well. Standard and clearly defined measurements were used by Simmons *et al.* (1990), and subsequently, the stature estimates obtained were more accurate. Wright and Vasquez (2003) found that greater reliance on articular landmarks was one way to improve accuracy of the measurements. Steele (1970) originally wrote that the indirect method of stature estimation from fragmentary long bones provided a more accurate result than the direct method. Subsequent analyses by Wright and Vasquez (2003) and Bidmos (2009) arrive at the conclusion that the direct method is not only more accurate, but is also less complicated. The indirect method involves two sets of equations. This can take extra time and the extra step is another point where human error can be introduced. When following the two-step indirect method, the standard errors of estimation apply to both regressions, and the final standard error is quite large compared to that of the direct method. A larger standard of error suggests a less accurate estimate. The proximal femoral breadth, measured along the axis of the femoral neck, has been tested on skeletal populations of known stature, and has been shown to have a high correlation with the length of the femur (Simmons *et al.,* 1990). Length of the femur is in turn highly correlated with living stature. A measurement that is slightly modified, but simpler to collect, was tested with similar results by Bidmos (2008a, 2008b) in skeletal populations which lack living stature information. Bidmos (2008a) collected data from a sample of 100 indigenous South Africans from the Raymond A. Dart collection, which is housed at the School of Anatomical Sciences, University of the Witwatersrand, Johannesburg, South Africa. The individuals were from a number of tribes. The majority of the samples were from four

tribes, but were lumped together as they showed no statistically significant intertribal differences (Bidmos, 2008a). It was found that the correlation of the upper breadth of the femur to be 0.61 to total skeletal height, and 0.65 to the maximum femur length in males (Bidmos, 2008a). Females in the study had a higher correlation at 0.79 to total skeletal height and 0.80 to maximum length of femur. Total skeletal height was used in the study since no living stature information was available, determined by using an updated version of the Fully method (Bidmos, 2008a). Bidmos (2008b) completed similar research on a sample consisting of South Africans of European descent. The individuals were descendants of migrants from many European countries, including the Netherlands, the U.K., France, and Germany. As with Bidmos's study on indigenous South Africans, this sample comes from the Dart collection (Bidmos, 2008a, 2008b). Correlations for the European males were similar to those for indigenous South African males, at 0.66 between upper breadth of the femur and total skeletal height, and 0.61 between upper breadth of the femur and maximum length of the femur. Correlations with these measurements in females were much lower than with the previous study. Upper breadth of the femur was correlated with total skeletal height at only 0.56 and with maximum length of the femur at 0.62 (Bidmos, 2008b).

Occasionally, researchers' complete analyses on established methods in order to determine the most accurate version that should be used. In an effort to understand which anatomical method is the most accurate, Maijanen and Niskanen (2010) tested eight procedures on a sample of males from the Bass Donated Skeletal Collection. Included were the Fully method and the Raxter and colleagues revised Fully method mentioned above. A modified Fully method in which measurements of the vertebrae are taken at the posterior midline had the highest correlation with living stature at 0.94 (Maijanen and Niskanen, 2010). New methods of stature estimation have been developed in an effort to

achieve accurate results from as much as a full skeleton to as little as a fragment of a single bone. The upper breadth of the femur is one of the most recent methods that has been tested that has applicability in modern forensic and human rights work. By studying this method of stature estimation and testing on modern American populations, previous work is being verified and extended to a new population (Fitzpatrick, 2012).

2.11 Factors Affecting Stature

There are five main factors that have been found to affect adult stature regardless of sexual dimorphism. These five factors are genetics, altitude, climate, nutrition, and pathology (Bogin and Varela-Silva, 2010; Beall, 2013; Vercellotti *et al.,* 2014; Wood *et al.,* 2014). Each of these conditions may affect individuals at different stages of their growth and development which, in turn, manifest variously as differences in their overall adult body size, limb lengths, radial and crural indices, and appendicular morphology when compared to other individuals within the same population. All of these stimuli affect limb length differently and can thus be differentiated in skeletal analyses (Weinstein, 2005; Bogin *et al.*, 2007; Serrat *et al.,* 2008; Bogin and Varela-Silva, 2010; Wood *et al.,* 2014; Camara, 2015). The results from these studies suggest that the difference between potential height (as provided by genetic inheritance) and actual height (as affected by extrinsic pressures) account for the wide variety of statures observed within relatively isolated geographic populations. Extrinsic pressures affect individuals during critical phases of growth and development, leading to trade-offs in energy consumption and stunting stature (Bogin *et al.,* 2007; Schooling *et al.,* 2008a; Schooling *et al.,* 2008b; Pomeroy *et al.,* 2012). Of the previously mentioned factors affecting stature, climate and altitude are particularly important to evolutionary studies due to their implications of evolutionary biology. Humans are the only species to be adapted across extremes of climate and altitude and the effects of these varied living conditions create

observable differences in humans (Bailey *et al.,* 2007; Weinstein, 2005; West, 2006). Nutrition and pathology, as they relate to stature, have the ability to demonstrate patterns of inequality and disparities in access to resources (Pfeiffer and Harrington, 2011; Vercellotti *et al.*, 2014; Camara, 2015). Due to the multidimensionality of stature, factors not directly related to research questions in a study must be controlled or the researcher may mistakenly interpret their results (Byers, 1994).

2.11.1 Genetics and stature

It is commonly believed that genetic inheritance accounts for a significant portion of achieved adult stature. Although inheritance can account for up to 90% of stature variation, genetic studies have found that as many as 9,500 Single Nucleotide Polymorphisms (SNPs) account for only 29% of stature diversity (Yang *et al.,* 2010; Wood *et al.,* 2014). This suggests that variations in the genome control a very small portion of the diversity observed in stature. The highly complex nature of stature in genetics directly translates to the inability of using ancient DNA to study the divergence of potential and actual height. Studies on the role of the environment on stature have also reduced the importance of genetic inheritance on adult stature (Bogin *et al.,* 2007; Ruff, 2002; Bogin and Varela-Silva, 2010; Becker *et al.,* 2012; Vercellotti *et al.*, 2014; Camara, 2015).

2.11.2 Altitudinal changes and stature

Altitude, climate, and nutritional deficiency are intricately tied, but the one factor affecting individuals at high altitude, defined as environments above 2,500 meters above sea level, that does not affect individuals at lower altitudes is hypobaric hypoxia-reduced oxygen in the air due to reduced atmospheric pressure (Beall, 2013). Lifelong residents of these high-altitude regions have developed biological responses to the environment

that allow them to thrive with limited oxygen (Beall, 2013). Many of these responses, however, result in what would be considered abnormalities in sea-level populations (Bogin *et al.,* 2007). Research has found that non-residents in these regions are more severely affected by the hypobaric hypoxia than lifelong residents, and this diminishing of the negative effects during adulthood have been explained as adaptations and trade-offs (Bogin *et al.,* 2007; Moore *et al.,* 1998; Pomeroy *et al.,* 2012). These adaptations are separated into four categories: cultural, acclimatization, developmental, and genetic (Beall, 2013). All adaptations rely on the need for reduced energy expenditure and reduced energy intake, which in turn affect growth and development (Moore *et al.,* 1998; Bailey *et al.,* 2007). The developmental category of adaptations is the locus of affected stature. Oxygen deprivation and the energy requirements of high-altitude environments affect the growth of individuals in utero as well as throughout childhood (Bailey *et al.,* 2007; Beall, 2013). Specifically, stunted growth (which affects final stature) appears in the lower limbs, and is more pronounced in the tibia (Bailey *et al.,* 2007). Growth and development in a high-altitude environment are affected such that those individuals are generally shorter but present overall longer limbs for their standing height when compared to individuals living at or near sea level (Weinstein, 2005). In the Andes, there are marked differences between mid-altitude and high-altitude Andean groups in the ratio of appendicular length to trunk height (Pomeroy and Stock, 2012). Compared with relative newcomers, lifelong residents of high-altitude regions present fewer detrimental effects of hypobaric hypoxia. Specifically pertaining to development, these adapted populations exhibit less intrauterine growth retardation, better neonatal oxygenation, and more complete cardiopulmonary transition, which directly translate into better oxygenation of growing tissue and a better postpartum outlook for the child (Moore *et al.,* 1998). Andean populations, in this case, are considered newcomers, and thus are affected by hypobaric hypoxia (Beall, 2013).

2.11.3 Climatic effect and stature

In studies of human skeletal morphology and evolutionary adaptation, climate is defined as the relative mean ambient temperature for a geographic region (Roberts, 1978; Serrat *et al.,* 2008; Wells, 2012). Since the middle of the 19th century, the effect of climate on body proportions and limb morphology has been described (Allen, 1877; Bergmann, 1847). The first of these descriptions is attributed to Carl Bergmann and has been termed Bergmann's rule. It states that populations found in colder climates will have larger body mass than those in warmer climates since endothermic animals require a stable body temperature (Bergmann, 1847). Joel Allen expanded the explanation for this rule by adding that differences occur in the ratio between volume and surface area of the body (Allen, 1877). As surface area increases, heat is more easily transferred between the individual and the environment leading to a reduction in heat trapped within the body. The opposite is true for a lower surface area-to-volume ratio, which leads to a reduced loss of internal heat in colder environments. In order for the body to adapt and change the surface area while maintaining the volume, the limbs must increase in length and robusticity must be reduced leading to taller, thinner individuals in warmer environments and shorter, more robust individuals in colder environments (Roberts, 1978; Wells, 2012). A recent study by Serrat *et al.* (2008) has discovered that cold environments affect growth by reducing the proliferation of chondrocytes. Chondrocytes control the deposition of endochondral bone, but not intramembranous bone, thus affecting long bone diaphysis while maintaining cranial and trunk proportions (Serrat *et al.,* 2008). This can lead to a lower surface area for the individual via reduced limb length, as was predicted by Allen (1877).

2.11.4 Nutritional deficiency and stature

Pathological conditions may also be related to nutritional deficiency. Primary among these diseases due to nutritional stress are rickets and osteomalacia. Rickets and osteomalacia are difficult to discern from each other, but they greatly affect long bone morphology during growth and development (Ortner and Mays, 1998; New and Bonjour, 2003; Ortner, 2003). They are associated with a vitamin D deficiency. While vitamin D can be synthesized by the body through exposure to the sun (UVB radiation) or acquired through diet, colder regions and those with less sunlight due to increased cloud cover as well as general malnutrition possibly lead to the manifestation of these disorders. The result is brittle appendicular bones, with thin cortexes and sparse trabecular bone (Hoffman and Klein, 2012). Growth is slowed, but the timing of ossifications centers remains within normal expectations, leading to shorter limbs but generally normal development. Sub-periosteal bone deposition thickens the diaphysis at the mid-shaft, which gives the bones a column-like appearance and thus do not exhibit the normal tapering at the mid-shaft. Lastly, and most diagnostically, the pliability of long bones with rickets often leads to an extreme curvature of the diaphysis including bowed legs and reduced stature; however, this is not always the case (Ortner and Mays, 1998; New and Bonjour, 2003). Most pathological conditions that affect morphology severely can be identified through simple observations; however, not all pathological conditions are so easily diagnosed (especially in fragmentary remains), and some may have been obliterated by the time the individual dies. Less severe variation in nutrition, specifically iron and zinc deficiencies, will lead to stunted growth (Dietz *et al.,* 1989; Black *et al.,* 2008). These deficiencies manifest most often in the bones of the lower limb with little to no changes in the height/length of the torso (Bogin and Varela-Silva, 2010). Thus, comparisons of torso length to leg length become efficient metrics to discover deficiencies in nutrition between individuals within a population (Bogin and Varela Silva, 2010; Camara, 2015). In modern societies, the nutritional deficiencies are also

correlated with socio-economic status and limited access to other resources such as healthcare (Black *et al.*, 2008; Baten and Blum, 2012). Investigations of differences in the diets of pre-historic societies have often revealed inequalities in access to high-value foods, such as meat, which also contain high levels of iron necessary for adequate bone tissue growth (Le Huray and Schutkowski, 2005; Curet and Pestle, 2010; Cheung *et al.*, 2012; Pearson *et al.*, 2013). These differences are rarely seen within less complex, more egalitarian societies (Dietz *et al.*, 1989). Variations in nourishment that lead to these periods of nutritional and subsequent physiological of stress in individuals, when observed in some defined sub-groups and not others, may suggest differential access to resources and a socially stratified complex society.

2.11.5 Pathological changes and stature

Congenital conditions, those affecting skeletal morphology since birth, are clearly discernible in the long bones, and the two most well-known conditions that stunt growth and produce reduced stature are achondroplasia and pituitary dwarfism. Achondroplasia is a specific form of dysplasia that leads to limited endochondral growth but normal intramembranous bone formation (Ortner, 2003; Sables, 2010). Diagnostic postcranial traits include disproportionate length of bones most pronounced in the femur and humerus and normal diaphyseal diameters and cortical thicknesses with disproportionately wide epiphysis and metaphysis (Rodriguez *et al.*, 2012; Waters-Rist and Hoogland, 2013). Pituitary dwarfism is the result of a deficiency in a growth hormone leading to proportional dwarfism. The skeleton is generally gracile, with thin cortical bone, sparse trabeculae, and a thin layer of bone closing the metaphyseal surface indicating stunted growth and leading to non-union of the epiphysis until possibly much later in life (Aristova *et al.*, 2006). Other pathological conditions during growth and development cause a redirection of resources from growth and development causing

stunted growth (Bush, 1991; Aufderheide and Rodriguez-Martin, 1998; Ortner, 2003). These conditions must be addressed as factors affecting growth but do not require direct diagnosis in a population-wide study.

2.12 Stature and Health

Stature estimates are often used as a proxy for health when creating cross-cultural comparisons (Holliday, 2002; Raxter *et al.,* 2006; Pfeiffer and Harrington, 2011; Pomeroy and Stock, 2012). Some scholars have suggested that health and stature are inextricably linked, and thus support the use of stature as a marker of population health (Baten and Blum, 2012; Williams and Murphy, 2013; Camara, 2015). Regional and ancestral variations have been extensively studied in regards to stature (Trotter, 1951; Feldesman and Fountain, 1996; Moore *et al.,* 1998; Pomeroy and Stock, 2012), but the simplistic perspective of stature as an indicator of health prevails in diachronic analyses within bioarchaeology (Larsen, 1995; Pietrusewsky *et al.,* 1997). Stature has also varied widely in human populations since before the Neolithic period (Larsen, 1995; Holliday, 2002; Pinhasi *et al.,* 2011). Therefore, many researchers that have attempted this approach have discovered problems in such an interpretation due to the complexities involved in attaining adult stature (Pfeiffer and Harrington, 2011; Becker *et al.,* 2012; Gahtan and Mark, 2013). Although multiple studies have used stature as a proxy for health, this relationship appears oversimplified when other factors involved are not controlled, leading to fallacies in the conclusions being drawn. If an individual suffers stress during growth and development and is shorter than their peers, they thus demonstrate a hidden frailty and are more susceptible to further stress during adulthood (Byers, 1994). Some studies have suggested link between short stature and further stress in adulthood leading to diminished longevity in the past (Kemkes-Grottenthaler, 2005; DeWitte and Hughes-Morey, 2012; Amoroso *et al.,* 2014). However, research on modern

populations seems to suggest the opposing correlation of shorter men actually living longer, demonstrating the complexity of this subject (Samaras, 2007; Bartke, 2012; Salaris *et al.,* 2012; Kabat *et al.,* 2013; He *et al.,* 2014).

2.13 Effect of Month and Season of Birth, and Final Adult Stature

One of the factors that is believed to affect many morphological and physiological features, as well as health outcomes, is the month or season of birth, even though the underlying mechanisms still remain obscure (Douros *et al.,* 2019). Among other things, month or season of birth, have been linked with adult adiposity and leg length (Lv *et al.,* 2015), longevity (Doblhammer and Vaupel, 2001), psychiatric disorders (Giezendanner *et al.,* 2013), and timing of menopause (Cagnacci *et al.,* 2005). The effect of month of birth on human height has been examined in a number of studies. Although, in general, these studies tend to report that individuals born in spring and summer are taller (Henneberg and Louw, 1990; Weber *et al.,* 1998), results vary enough across studies and definite conclusions cannot yet be drawn (Pomeroy *et al.,* 2014; Sohn, 2015; Rosset *et al.,* 2017). Season of birth, a marker of *in utero* vitamin D exposure, has been associated with a wide range of health outcomes. Studies have shown a significant association between seasonality and age at menarche, birth weight and adult stature. Individuals born in summer (dry season) have higher mean birth weight, later pubertal development and taller adult stature compared to those born in all other seasons. Concordantly, those born in winter (rainy season) shows directionally opposite differences in this outcome (Day *et al.,* 2015). A number of previous studies have revealed a link between season and month of birth and adult height, but with contrasting patterns among the different populations. In 18 years, old Austrian conscripts, there was a clear sinusoidal variation of height with a period of 12 months; the maximum was reached in April and the minimum in October; that in Australia (southern hemisphere) males born between February to July were taller

than those born in the remaining months (Weber *et al.,* 1998). Kihlbom and Johansson (2004) reported that in Sweden (northern hemisphere), males born between March and May were significantly taller than those born in November or December. Because the effect seems to be similar in both the hemispheres, some common factors across the world was suggested. However, the studies of Shephard *et al.* (1979) and Koscinski *et al.* (2004), both in the northern hemisphere, revealed contradicting findings that children born between July and March and those between October and March were significantly taller and heavier, respectively, than those born in the remaining months. These inconsistent results may surface from differences in geographical location, season, climate, month of anthropometric measurement, genetics, environmental and socioeconomic factors. In Spanish middle-aged men (but not women), the tallest group were those born in June and July (Banegas *et al.,* 2001). Men from rural China born in the winter were shorter to those born in other seasons (Zhang, 2011). In adult men and women from the UK, those born in summer months were taller than those born during the rest of the year (Day *et al.,* 2015). Nevertheless, the relationship between month or season of birth and adult height was not obvious in some other studies. In Indonesia, adult height in both men and women was not affected by the month of birth in either men or women; small differences appeared only with the comparison of wet and dry seasons (Sohn, 2015). In a large international sample of adult actors, no relationship between month or season of birth and height was observed (Kramer, 2016). In a study that included women of European origin living in northern and southern hemispheres (Poland and Australia), no association was found between adult height and month of birth. The results of the study conducted by Douros *et al. (*2019), suggesting a seasonality in human height, even though no definitive explanation was made for this phenomenon, are in close agreement with that of the Austrian study since both demonstrate a valid correlation described by a sinusoidal model with a period of 12 months and, the position of the two

extremes being practically the same (Weber *et al.,* 1998). According to Douros and colleagues, there was a statistically significant month-of-birth effect on height variation, which was described by a sinusoidal model with period T = 12 months, amplitude 0.22 cm and, two extremes which corresponded to the end of April/beginning of May (peak) and to the end of October/beginning of November (nadir). The discrepancies among studies may be related to differences in each distinct population. Also, some studies are based on small or not representative samples or, include subjects with a wide age range that were born under dissimilar conditions or may have entered the age-related height shrinking. Furthermore, in the majority of the studies, the measurements were not performed for the purposes of the particular research project but were rather obtained from existing databases, a fact that renders the accuracy of the measurements questionable (Douros *et al.,* 2019).

There are several possible explanations of the observed dependence of height and weight on month and season of birth. Firstly, Weber *et al.* (1998) postulated that the periodicity of height and weight may be due to influence extending from the time of late pregnancy to the first postnatal year, and infer a phylogenetic remnant in humans because seasonal photic input is known to regulate various body functions and growth in mammals. Human growth appears to be the fastest during the three months before birth and during infancy. Weight doubles and infants grow taller by about 10 cm during the first three months of birth (Kuroda, 2001), and body fat percentage increases rapidly from 12% at birth to 25% in about 6 months. Meanwhile, growth deficits that arise before the fourth year cannot be compensated fully even if good or excellent environmental conditions follow (Morikawa and Uchiyama, 2004). Secondly, the dependence of height, weight and obesity on nutritional factors and diseases has been known for a long time. Eating habits and the composition of food have been influenced by changes in climate and temperature

over the seasons. Of the nutritional components of diet, most intakes (87%), including energy, proteins, lipids, vitamins and minerals varied significantly with seasons. The average daily intake of these nutrients reduced in the order of season, autumn, winter, spring and summer (Tokudome *et al.,* 2001; Sasaki *et al.,* 2003). Studies on Japanese young female subjects have shown a significant seasonal variation in the amount of unabsorbed dietary carbohydrate from breakfast, which was the largest during winter and the smallest during autumn (Tsumura *et al.,* 2005). On the other hand, children are more prone to infectious diseases in the cold season than in others and birth month affects the probability of falling ill (Nonaka and Imaizumi, 2000). Thus, it can be inferred that the effect of month of birth on height and weight may be due to seasonal variation in food intake, eating habits and early exposure to diseases. Thirdly, the socioeconomic status of family may be important in determining height and weight. Kihlbom and Johansson (2004) and Koscinski *et al.* (2004), reported strong and significant effect of month of birth in a group of people with high socioeconomic status, that fathers in this group more often had their children during spring, even though no conclusion was drawn from this relationship owing to lack of socioeconomic data. These growth characteristics (height, weight and obesity) are influenced by genetic factors as well as environmental and socioeconomic conditions. Studies on candidate-gene associations and genome-wide scans for human obesity have implicated many loci and genes on autosomal chromosomes in the development of human height and obesity (Christopher *et al.,* 2005; Liu *et al.,* 2006).

2.14 Stature and Anthropometric Parameters of the Body

2.14.1 Mandibular measurements (bigonial width and length of mandibular arch)

Morphological criteria are observable and need enough experience but metric parameters of the mandible like bigonial width and length of mandibular arch can be used in

identifying the sex of mutilated and unidentified bodies when combined with some other criteria used for sex determination. Through ages, the skull has remained useful for creation of biological profiles in mass disasters. However, in most cases when the entire skull is not available, the technical procedures have to be based on fragmented bones of skull. In such cases, mandible, which is the largest and the most dimorphic part of skull, plays a vital role in sex determination in corpse remains of the subjects. Mandibles were used for the analysis for two simple reasons: firstly, there appears to be a paucity of standards utilizing this element and secondly, this bone is often recovered largely intact. The presence of a dense layer of compact bone makes it very durable, and hence remains well preserved than many other bones. Mandibles can be used for sexual dimorphism as it is readily available and resistant to any disintegration process. However, levels of sexual dimorphism are population specific due to a combination of genetic and environmental factors (Rai *et al.,* 2007). Dimorphism in mandible is reflected in its shape and size (Saini *et al.,* 2011). Male bones are generally bigger and more robust than female bones (Scheuer, 2002). The relative development (size, strength, and angulation) of the muscles of mastication is known to influence the expression of mandibular dimorphism as masticatory forces exerted are different for males and females (Franklin *et al.,* 2008). Humphrey *et al*. (1999) emphasized that almost any site of mandibular bone deposition, resorption, or remodelling seems to have a potential for becoming sexually dimorphic. Hence, mandibular condyle and ramus in particular are generally the most sexually dimorphic as they are the sites associated with the greatest morphological changes in size and remodelling during growth. Measurements of the mandibular ramus tend to show higher sexual dimorphism, and differences between the sexes are generally more marked in the mandibular ramus than in the mandibular body (Humphrey *et al.,* 1999). Methods based on measurements and morphometry are accurate and can be used in determination of sex (Vodanovic *et al.,* 2006).

Sexual dimorphism in the mandible may be due to the relative difference in the development of the musculoskeletal system, especially the muscles of mastication attached to the mandible (Ongkana and Sudwan, 2009). In the adult skeleton, sex determination is usually the first step of the identification process, as subsequent methods for age and stature estimation are sex dependent. Dependability of sex determination relies on the completeness of the remains and the degree of sexual dimorphism inherent in a population, but it is usually considered that the two most sexually dimorphic elements of the skeleton are the skull (including the mandible) and the pelvis. The need for such a type of research is due to the increased incidents of violence and the increased number of unidentified and mutilated bodies being referred to the forensic expert (Franklin *et al.,* 2008). If different parameters are tested within specific population groups, both qualitative and quantitative criteria can be identified and used in combination to distinguish sex, age and ethnicity (Fabian and Pembeni, 2002). Various studies have clearly indicated that the skeletal characters vary by population, and there is a need to lay down population-specific standards (Vodanovic *et al.,* 2006). The mandible is the largest and strongest bone in the face with a horizontally curved body that is convex forwards with two broad rami, which ascend from the posterior end of the body. The rami bear the coronoid and condyloid processes (Susan, 2008). The mandible is considered suitable for study as it is the most durable bone of the facial skeleton and retains its shape better than other bones. Sexual dimorphism in the mandible may be due to the relative difference in the development of the musculoskeletal system, especially the muscles of mastication attached to the mandible (Ongkana and Sudwan, 2009). The knowledge about the anatomy of the mandible and its variations in age, sex and race will help physicians, surgeons, medico-legal authorities and anthropologists to give correct interpretations for the diagnostic procedures in living. The differences observed in male

and female mandibles may be explained on the basis of genetically determined factors, like the size of teeth, and local factors, like muscle forces (weaker in females as compared with males). Sexual division of labour and access to adequate nutrition are the other factors responsible for sexual dimorphism of bones (Babita *et al.,* 2017). It has been established that socio-environmental factors (e.g. nutrition, food, climate, pathologies, etc.) influence the development, and thus the appearance of bones (Suazo *et al.,* 2008a; Saini *et al.,* 2011; Indira *et al.,* 2012). Numerous studies have demonstrated that skeletal characteristics differ in each population and have emphasized the need for population-specific osteometric standards for sex determination (Vodanovic *et al.,* 2006). Various studies have investigated the sexual dimorphism of the mandibular ramus flexure using direct visual assessment, e.g. Hill (2000) found that results of these studies were contradictory and not repeatable (Oettle *et al.,* 2005). Hill (2000) questioned the predictive accuracy of mandibular ramus flexure as a single indicator of sexual dimorphism and suggests that caution be used when applying this technique in the absence of other morphological and osteometric indicators, especially in the case of fragmentary forensic or rare fossil remains.

Giles measured mandibles of known sex using anthropometric measurements and reported mandibular ramus height, maximum ramus breadth, and minimum ramus breadth as highly significant, with an accuracy of 85% in American Whites and Negroes (Giles, 1964). Steyn and Iscan (1998) achieved an accuracy of 81.5% with five mandibular parameters (i.e. bigonial breadth, total mandibular length, bicondylar breadth, minimum ramus breadth, and gonion-gnathion) in South African Whites.

Saini *et al.* (2011) conducted a study on dry adult mandibles of northern part of India and found that ramus expresses strong sexual dimorphism in this population. That the overall prediction rate using five variables was 80.2%, and the best parameters were coronoid

height, condylar height, and projective height of ramus, and that breadth measurements were not very dimorphic in their sample.

Studies conducted by Behl *et al.* (2020) and Batool and Areej (2020) showed that gonial angles were influenced by both gender and age. As gonial angles decreases with increasing age, there seems to be the difference in gonial angles with different age groups but little significant and definitely reliable. Gonial angles can serve as adjunct and additional forensic parameter which guides for age group assessment and sex determination. Bigonial width was larger in males and increases with age, so the mandible increases in size collectively with age.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

The following anthropometric tools and equipments were used for the study. These include: Adjustable chair, Gulick Measuring tape (Tanita, USA), Altura Exata portable Anthropometer (Belo Horizonte, Brazil), Digital Caliper (Cerscorf, Brazil), Stadiometer (Alturexata MG, Brazil), Hand gloves, Bitec Calculator, Pachymeter (Cerscorf, Brazil) and digital weight scale.

3.2 Research Participants

The subjects that participated in the study were indigenes of Cross River State, from Calabar Municipal, Odukpani, Akamkpa, Yakurr, Abi, Ikom, Ogoja, Obanliku and Obudu Local Government Areas (n = 1200 with age range 5 - 45 years).

3.3 Study Area

Random selection of subjects in urban and rural communities of the representative Local Government Areas was made. Participants included students and non-students of the named Local Government Areas.

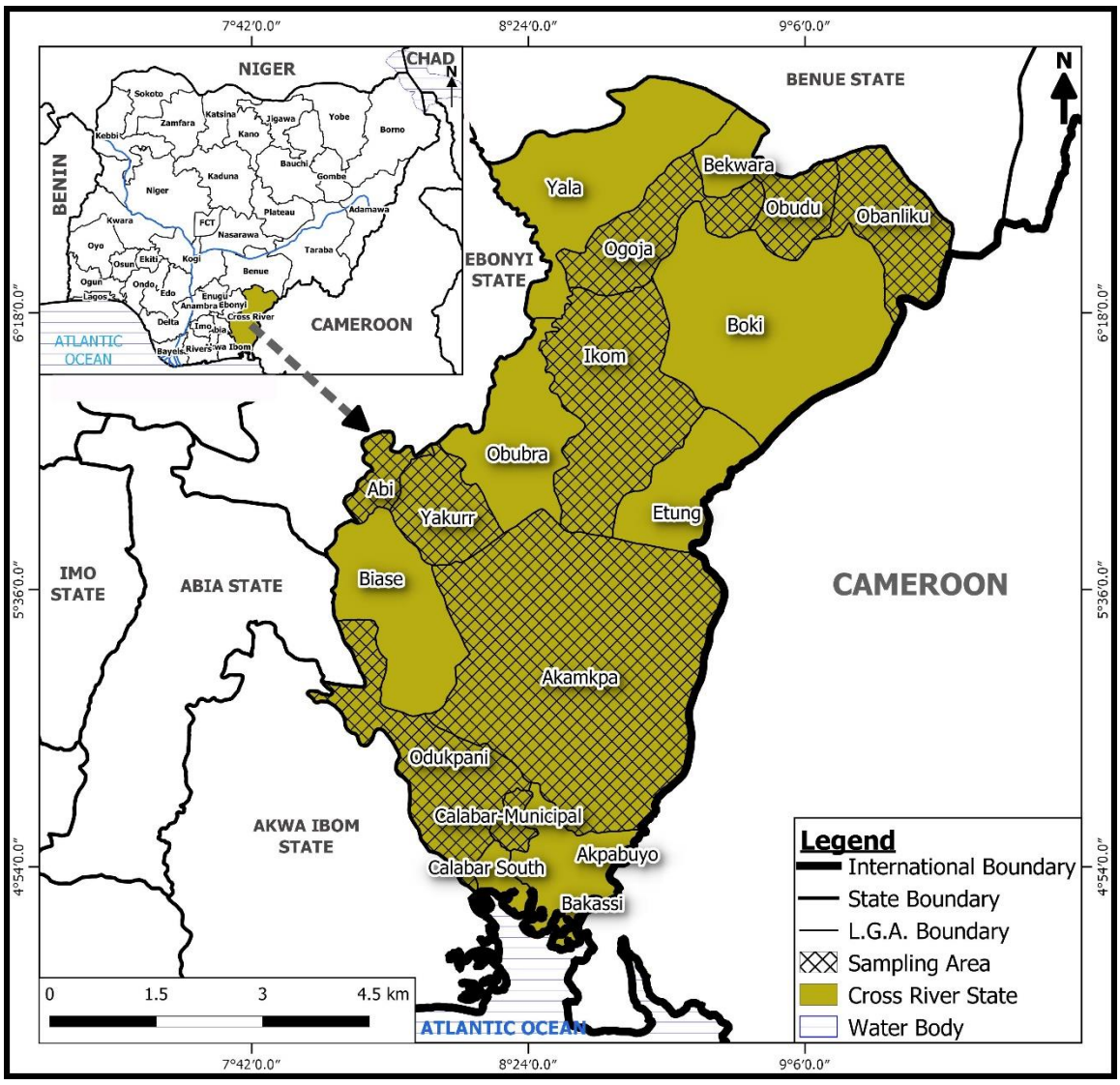


Figure 3.1: Map of Cross River State (Study Areas) showing sampling areas

Source: Map Gallery, Geography Department, ABU Zaria

3.4 Cross River State

Cross River State is a coastal state in South south Nigeria, named after the Cross River (Oyono), which passes through the state. Located in the Niger Delta, Cross River State occupies 20,156 square kilometers land area. It shares boundaries with Benue State to the north, Enugu and Abia States to the west, to the east by Cameroon Republic and to the south by Akwa-Ibom State and the Atlantic Ocean. The Cross River, with a catchment area of 53,590 sqkm, delivers more sediment load to the coast, than the present Niger Benue drainage system (Ukpenetu, 1987). The same Niger Delta shoreline is therefore undergoing erosion on account of sediment starvation. The strength of the Cross River deltaic sedimentation derives from the Cameroon mountain which is the most active sediment source area along the West African coast (Ukpenetu, 1987).

3.4.1 Government

Cross River State was created on May 27, 1967 from the former Eastern Region, Nigeria by the General Yakubu Gowon regime. Its name was changed to Cross River State in the 1976 state creation exercise by the then General Murtala Mohammed regime from South Eastern State (Ukpenetu, 1987). The present day Akwa Ibom State was excised from it in

the state creation exercise of September 1987 by the then regime of General Ibrahim Babangida. Its capital is Calabar. It consists of eighteen (18) local government areas, which includes Abi, Akamkpa, Akpabuyo, Bekwarra, Bakassi, Biase, Boki, Calabar Municipal, Calabar South, Etung, Ikom, Obanliku, Obubra, Obudu, Ogoja, Odukpani, Yakurr and Yala. Its major towns are Calabar Municipal, Calabar South, Ugep, Abi, Akamkpa, Odukpani, Ikom, Obubra, Biase, Ogoja, Obudu, Obanliku and Akpabuyo, Boki, Bendeghe Ekiem, Yala, Igede, Etomi, Ofutop, Iso-bendghe, Danare, Ukpe and Ukelle (Ukpenetu, 1987).

3.4.2 Demographics

The state is composed of several ethnic groups, which include the Efik, the Ejagham, Yakurr, Bette, Yala, Igede, Ukelle and the Bekwarra. The three major languages spoken in the state are Efik, Ejagham and Bekwarra (Okoi, 2011). The Efik language is widely spoken in the southern part of Cross River State, especially in Calabar Municipality, Calabar South, Akpabuyo, Bakassi and Odukpani local government areas. The Ejagham language is the most widely spoken language in the state; from Calabar Municipality, Akamkpa, Yakurr, Obubura, Ikom, Ogoja, Obudu and Etung local government areas, to the south west province of Cameroon (Okoi, 2011).

The Efik-speaking people live mainly in the southern senatorial districts (greater Calabar district), which includes Calabar Municipality, Calabar South, Bakassi, Akpabuyo, Odukpani and Akamkpa LGAs. The main Ejagham group occupies mostly the greater Calabar areas of Calabar Municipality, Odukpani, Biase and Akamkpa. There is also the Qua community in Calabar, which speaks Ejagham (Okoi, 2011).

There are also the Yakurr/Agoi/Bahumono ethnic groups in Yakurr and Abi LGA, while the Mbembe are predominately found in Obubra LGA. Further up the northern part of the state are several sub-dialectical groups, among which are Etung, Olulumo, Ofutop, Nkim/Nkum, Abanajum, Nseke and Boki in both Ikom, Etung and Boki LGAs. Also, the Yala/Yache, Igede, Ukelle, Ekajuk, Mbube, Bette, Bekwarra and Utugwanga people are found in Ogoja, Yala, Obudu, Obanliku and Bekwarra LGAs. The Yala are a subgroup of the Idoma nation, part of the Yala LGA's subgroups are the Igede speaking people believed to have migrated from the Uju part of Benue State, who migrated from Ora, in Edo North (Okoi, 2011).

In Cross River North, Bekwarra is the most widely spoken language. It is understood by other tribes in the district. This language along with Efik and Ejagham is used for news broadcast in the state-owned radio and TV stations, and thus, constitutes the three major ethnic groups/languages in the state (Okoi, 2011). Cross River State epitomizes the nation's linguistic and cultural plurality and it is important to note that, in spite of the diversity of dialects, all the indigenous languages in the state have common linguistic roots as Niger-Congo languages. Finally, the state boasts of being the venue of the largest carnival in Africa (Okoi, 2011).

3.4.3 People and culture

The state has an estimated population of about 2.89 million people (2006 projections) who have a rich and unique cultural heritage (Okoi, 2011). Ejagham and Efik are major languages of this state, but the Igbo tribe and language are also present in its western land borders. Forty percent of the estimated population constitutes the active population that is engaged in various economic activities; ranging from subsistence agriculture to urban commerce and transport business (Okoi, 2011).

Traditional festivals relating to farming activities such as the Leboku New Yam Festival, Ugep are observed in the state every 28th Aughust annually to celebrate the rich harvest of the season; Anong Bahumono festival which is held in Anong village, during which different cultural dances are showcased, including Ikpobin (acclaimed to be the most entertaining dance in the state), Ekoi, Obam, Emukei and Eta; Bekwarra, Obudu, Obanliku new yam festival which is held every 1st Saturday of September annually; the Cross River State carnival float which is held 26th and 27th December yearly; the Calabar boat regatta, and the Cross River State Christmas festival which is celebrated from 1st December to 31st December annually (Okoi-Uyouyo, 2002).

As regards tourism, Cross River State offers both its visitors and interested indigenes many centers of attraction. The outstanding ones are Obudu Cattle Ranch, Obudu, Old Residency Museum, Calabar, Agbokin water falls, Ikom, Etanpim cave, Odukpani, Tinapa business resort, Calabar, Mary Slessor's Tomb, Calabar, Ikom monoliths (a series of volcanic stones monoliths of unknown age), Cross River national park, Boki, Calabar drill monkey sanctuary, Calabar marina and Calabar slave park along its course. The state capital, Calabar, can be reached by air through the Margaret Ekpo International Airport at Calabar (Arik Airlines and Aero Contractors), sea and road, while other parts of the state are accessible by road (Enang, 2009).

3.4.4 Weather and climate

Cross River State belongs to tropical rainfall belt where rainfall is usually seasonal and at times very heavy. Humid tropical climate of about 1300 to 3000 mm rainfall and 30 ^{o}C mean annual temperatures prevail over the state, except on the Obudu plateau, where the climate is sub-temperate, with temperatures of 15 ^{o}C to 23 ^{o}C (Okoi, 2011). The high plateau of Obudu experience climatic conditions which are markedly different from the generalized dry and wet period in the rest of Cross River State. Temperatures are 4^{o}C to

10^{o}C lower due to high altitude than in the surrounding areas (Okoi, 2011). Similarly, the annual rainfall figures are higher than in areas around them, particularly on the windward side. Cross River State can, thus, be broadly divided into the following Sub-climatic regions:

i. The moderated sub-temperate within the high plateaus of Obudu, and

ii. The hot, wet tropical extending from the Southern lowlands to the Central and Northern hinterland parts.

The vegetation ranges from mangrove swamps, through rainforest, to derived savannah, and montane parkland. Just as its rocks are diverse, so also are the mineral resource potentials of the state (Okoi, 2011).

3.5 Ethical Approval

The study protocol was reviewed and approved by Health Research Ethics Committee on Human Subjects of the Ahmadu Bello University Zaria and given the **approval no: ABUCUHSR/2020/018**. Written permission to conduct the study was obtained from the authorities of the participating towns and communities. Written and informed consent was obtained from the study participants before commencement of the study, and utmost confidentiality was maintained. Only subjects who gave informed consent to participate in the research were included in this study.

3.6 Inclusion and Exclusion Criteria

3.6.1 Inclusion criteria

The following were used as inclusion criteria:

i. subjects who are indigenes of Cross River State.

ii. subjects within the age range of 5-45 years.

iii. apparently healthy individuals with no obvious physical deformities.

iv. Only subjects who gave informed consent.

3.6.2 Exclusion criteria

The following were used as exclusion criteria:

i. subjects who are non-indigenes of Cross River State.

ii. subjects below or above the stipulated age range

iii. subjects with physical deformities

iv. pregnant women

v. subjects not willing to participate.

3.7 Methods

Data for this study were collected from participants after informed verbal consent was obtained from participants who were between five and fourty-five years old and willing to participate in the survey. In order to encourage more candid and reliable responses, participants were made to complete a self-administered proforma in confidence with their peers unable to see their answers. Random sampling method was used to select 1200 subjects from nine Local Government Areas of Cross River State, and the Local Government Areas were selected based on convenience.

Data were collected through self-administered proforma. Data pertaining to parents' ethnic group, socio-demographic variables and anthropometric parameters were taken.

Anthropometric measurements on participants were carried out by well-trained male and female research assistants. In order to reduce observation errors, anthropometric measurements were taken twice independently and the mean of the two measurements was taken as the actual value.

Social status was analysed according to parents' level of education, birth order, and the number of children in the family.

The following data were filled by each participant using pre-designed proforma:

i Demographics: Data pertaining demographics include current age (years), place of birth, ethnic group, number of siblings, birth order, parents' occupation and parents' level of education.

ii Anthropometric assessment: Anthropometric variables measured were height, weight, BMI, bigonial width, length of mandibular arch, neck length, demi span length, biaxillary length, hand length, hand breadth, wrist breadth, thigh length, leg length, foot length, foot breadth, ankle breadth and sitting height

3.8 Data Collection Technique

Samples for this study were collected from randomly selected subjects (students and non-students) in rural and urban communities of the named Local Government Areas of Cross River State. We recruited 1200 subjects (600 males and 600 females) from the Southern, Central and Northern senatorial zones of Cross River State. The study protocol was divided into four age groups, from children (5 to 11 years), adolescents (12 to 17 years), young adults (18 to 30 years) and adults (31 to 45 years). In order to examine further the rate of change across age groups, we considered the male and female samples from the four age bands separately.

3.9 Sample Size Determination

The sample size for this study was determined from the formula, as described by (Daniel, 1999) [$n=z^2pq/d^2$]

Where:

- n= the desired sample size per ethnic group
- z= the standard normal deviation, usually set at 1.96 (≈2.0)
- p= the proportion in the target population within the desired age range (when no estimate 50% is used; i.e. 0.5)
- q= 1-P
- d= degree of accuracy desired, usually set at 0.05.

  Therefore, n= $(1.96)^2$ (0.5) (0.5)/ $(0.05)^2$ =384.

  For the purpose of this study a total number of 1200 of subjects was used, n = 200 for each sex in each of the senatorial zones in Cross River State.

3.10 Anthropometry

All anthropometric measurements were done in centimetres (cm), following defined landmarks as described by Lohman *et al.* (1988) and Aragao *et al.* (2019).

i. **Height**: was measured to the nearest centimetre (cm) using a stadiometer with subject standing erect on a horizontal resting plane, bare footed, having the palms of the hands turned inward and the finger pointing downwards. The height was measured from the sole of the feet to the vertex of the head (Lohman *et al.*, 1988), (Plate I).

ii. **Weight**: was measured using digital weighing balance to the nearest kg according to the standard procedures (Lohman *et al.*, 1988).

iii. **BMI:** was calculated by dividing weight by the converted height squared (weight/height squared (kg/m^2). Body Mass Index (BMI) is a number calculated from a subject's weight and height (Lohman *et al.*, 1988).

$$\text{Body mass index} = \frac{Weight\ (kg)}{Height\ (m^2)}$$

iv. **Sitting height (SHt):** was measured as the distance from the vertex of the head to the base of the sitting surface using an anthropometer. It gives a measure of the length of the trunk (Lohman *et al.,* 1988), (Plate II).

v. **Hand length (HL):** was measured as the linear distance from the distal crease to the tip of the middle finger using a digital caliper. The measurements and readings from each subject were taken twice and recorded and if the two measurements and readings for each parameter agreed within 0.4 ranges, the average was taken as the best estimate for the true value. When the two initial measures did not satisfy the 0.4 range criteria, two additional measurements and readings were made and the mean of the closest records was used as the best estimate (Aragao *et al.,* 2019), (Plate III).

vi. **Hand breadth (HB):** was measured as the linear distance between the middle projecting part of the thumb in adducted position and the corresponding part of the ulna side of the hand using a digital caliper (Aragao *et al.,* 2019), (Plate III).

vii. **Wrist breadth (WRB):** was measured as the distance taken across the styloid processes (oblique to the long axis of the arm) with pressure to compress to tissue using a sliding caliper (Aragao *et al.,* 2019), (Plate IV).

viii. **Demi span length (DSLt):** was measured as the distance from the middle of the sternal notch to the tip of the middle finger in the coronal plane using a calibrated non stretch tape (Lohman *et al.,* 1988), (Plate V).

ix. **Biaxillary length (BALt):** was measured on the ventral surface, side to side at the junction of deltopectoral groove and anterior axillary fold, in a supine or sitting position with an abduction close to the body using a calibrated non stretch tape (Lohman *et al.,* 1988), (Plate VI).

x. **Thigh length (ThL):** was measured as the distance from the midpoint of the inguinal ligament to the proximal edge of the patella using a calibrated non stretch tape (Lohman *et al.,* 1988).

xi. **Leg length (LL):** was measured from the tibiale to the medial malleolus of the tibia using a calibrated non stretch tape (Lohman *et al.,* 1988).

xii. **Foot length (FL):** was measured as the maximum distance between the most prominent part of the heel to the most distal part of the longest toe (great or second toe) with a sliding caliper (Aragao *et al.,* 2019), (Plate VII).

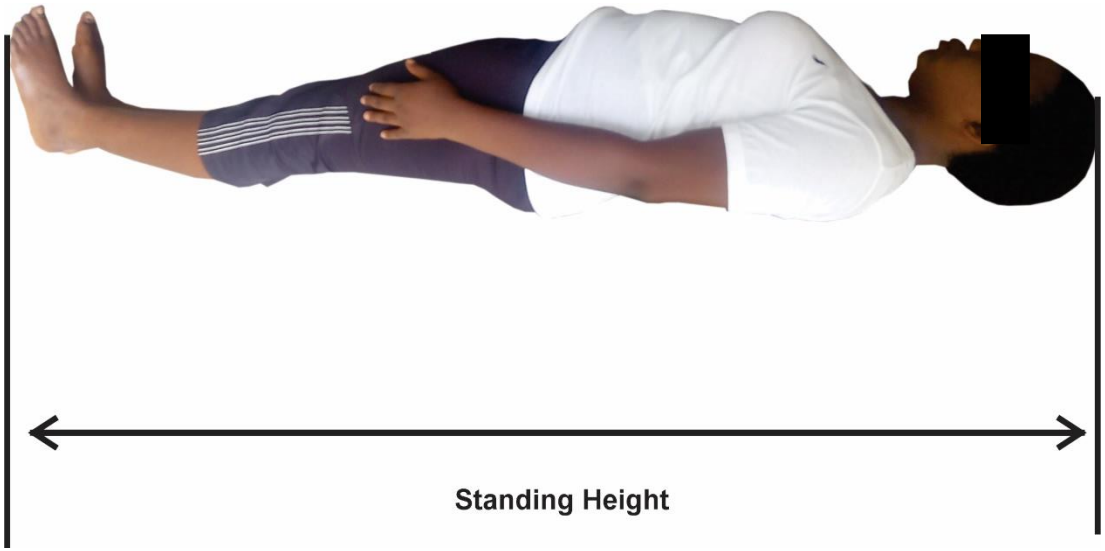
xiii. **Foot breadth (FB):** was measured as the distance between the most prominent point on the medial aspect of head of first metatarsal and the most prominent point on the lateral aspect of head of fifth metatarsal using a sliding caliper (Aragao *et al.,* 2019), (Plate VII).

xiv. **Ankle breadth (AKB):** was measured as the distance taken across the malleoli with pressure to compress the tissues using a sliding caliper (Aragao *et al.,* 2019), (Plate VIII).

xv. **Bigonial width (BGW):** was measured as the linear distance between the two gonia, which are points at the external angle of the mandible, in posterior view, with the aid of a pachymeter (Cerscof) (Aragao *et al.,* 2019), (Fig. 3.2).

xvi. **Length of mandibular arch (LOMA):** was measured in anterior view between the mandibular angles, following the lower edge of the mandible, using an inelastic measuring tape (Aragao *et al.,* 2019), (Fig. 3.3).

xvii. **Neck length (NL):** was measured as the linear distance between two easily recognizable and fixed bony points- the external occipital protuberance and the spinous process of C7 vertebra (vertebra prominence), with the individual standing upright and the neck held in neutral position using an inelastic measuring tape (Lohman *et al.,* 1988).


Standing Height

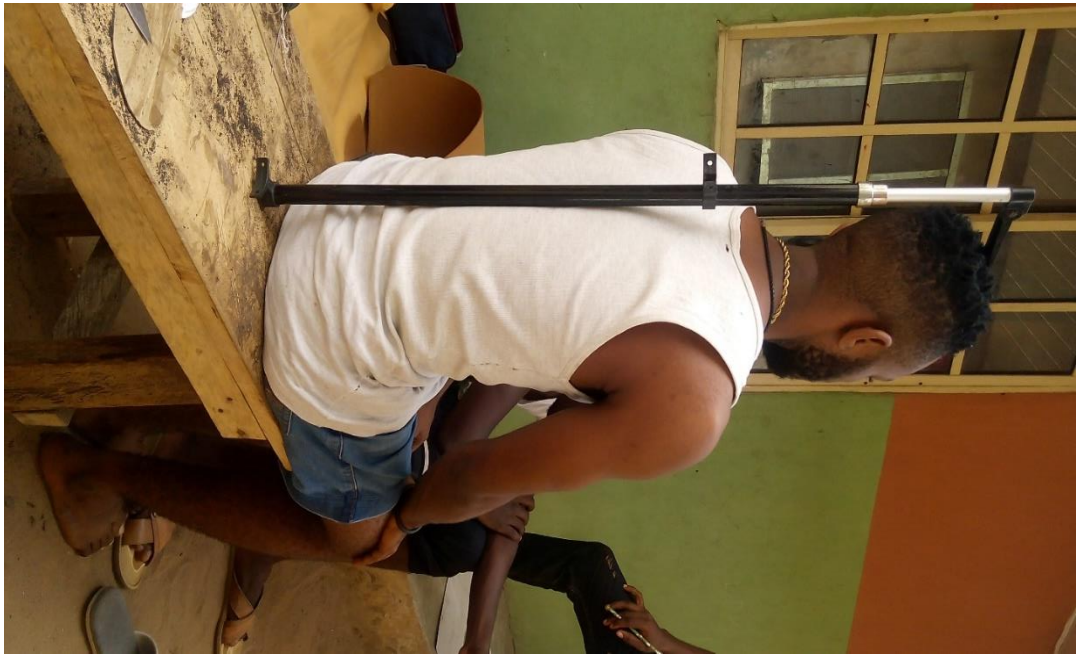


Plate I: Measurement of standing height

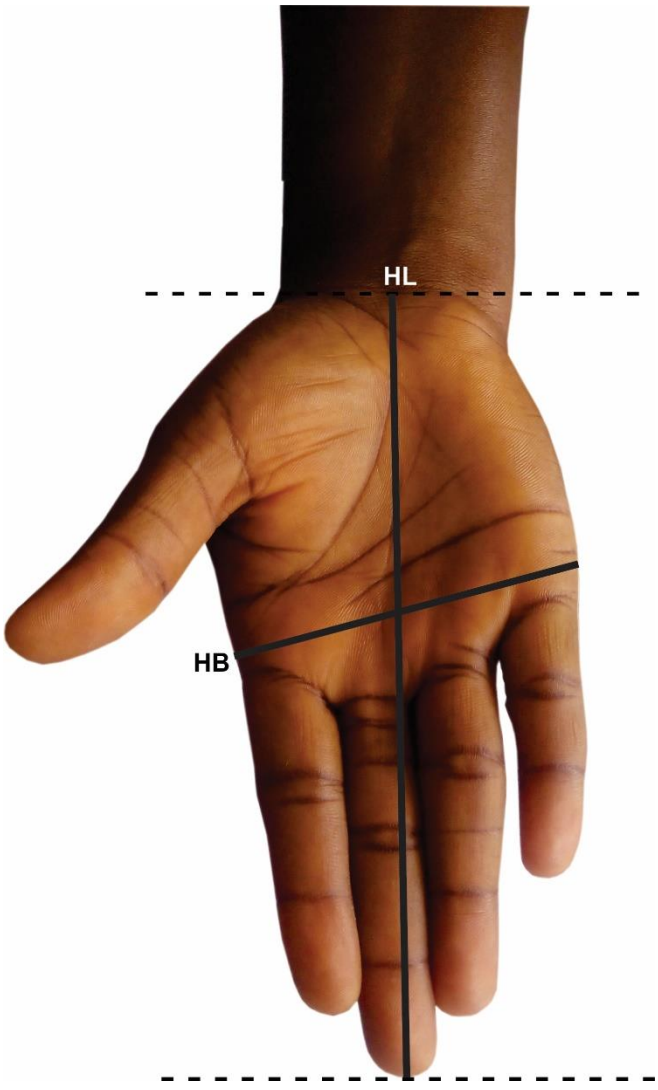


Plate II: Measurement of sitting height



Plate III: Measurement of hand length and hand breadth Plate IV: Measurement of wrist breadth

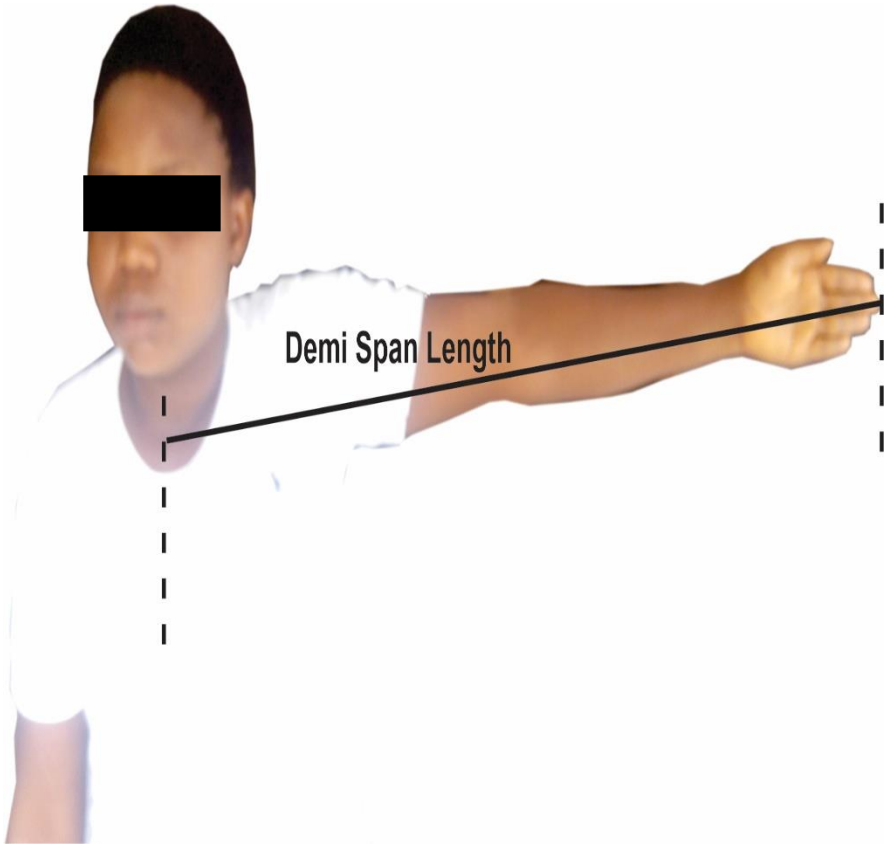


Plate V: Measurement of demi span length



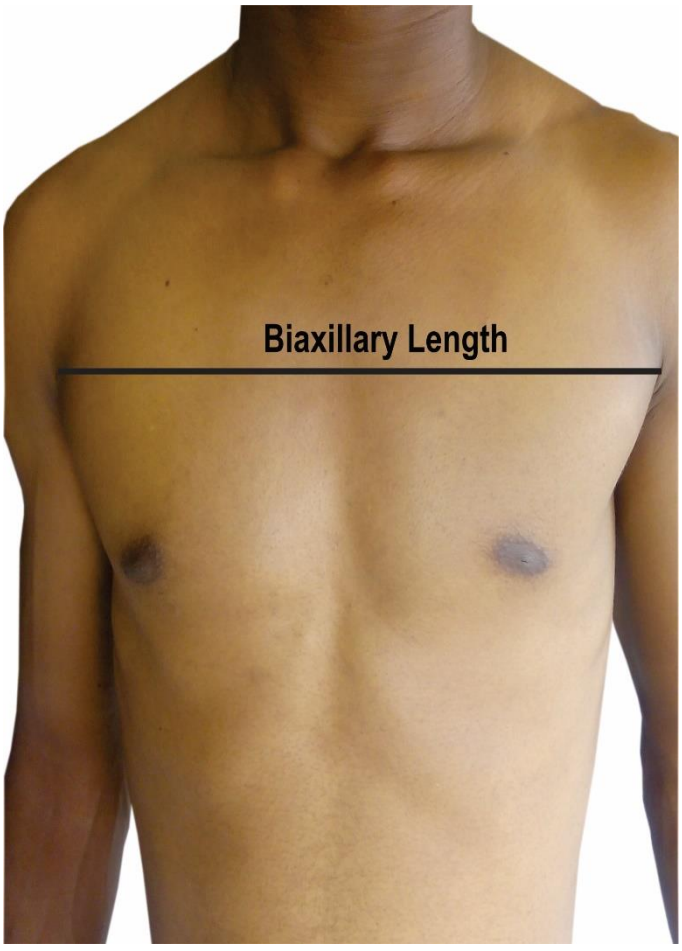
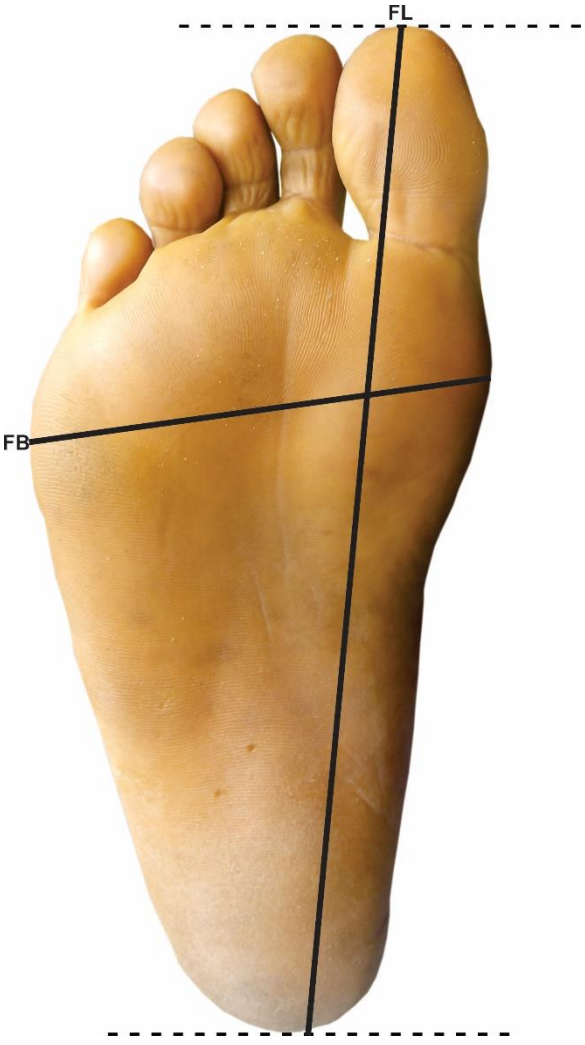


Plate VI: Measurement of biaxillary length


FL
FB

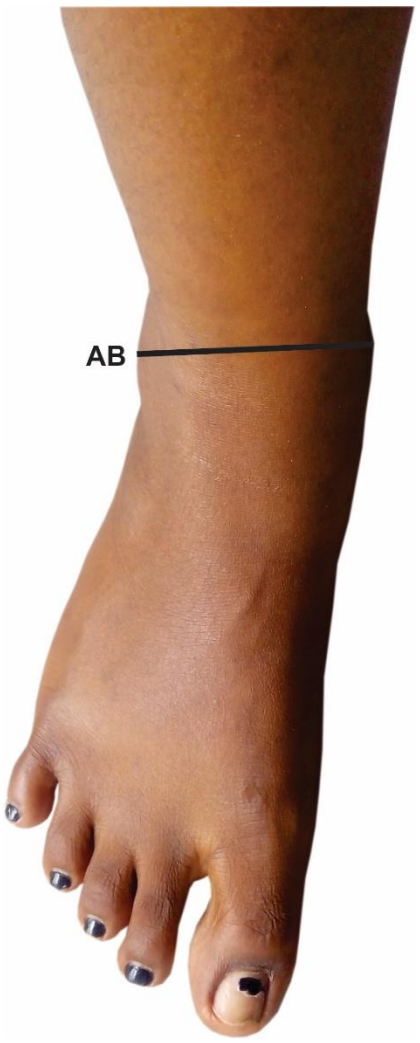

AB

Plate VII: Measurement of foot length and foot breadth Plate VIII: Measurement of ankle breadth

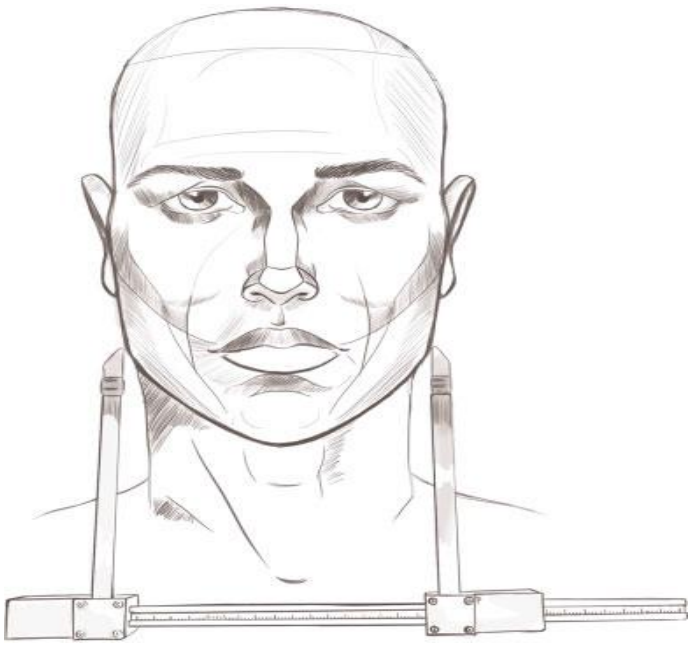


Figure 3.2: Measurement of bigonial width (Aragao *et al.*, 2019)

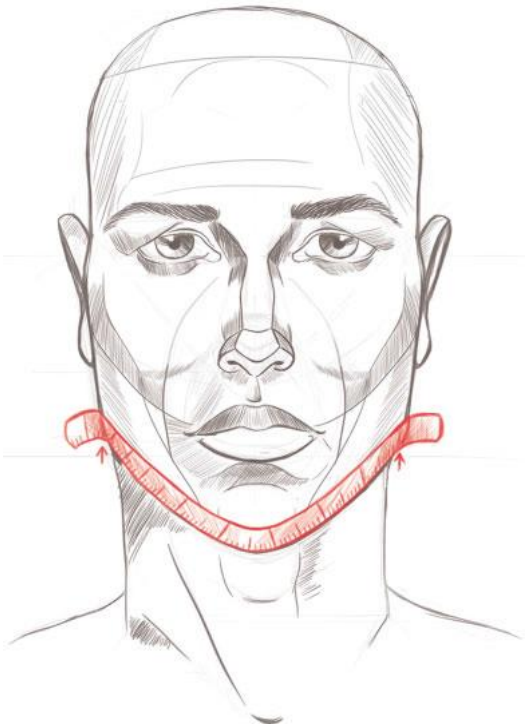


Figure 3.3: Measurement of mandibular arch length (Aragao *et al.,* 2019).

3.11 Data Analyses

Data were expressed as mean ± standard deviation (SD). Student's independent *t*-test was used to investigate significant difference between males and females. One-way ANOVA was used to test the differences in means in the three senatorial zones and according to age group. Pearson's correlation was used to determine the relationship between anthropometric variables. Simple linear and multiple linear regression analyses were performed to derive population-specific equations for predicting stature in the study populations. $P < 0.05$ was deemed statistically significant and SigmaStat 3.5 (Systat, Inc., San Rafael, CA) for Windows was used for the data analyses, Microsoft Excel (Microsoft, Inc, WA) was used to plot charts.

CHAPTER FOUR

4.0 RESULTS

4.1 Analysis of Study Population

A total of one thousand two hundred subjects (students and non-students) participated in this study (n = 1200). This study comprising of 600 males and 600 females from the Southern, Central and Northern Senatorial Zones of Cross River State was conducted in Cross River State, Nigeria. Nine representative Local Government Areas were sampled, three from each senatorial zone. In the Southern Senatorial Zone, Calabar Municipal, Odukpani, and Akamkpa L.G.A. were sampled; in the Central Senatorial Zone, Yakurr, Abi and Ikom L.G.A. were sampled; and in the Northern Senatorial Zone, Obanliku, Obudu and Ogoja L.G.A. were sampled. The age range of the study subjects was 5 – 45

years, while the mean age was 20.35 ± 10.70 years. The study protocol was divided into four age groups, from children (5 to 11 years), adolescents (12 to 17 years), young adults (18 to 30 years) and adults (31 to 45 years). In order to examine further the rate of change across age groups, we considered the male and female samples from the four age bands separately.

4.2 Anthropometric Variables and Stature

Data were collected from subjects using proforma. Descriptive statistics of the entire sample population is shown in Table 4.1. The mean age and mean height of the entire population were 20.35 ± 10.70 years and 153.09 ± 17.98 cm. The minimum age of the population was 5 years while the maximum age was 45 years. Also, average ages of males to females for the study were 20.38 ± 10.56 and 20.31 ± 10.84 years respectively. The mean height for males to females were 155.88 ± 20.13 cm and 150.29 ± 15.03 cm respectively indicating that the males were significantly taller in stature when compared to the females ($t = 5.46$, $P < 0.001$). The mean anthropometric parameters were higher in males when compared to the females in Cross River State $P < 0.05$ except for BMI ($t = -4.91$, $P < 0.001$) which was significantly higher in the females when compared to the males. Weight ($t = 0.70$, $P = 0.486$) and biaxillary length ($t = 0.25$, $P = 0.799$) values were insignificantly higher in the males.

Table 4.1: Anthropometric parameters and sexual dimorphism of the overall population of Cross River State

Variable	Male + Female (n = 1200) Mean + SD	Min - Max	Males (n = 600) Mean + SD	Min - Max	Females (n = 600) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	20.35 ± 10.70	5.00 – 45.00	20.38 ± 10.56	5.00 – 45.00	20.31 ± 10.84	5.00 – 45.00	0.12	0.906	-0.34
Height (cm)	153.09 ± 17.98	100.00 – 198.00	155.88 ± 20.13	101.00 - 198.00	150.29 ± 15.03	100.00 – 191.00	5.46	<0.001	-3.72
Weight (kg)	51.57 ± 19.22	14.00 – 113.00	51.95 ± 19.43	16.00 – 101.00	51.18 ± 19.02	14.00 – 113.00	0.70	0.486	-1.50
BMI (kg/m^2)	21.14 ± 5.06	10.06 – 48.07	20.44 ± 4.14	11.25 – 48.07	21.86 ± 5.75	10.06 – 47.65	-4.91	<0.001	6.50
SHt (cm)	75.27 ± 8.61	50.00 – 94.00	75.90 ± 9.32	50.00 – 94.00	74.63 ± 7.78	50.60 – 90.00	2.56	0.011	-1.70
BGW (cm)	11.28 ± 1.34	7.50 – 20.00	11.55 ± 1.43	7.50 – 20.00	11.02 ± 1.18	7.60 – 14.00	6.92	<0.001	-4.81
LOMA (cm)	19.43 ± 2.16	13.00 – 28.00	19.57 ± 2.23	14.00 – 28.00	19.28 ± 2.08	13.00 – 26.00	2.38	0.018	-1.50
NLt (cm)	11.81 ± 1.79	7.00 – 19.00	12.48 ± 1.65	8.00 – 19.00	11.14 ± 1.68	7.00 – 19.00	14.01	<0.001	-12.03
BALt (cm)	33.30 ± 5.11	20.00 – 52.00	33.34 ± 5.20	20.00 – 48.00	33.26 ± 5.02	20.00 – 52.00	0.25	0.799	-0.24
DSLt (cm)	82.15 ± 10.64	51.00 – 103.00	84.05 ± 11.84	53.00 – 103.00	80.25 ± 8.91	51.00 – 98.00	6.28	<0.001	-4.74
HLt (cm)	18.21 ± 2.23	11.50 – 26.00	18.63 ± 2.45	12.50 – 26.00	17.79 ± 1.90	11.50 – 25.00	6.67	<0.001	-4.72
HB (cm)	10.47 ± 1.52	6.00 – 15.00	10.97 ± 1.65	7.00 – 15.00	9.97 ± 1.17	6.00 – 13.00	12.17	<0.001	-10.03
WRB (cm)	8.37 ± 1.17	5.00 – 12.00	8.63 ± 1.23	5.00 – 12.00	8.11 ± 1.03	5.00 – 12.00	7.79	<0.001	-6.41
ThLt (cm)	49.65 ± 6.97	20.00 – 66.00	49.28 ± 7.30	30.00 – 66.00	50.02 ± 6.60	20.00 – 64.00	-1.82	0.068	1.48
LL (cm)	38.89 ± 5.43	23.00 – 53.00	39.52 ± 6.05	23.00 – 53.00	38.27 ± 4.66	24.00 – 52.00	4.01	<0.001	-3.27
FL (cm)	24.22 ± 2.69	16.00 – 36.00	24.75 ± 3.01	17.00 – 36.00	23.70 ± 2.21	16.00 – 29.00	6.89	<0.001	-4.43
FB (cm)	13.15 ± 1.53	9.00 – 18.00	13.55 ± 1.61	9.00 – 18.00	12.74 ± 1.34	9.00 – 16.00	9.45	<0.001	-6.36
AKB (cm)	13.18 ± 1.47	9.00 – 17.00	13.52 ± 1.54	9.00 – 17.00	12.84 ± 1.31	9.00 – 17.00	8.21	<0.001	-5.30

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.2 shows the mean age and mean height of the entire Southern population of Cross River State. The mean age and mean height were 20.12 ± 10.38 years and 152.90 ± 17.16 cm. The minimum age of the population was 5 years while the maximum age was 45 years. Also, average ages of males to females were 20.18 ± 10.39 and 20.07 ± 10.40 years respectively. The mean height for males to females were 155.35 ± 20.09 cm and 150.45 ± 13.21 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 2.88, P = 0.004). The mean anthropometric parameters were higher in males when compared to the females in Cross River State Southern population p < 0.05, except for body mass index (t = -2.76, P = 0.006), length of mandibular arch (t = -0.10, P = 0.924), biaxillary length (t = -0.17, P = 0.869) and thigh length (t = -1.83, P = 0.068) which were insignificantly higher in the females when compared to males.

Table 4.3 shows the mean age and mean height of the entire Central population of Cross River State. The mean age and mean height were 20.61 ± 10.77 years and 154.44 ± 18.01 cm. The minimum age of the population was 5 years while the maximum age was 45 years. Also, average ages of males to females were 20.73 ± 10.60 and 20.50 ± 10.97 years respectively. The mean height for males to females were 157.59 ± 19.95 cm and 151.30 ± 15.26 cm respectively, indicating that the males were significantly taller in stature when compared to the females (t = 3.54, P < 0.001). The mean anthropometric parameters were higher in males when compared to the females in Cross River State Central Population P < 0.05, except for biaxillary length (t = -0.05, P = 0.964) and thigh length (t = -0.65, P = 0.515) which were insignificantly higher in the females when compared to the males. Also, females have significantly higher mean body mass index (t = -2.71, P = 0.007) when compared to the males (P < 0.05). However, weight (t = 0.69, P = 0.49) and leg

length (t = -1.82, *P* = 0.069) were insignificantly higher in the males when compared to the females.

Table 4.4 shows the mean age and mean height of the entire Northern population of Cross River State. The mean age and mean height were 20.31 ± 10.95 years and 151.92 ± 18.68 cm. The minimum age of the population was 5 years while the maximum age was 45 years. Also, average ages of males to females were 20.25 ± 10.72 and 20.37 ± 11.19 years respectively. The mean height for males to females were 154.71 ± 20.35 cm and 149.12 ± 16.43 cm respectively, indicating that the males were significantly taller in stature when compared to the females (t = 3.02, *P* = 0.003). The mean anthropometric parameters were higher in males when compared to the females in Cross River State Northern population p < 0.05, except for BMI (t = -3.05, *P* = 0.002) which was significantly higher in the females when compared to the males. Also, weight (t = 0.17, *P* = 0.862), sitting height (t = 1.56, *P* = 0.119), LOMA (t = 1.54, *P* = 0.125) and BALt (t = 0.64, *P* = 0.520) were insignificantly higher in the males when compared to the females, except for thigh length (t = -0.73, *P* = 0.469) which was insignificantly higher in the females when compared to the males.

Table 4.2: Anthropometric parameters and sexual dimorphism of the SSZ subjects

Variable	Male + Female (n = 400) Mean + SD	Min - Max	Males (n = 200) Mean + SD	Min - Max	Females (n = 200) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	20.12 ± 10.38	5.00 – 45.00	20.18 ± 10.39	5.00 – 45.00	20.07 ± 10.40	5.00 – 45.00	0.11	0.916	-0.55
Height (cm)	152.90 ± 17.16	101.00 – 198.00	155.35 ± 20.09	101.00 – 198.00	150.45 ± 13.21	110.00 – 174.00	2.88	0.004	-3.26
Weight (kg)	50.45 ± 17.92	15.00 – 92.00	50.75 ± 18.65	19.00 – 90.00	50.15 ± 17.21	15.00 – 92.00	0.33	0.739	-1.20
BMI (kg/m^2)	20.85 ± 4.81	10.96 – 48.07	20.19 ± 4.20	11.25 – 48.07	21.51 ± 5.27	10.96 – 38.29	-2.76	0.006	6.14
SHt (cm)	75.14 ± 8.21	53.00 – 92.00	75.42 ± 9.04	53.00 – 92.00	74.86 ± 7.30	53.00 – 89.00	0.68	0.500	-0.75
BGW (cm)	11.24 ± 1.30	7.50 – 15.00	11.59 ± 1.38	7.50 – 15.00	10.89 ± 1.13	7.60 – 14.00	5.53	<0.001	-6.43
LOMA (cm)	19.81 ± 2.10	14.00 – 28.00	19.80 ± 2.31	14.00 – 28.00	19.82 ± 1.87	15.00 – 24.00	-0.10	0.924	0.10
NL (cm)	11.39 ± 1.57	8.00 – 16.00	12.05 ± 1.45	8.00 – 16.00	10.74 ± 1.41	8.00 – 16.00	9.19	<0.001	-12.20
BALt (cm)	32.50 ± 4.55	21.00 – 42.00	32.46 ± 4.62	21.00 – 41.00	32.54 ± 4.49	22.00 – 42.00	-0.17	0.869	0.25
DSLt (cm)	81.98 ± 10.31	53.00 – 103.00	83.47 ± 11.99	53.00 – 103.00	80.49 ± 8.04	59.00 – 98.00	2.92	0.004	-3.70
HL (cm)	18.18 ± 2.13	13.00 – 26.00	18.52 ± 2.44	13.00 – 26.00	17.84 ± 1.72	13.00 – 22.00	3.21	0.001	-3.81
HB (cm)	10.17 ± 1.52	6.50 – 15.00	10.71 ± 1.73	7.00 – 15.00	9.63 ± 1.02	6.50 – 13.00	7.63	<0.001	-11.21
WRB (cm)	8.28 ± 1.17	5.00 – 12.00	8.57 ± 1.35	5.00 – 12.00	7.10 ± 0.88	6.00 – 11.00	5.01	<0.001	-20.70
ThL (cm)	50.53 ± 6.74	34.00 – 66.00	49.91 ± 7.49	34.00 – 66.00	51.14 ± 5.87	36.00 – 64.00	-1.83	0.068	2.41
LL (cm)	39.07 ± 5.26	23.00 – 52.00	39.82 ± 6.13	23.00 – 52.00	38.33 ± 4.09	25.00 – 47.00	2.85	0.005	-3.89
FL (cm)	24.18 ± 2.60	17.00 – 36.00	24.51 ± 3.05	17.00 – 36.00	23.86 ± 2.01	18.00 – 29.00	2.51	0.012	-2.72
FB (cm)	13.03 ± 1.28	9.00 – 16.00	13.26 ± 1.39	9.00 – 16.00	12.81 ± 1.13	9.00 – 15.00	3.54	<0.001	-3.51
AKB (cm)	13.04 ± 1.26	9.00 – 16.00	13.25 ± 1.36	9.00 – 16.00	12.83 ± 1.11	9.00 – 15.00	3.42	<0.001	-3.27

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SDI = Sexual Dimorphism Index; SSZ = Southern Senatorial Zone; Min = Minimum; Max = Maximum

Table 4.3: Anthropometric parameters and sexual dimorphism of the CSZ subjects

Variable	Male + Female (n = 400) Mean + SD	Min - Max	Males (n = 200) Mean + SD	Min - Max	Females (n = 200) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	20.61 ± 10.77	5.00 – 45.00	20.73 ± 10.60	5.00 – 45.00	20.50 ± 10.97	5.00 - 45.00	0.21	0.835	-1.12
Height (cm)	154.44 ± 18.01	101.00 – 191.00	157.59 ± 19.95	101.00 – 191.00	151.30 ± 15.26	107.00 -191.00	3.54	<0.001	-4.16
Weight (kg)	52.65 ± 20.08	16.00 – 113.00	53.34 ± 20.35	17.00 – 101.00	51.96 ± 19.83	16.00 – 113.00	0.69	0.492	-2.66
BMI (kg/m^2)	21.19 ± 5.30	10.06 – 47.65	20.48 ± 4.30	12.93 – 36.73	21.90 ± 6.07	10.06 – 47.65	-2.71	0.007	6.48
SHt (cm)	75.99 ± 8.47	50.50 – 94.00	76.91 ± 9.17	50.50 – 94.00	75.08 ± 7.63	50.60 – 90.00	2.18	0.030	-2.44
BGW (cm)	11.36 ± 1.44	8.00 – 20.00	11.53 ± 1.62	8.00 – 20.00	11.18 ± 1.22	8.00 – 13.00	2.47	0.014	-3.13
LOMA (cm)	19.02 ± 2.16	14.00 – 26.00	19.31 ± 2.25	15.00 – 26.00	18.73 ± 2.04	14.00 – 23.00	2.69	0.007	-3.10
NL (cm)	12.53 ± 1.77	8.00 – 19.00	13.12 ± 1.61	9.00 – 19.00	11.93 ± 1.73	8.00 – 17.00	7.14	<0.001	-9.97
BALt (cm)	34.36 ± 5.53	20.00 – 52.00	34.35 ± 5.62	20.00 – 48.00	34.37 ± 5.45	23.00 – 52.00	-0.05	0.964	0.06
DSLt (cm)	82.30 ± 10.48	55.00 – 102.00	84.66 ± 11.54	55.00 – 102.00	79.95 ± 8.71	56.00 – 98.00	4.61	<0.001	-5.89
HL (cm)	18.18 ± 2.20	13.00 – 25.00	18.67 ± 2.40	13.00 – 22.50	17.69 ± 1.85	13.00 – 25.00	4.56	<0.001	-5.54
HB (cm)	10.63 ± 1.46	7.00 – 14.00	11.09 ± 1.57	7.00 – 14.00	10.18 ± 1.18	7.00 – 13.00	6.57	<0.001	-8.94
WRB (cm)	8.28 ± 1.10	5.00 – 12.00	8.54 ± 1.10	6.00 – 11.00	8.02 ± 1.04	5.00 – 12.00	4.87	<0.001	-6.48
ThL (cm)	49.14 ± 7.06	30.00 – 64.00	48.91 ± 7.30	30.00 – 64.00	49.37 ± 6.82	30.00 – 63.00	-0.65	0.515	0.93
LL (cm)	38.82 ± 5.20	24.00 – 52.00	39.30 ± 5.54	25.00 – 50.00	38.35 ± 4.81	24.00 – 52.00	1.82	0.069	-2.48
FL (cm)	24.52 ± 2.70	17.00 – 35.00	25.27 ± 2.96	17.00 – 35.00	23.77 ± 2.17	17.00 – 29.00	5.80	<0.001	-6.31
FB (cm)	13.21 ± 1.68	9.00 – 18.00	13.79 ± 1.73	9.00 – 18.00	12.63 ± 1.41	9.00 – 16.00	7.36	<0.001	-9.18
AKB (cm)	13.27 ± 1.59	9.00 – 17.00	13.72 ± 1.63	9.00 – 17.00	12.83 ± 1.42	9.00 – 17.00	5.84	<0.001	-6.94

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SDI = Sexual Dimorphism Index; CSZ = Central Senatorial Zone; Min = Minimum; Max = Maximum

Table 4.4: Anthropometric parameters and sexual dimorphism of the NSZ subjects

Variable	Male + Female (n = 400) Mean + SD	Min - Max	Males (n = 200) Mean + SD	Min - Max	Females (n = 200) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	20.31 ± 10.95	5.00 – 45.00	20.25 ± 10.72	5.00 – 45.00	20.37 ± 11.19	5.00 – 45.00	-0.11	0.916	0.59
Height (cm)	151.92 ± 18.68	100.00 – 188.00	154.71 ± 20.35	101.00 – 188.00	149.12 ± 16.43	100.00 – 174.00	3.02	0.003	-3.75
Weight (kg)	51.60 ± 19.59	14.00 – 103.00	51.77 ± 19.27	16.00 – 100.00	51.43 ± 19.95	14.00 – 103.00	0.17	0.862	-0.66
BMI (kg/m^2)	21.40 ± 5.05	12.40 – 39.45	20.64 ± 3.94	13.29 – 31.74	22.16 ± 5.87	12.40 – 39.45	-3.05	0.002	6.86
SHt (cm)	74.67 ± 9.08	50.00 – 92.00	75.38 ± 9.72	50.00 – 92.00	73.96 ± 8.36	52.00 – 90.00	1.56	0.119	-1.92
BGW (cm)	11.26 ± 1.27	8.00 – 14.00	11.52 ± 1.29	8.00 – 14.00	10.99 ± 1.19	8.00 – 14.00	4.23	<0.001	-4.82
LOMA (cm)	19.45 ± 2.15	13.00 – 26.00	19.61 ± 2.12	15.00 – 24.00	19.28 ± 2.17	13.00 – 26.00	1.54	0.125	-1.71
NL (cm)	11.50 ± 1.81	7.00 – 19.00	12.27 ± 1.68	8.00 – 17.00	10.74 ± 1.59	7.00 – 19.00	9.31	<0.001	-14.25
BALt (cm)	33.04 ± 5.04	20.00 – 48.00	33.20 ± 5.17	22.00 – 45.00	32.88 ± 4.92	20.00 – 48.00	0.64	0.520	-0.97
DSLt (cm)	82.18 ± 11.14	51.00 – 103.00	84.03 ± 11.10	55.00 – 103.00	80.33 ± 9.91	51.00 – 95.00	3.36	<0.001	-4.61
HL (cm)	18.27 ± 2.35	11.50 – 23.00	18.71 ± 2.51	12.50 – 23.00	17.84 ± 2.10	11.50 – 22.50	3.77	<0.001	-4.88
HB (cm)	10.60 ± 1.52	6.00 – 15.00	11.11 ± 1.63	7.00 – 15.00	10.10 ± 1.21	6.00 – 12.00	7.08	<0.001	-10.00
WRB (cm)	8.55 ± 1.20	5.00 – 12.00	8.78 ± 1.23	6.00 – 12.00	8.33 ± 1.14	5.00 – 11.00	3.76	<0.001	-5.40
ThL (cm)	49.29 ± 7.03	20.00 – 63.00	49.03 ± 7.12	31.00 – 62.00	49.54 ± 6.96	20.00 – 63.00	-0.73	0.469	1.03
LL (cm)	38.79 ± 5.82	23.00 – 53.00	39.45 ± 6.46	23.00 – 53.00	38.13 ± 5.04	24.00 – 49.00	2.27	0.024	-3.46
FL (cm)	23.97 ± 2.75	16.00 – 30.00	24.47 ± 2.96	17.00 – 30.00	23.47 ± 2.43	16.00 – 28.00	3.68	<0.001	-4.26
FB (cm)	13.21 ± 1.61	9.00 – 18.00	13.61 ± 1.64	10.00 – 18.00	12.80 ± 1.46	9.00 – 16.00	5.24	<0.001	-6.33
AKB (cm)	13.24 ± 1.54	9.00 – 17.00	13.60 ± 1.60	10.00 – 17.00	12.88 ± 1.40	9.00 – 16.00	4.81	<0.001	-5.59

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SDI = Sexual Dimorphism Index; NSZ = Northern Senatorial Zone; Min = Minimum; Max = Maximum

Table 4.5 shows the mean age and mean height of children in the SSZ of Cross River State. The mean age and mean height were 8.97 ± 1.62 years and 130.41 ± 10.57 cm. The minimum age of the children population was 5 years while the maximum age was 11 years. Also, average ages of boys to girls were 8.84 ± 1.66 and 9.10 ± 1.58 years respectively. The mean height for boys to girls were 128.84 ± 10.93 cm and 131.98 ± 10.07 cm respectively indicating that girls were insignificantly taller in stature when compared with the boys (t = -1.49, P = 0.138). The mean anthropometric parameters were insignificantly higher in girls when compared with the boys $P < 0.05$, except for BMI, bigonial width and neck length which were insignificantly higher in boys when compared with the girls. More so, thigh length was significantly higher in girls (t = -3.87, $P < 0.001$).

Table 4.6 shows the mean age and mean height of children in the CSZ of Cross River State. The mean age and mean height were 8.56 ± 1.84 years and 129.39 ± 10.75 cm. The minimum age of the children population was 5 years while the maximum age was 11 years. Also, average ages of boys to girls were 8.78 ± 1.88 and 8.34 ± 1.80 years respectively. The mean height of boys to girls were 129.04 ± 10.36 cm and 129.74 ± 11.23 cm respectively, indicating that girls were slightly and insignificantly taller in stature when compared with the boys (t = -0.32, P = 0.747). The mean anthropometric parameters were insignificantly higher in boys when compared with the girls $P < 0.05$, except for WT, BMI, SHt, BGW, BALt, HL, ThL and LL which were insignificantly higher in girls when compared with the boys. More so, neck length, foot breadth and ankle breadth were significantly higher in boys (t = 2.41, P = 0.018; t = 3.67, $P < 0.001$ and t = 2.35, P = 0.021) respectively.

Table 4.7 shows the mean age and mean height of children in the NSZ of Cross River State. The mean age and mean height were 8.06 ± 2.02 years and 125.17 ± 11.66 cm. The minimum age of the children population was 5 years while the maximum age was 11 years. Also, average ages of boys to girls were 8.36 ± 2.25 and 7.76 ± 1.74 years respectively. The mean height for boys to girls were 126.10 ± 12.12 cm and 124.24 ± 11.21 cm respectively indicating that boys were insignificantly taller in stature when compared with the girls (t = 0.08, P = 0.427). The mean anthropometric variables were insignificantly higher in boys when compared with the girls $P < 0.05$, except for LOMA and ThL which were insignificantly higher in girls. More so, bigonial width and neck length were significantly higher in boys when compared with the girls (t = 2.66, P = 0.009 and t = 3.51, $P < 0.001$) respectively.

Table 4.5: Anthropometric parameters and sexual dimorphism of children (5-11 years) in SSZ

Variable	Boys + Girls (n = 100) Mean + SD	Min - Max	Boys (n = 50) Mean + SD	Min - Max	Girls (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	8.97 ± 1.62	5.00 – 11.00	8.84 ± 1.66	5.00 – 11.00	9.10 ± 1.58	5.00 – 11.00	-0.80	0.424	2.86
Height (cm)	130.41 ± 10.57	101.00 – 154.00	128.84 ± 10.93	101.00 – 152.00	131.98 ± 10.07	110.00 – 154.00	-1.49	0.138	2.38
Weight (kg)	27.41 ± 5.48	15.00 – 42.00	27.32 ± 5.45	19.00 – 40.00	27.50 ± 5.56	15.00 – 42.00	-0.16	0.870	0.65
BMI (kg/m^2)	16.02 ± 1.90	10.96 – 21.70	16.36 ± 1.82	11.25 – 21.70	15.69 ± 1.94	10.96 – 20.11	1.77	0.081	-4.27
SHt (cm)	65.05 ± 5.98	53.00 – 87.00	64.76 ± 6.06	53.00 – 87.00	65.34 ± 5.95	53.00 – 79.00	-0.48	0.630	0.89
BGW (cm)	9.99 ± 1.01	7.50 – 12.00	10.09 ± 0.10	7.50 – 12.00	9.89 ± 1.02	7.60 – 12.00	0.98	0.329	-2.02
LOMA (cm)	17.62 ± 1.52	14.00 – 22.00	17.20 ± 1.49	14.00 – 20.00	18.04 ± 1.46	15.00 – 22.00	-2.86	0.005	4.66
NL (cm)	10.58 ± 1.42	8.00 – 16.00	10.70 ± 1.33	8.00 – 14.00	10.46 ± 1.50	8.00 – 16.00	0.85	0.399	-2.29
BALt (cm)	27.29 ± 2.70	21.00 – 34.00	27.22 ± 2.91	21.00 – 34.00	27.36 ± 2.50	22.00 – 32.00	-0.26	0.797	0.51
DSLt (cm)	68.41 ± 5.92	53.00 – 83.00	67.34 ± 5.94	53.00 – 83.00	69.48 ± 5.75	59.00 – 82.00	-1.83	0.070	3.08
HL (cm)	15.61 ± 1.36	13.00 – 19.00	15.34 ± 1.32	13.00 – 18.00	15.88 ± 1.36	13.00 – 19.00	-2.03	0.046	3.40
HB (cm)	8.65 ± 0.87	6.50 – 11.00	8.64 ± 0.92	7.00 – 11.00	8.65 ± 0.82	6.50 – 10.00	-0.06	0.954	0.12
WRB (cm)	7.11 ± 0.82	5.00 – 9.00	7.06 ± 0.87	5.00 – 9.00	7.16 ± 0.77	6.00 – 9.00	-0.61	0.542	1.40
ThL (cm)	41.91 ± 4.56	34.00 – 60.00	40.26 ± 3.84	34.00 – 50.00	43.56 ± 4.66	36.00 – 60.00	-3.87	<0.001	7.58
LL (cm)	32.92 ± 4.27	23.00 – 42.00	32.18 ± 4.33	23.00 – 40.00	33.66 ± 4.12	25.00 – 42.00	-1.75	0.083	4.40
FL (cm)	21.20 ± 2.09	17.00 – 27.00	20.87 ± 2.28	17.00 – 27.00	21.53 ± 1.84	18.00 – 27.00	-1.60	0.114	3.07
FB (cm)	11.64 ± 1.04	9.00 – 14.00	11.64 ± 1.06	9.00 – 14.00	11.64 ± 1.03	9.00 – 13.00	0.00	1.000	0.00
AKB (cm)	11.69 ± 1.06	9.00 – 13.00	11.70 ± 1.07	9.00 – 13.00	11.68 ± 1.06	9.00 – 13.00	0.09	0.925	-0.17

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.6: Anthropometric parameters and sexual dimorphism of children (5-11 years) in CSZ

Variable	Boys + Girls (n = 100) Mean + SD	Min - Max	Boys (n = 50) Mean + SD	Min - Max	Girls (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	8.56 ± 1.84	5.00 – 11.00	8.78 ± 1.88	5.00 – 11.00	8.34 ± 1.80	5.00 – 11.00	1.20	0.235	-5.28
Height (cm)	129.39 ± 10.75	101.00 – 160.00	129.04 ± 10.36	101.00 – 147.00	129.74 ± 11.23	107.00 – 160.00	-0.32	0.747	0.54
Weight (kg)	27.05 ± 5.92	16.00 – 49.00	26.76 ± 5.22	17.00 – 44.00	27.34 ± 6.59	16.00 – 49.00	-0.49	0.627	2.12
BMI (kg/m^2)	15.10 ± 1.78	10.06 – 20.64	15.94 ± 1.50	12.93 – 20.64	16.05 ± 2.04	10.06 – 20.16	-0.30	0.762	0.69
SHt (cm)	64.57 ± 5.13	50.50 – 73.00	64.42 ± 5.32	50.50 – 72.00	64.72 ± 4.99	50.60 – 73.00	-0.29	0.770	0.46
BGW (cm)	10.01 ± 1.04	8.00 – 12.50	10.00 ± 1.01	8.00 – 12.00	10.01 ± 1.08	8.00 – 12.50	-0.06	0.954	0.10
LOMA (cm)	16.72 ± 1.23	14.00 – 20.00	16.88 ± 1.02	15.00 – 20.00	16.56 ± 1.40	14.00 – 20.00	1.30	0.195	-1.93
NL (cm)	11.89 ± 1.66	9.00 – 18.00	12.28 ± 1.58	9.00 – 18.00	11.50 ± 1.66	9.00 – 16.00	2.41	0.018	-6.78
BALt (cm)	27.87 ± 2.83	20.00 – 36.00	27.42 ± 2.88	20.00 – 34.00	28.32 ± 2.74	23.00 – 36.00	-1.60	0.113	3.18
DSLt (cm)	68.11 ± 6.39	55.00 – 89.00	68.56 ± 6.76	55.00 – 89.00	67.65 ± 6.04	56.00 – 82.00	0.71	0.480	-1.35
HL (cm)	15.37 ± 1.35	13.00 – 19.20	15.34 ± 1.20	13.00 – 18.00	15.41 ± 1.50	13.00 – 19.20	-0.27	0.791	0.45
HB (cm)	8.98 ± 0.93	7.00 – 11.00	9.10 ± 0.88	7.00 – 11.00	8.85 ± 0.96	7.00 – 11.00	1.36	0.178	-2.82
WRB (cm)	7.06 ± 0.78	5.00 – 10.00	7.20 ± 0.76	6.00 – 10.00	6.92 ± 0.78	5.00 – 9.00	1.83	0.071	-4.05
ThL (cm)	39.78 ± 5.24	30.00 – 64.00	39.38 ± 5.38	30.00 – 64.00	40.18 ± 5.12	30.00 – 54.00	-0.76	0.448	1.99
LL (cm)	32.33 ± 3.96	24.00 – 44.00	32.28 ± 3.74	25.00 – 42.00	32.38 ± 4.20	24.00 – 44.00	-0.13	0.900	0.31
FL (cm)	21.32 ± 2.07	17.00 – 26.00	21.46 ± 2.11	17.00 – 26.00	21.18 ± 2.04	17.00 – 25.00	0.67	0.502	-1.32
FB (cm)	11.19 ± 1.01	9.00 – 13.00	11.54 ± 1.05	9.00 – 13.00	10.84 ± 0.84	9.00 – 12.00	3.67	<0.001	-6.46
AKB (cm)	11.31 ± 1.00	9.00 – 13.00	11.54 ± 1.05	9.00 – 13.00	11.08 ± 0.90	9.00 – 13.00	2.35	0.021	-4.15

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.7: Anthropometric parameters and sexual dimorphism of children (5-11 years) in NSZ

Variable	Boys + Girls (n = 100) Mean + SD	Min - Max	Boys (n = 50) Mean + SD	Min - Max	Girls (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	8.06 ± 2.02	5.00 – 11.00	8.36 ± 2.25	5.00 – 11.00	7.76 ± 1.74	5.00 – 11.00	1.49	0.139	-7.73
Height (cm)	125.17 ± 11.66	100.00 – 150.00	126.10 ± 12.12	101.00 – 148.00	124.24 ± 11.21	100.00 – 150.00	0.80	0.427	-1.50
Weight (kg)	26.06 ± 7.40	14.00 – 56.00	26.74 ± 7.16	16.00 – 46.00	25.38 ± 7.65	14.00 – 56.00	0.92	0.360	-5.36
BMI (kg/m^2)	16.34 ± 2.35	12.40 – 27.76	16.56 ± 2.38	13.29 – 27.76	16.11 ± 2.32	12.40 – 24.89	0.97	0.337	-2.79
SHt (cm)	62.15 ± 4.87	50.00 – 74.00	62.70 ± 5.04	50.00 – 74.00	61.60 ± 4.69	52.00 – 73.00	1.13	0.261	-1.79
BGW (cm)	9.90 ± 0.85	8.00 – 12.00	10.12 ± 0.77	8.00 – 12.00	9.68 ± 0.88	8.00 – 12.00	2.66	0.009	-4.55
LOMA (cm)	17.17 ± 1.51	13.00 – 22.00	17.16 ± 1.27	15.00 – 20.00	17.18 ± 1.72	13.00 – 22.00	-0.07	0.947	0.12
NL (cm)	10.70 ± 1.87	7.00 – 19.00	11.32 ± 1.60	8.00 – 16.00	10.08 ± 1.93	7.00 – 19.00	3.51	<0.001	-12.30
BALt (cm)	27.13 ± 3.02	20.00 – 39.00	27.22 ± 2.54	22.00 – 32.00	27.04 ± 3.46	20.00 – 39.00	0.30	0.767	-0.67
DSLt (cm)	66.47 ± 6.96	51.00 – 81.00	67.42 ± 6.92	55.00 – 81.00	65.52 ± 6.94	51.00 – 80.00	1.37	0.173	-2.90
HL (cm)	15.19 ± 1.68	11.50 – 19.00	15.35 ± 1.67	12.50 – 19.00	15.02 ± 1.69	11.50 – 18.50	1.01	0.316	-2.20
HB (cm)	8.91 ± 1.14	6.00 – 12.00	9.09 ± 1.09	7.00 – 12.00	8.72 ± 1.17	6.00 – 11.00	1.64	0.104	-4.24
WRB (cm)	7.33 ± 1.07	5.00 – 10.00	7.50 ± 1.02	6.00 – 10.00	7.16 ± 1.11	5.00 – 10.00	1.60	0.114	-4.75
ThL (cm)	39.92 ± 5.29	20.00 – 52.00	39.78 ± 5.08	31.00 – 50.00	40.06 ± 5.53	20.00 – 52.00	-0.26	0.793	0.70
LL (cm)	31.46 ± 4.03	23.00 – 41.00	31.56 ± 4.34	23.00 – 40.00	31.36 ± 3.74	24.00 – 41.00	0.25	0.806	-0.64
FL (cm)	20.45 ± 2.21	16.00 – 26.00	20.54 ± 2.12	17.00 – 25.00	20.35 ± 2.32	16.00 – 26.00	0.43	0.670	-0.93
FB (cm)	11.32 ± 1.28	9.00 – 15.00	11.56 ± 1.11	10.00 – 15.00	11.08 ± 1.40	9.00 – 14.00	1.90	0.060	-4.33
AKB (cm)	11.43 ± 1.23	9.00 – 15.00	11.62 ± 1.11	10.00 – 15.00	11.24 ± 1.33	9.00 – 14.00	1.55	0.124	-3.38

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.8 shows the mean age and mean height of adolescent age-group in the SSZ of Cross River State. The mean age and mean height were 14.26 ± 1.68 years and 152.25 ± 9.52 cm. The minimum age of the subjects was 12 years while the maximum age was 17 years. Also, average ages of males to females were 14.28 ± 1.67 and 14.24 ± 1.71 years respectively. The mean height for males to females were 151.78 ± 11.37 cm and 152.72 ± 7.30 cm respectively indicating that the females were insignificantly taller in stature when compared to the males (t = -0.49, P = 0.624). The mean anthropometric parameters were significantly higher in females when compared to the males in Cross River State Southern Population $P < 0.05$, except for bigonial width, neck length, hand breadth and wrist breadth which were significantly higher in the males when compared to the females $P < 0.05$. More so, demispan length (DSLt), BALt and LL were insignificantly higher in the females (t = -1.84, P = 0.069; t = -0.19, P = 0.851 and t = -0.07, P = 0.949) respectively. While, hand length, foot length, ankle breath (AKB) and foot breadth (FB) were insignificantly higher in the males (t = 0.69, P = 0.492; t = 0.31, P = 0.758; t = 1.11, P = 0.270 and t = 1.68, P = 0.096) respectively.

Table 4.9 shows the mean age and mean height of adolescent age-group in the CSZ of Cross River State. The mean age and mean height were 14.48 ± 1.76 years and 155.68 ± 10.70 cm. The minimum age of the subjects was 12 years while the maximum age was 17 years. Also, average ages of males to females were 14.70 ± 1.64 and 14.26 ± 1.85 years respectively. The mean height for males to females were 157.58 ± 12.41 cm and 153.78 ± 8.35 cm respectively indicating that the males were insignificantly taller in stature when compared to the females (t = 1.80, P = 0.075). The mean anthropometric parameters were significantly higher in the males when compared to the females in Cross River State Central Population $P < 0.05$, except for BMI and thigh length which were significantly higher in the females when compared to the males $P < 0.05$. More so, leg length (LL) and BGW were insignificantly higher in the males (t

= 1.42, *P* = 0.158 and t = 0.18, *P* = 0.856) respectively. While, weight (WT), sitting height (SHt), biaxillary length (BALt) and LOMA were insignificantly higher in the females when compared to the males (t = -0.25, *P* = 0.804; t = 0.59, *P* = 0.555; t = -1.00, *P* = 0.318 and t = -1.02, *P* = 0.311).

Table 4.10 shows the mean age and mean height of adolescent age-group in the NSZ of Cross River State. The mean age and mean height were 14.21 ± 1.74 years and 155.13 ± 10.24 cm. The minimum age of the subjects was 12 years while the maximum age was 17 years. Also, average ages of males to females were 14.10 ± 1.80 and 14.32 ± 1.70 years respectively. The mean height for males to females were 154.33 ± 12.66 cm and 155.92 ± 7.10 cm respectively indicating that the females were slightly and insignificantly taller in stature when compared to the males (t = -0.78, *P* = 0.440). The mean anthropometric parameters were significantly higher in the females when compared to the males in Cross River State Northern Population *P* < 0.05, except for neck length, hand breadth, foot breadth and ankle breadth which were significantly higher in the males when compared to the females *P* < 0.05. More so, weight (t = -1.58, *P* = 0.118), BMI (t = -1.55, *P* = 0.125), LOMA (t = -1.67, *P* = 0.097), BALt (t = -1.69, *P* = 0.094), DSLt (t = -0.61, *P* = 0.541) and leg length (t = -1.06, *P* = 0.291) were insignificantly higher in the females, while, BGW (t = 0.45, *P* = 0.657), hand length (t = 0.09, *P* = 0.932), wrist breadth (t = 0.32, *P* = 0.753) and foot length (t = 1.13, *P* = 0.263) were insignificantly higher in the males when compared to the females.

Table 4.8: Anthropometric parameters and sexual dimorphism of adolescent age-group (12-17 years) in SSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	14.26 ± 1.68	12.00 – 17.00	14.28 ± 1.67	12.00 – 17.00	14.24 ± 1.71	12.00 – 17.00	0.12	0.906	-0.28
Height (cm)	152.25 ± 9.52	130.00 – 191.00	151.78 ± 11.37	130.00 – 191.00	152.72 ± 7.30	136.00 – 169.00	-0.49	0.624	0.62
Weight (kg)	45.05 ± 9.08	30.00 – 66.00	42.20 ± 8.63	30.00 – 61.00	47.90 ± 8.69	30.00 – 66.00	-3.29	0.001	11.90
BMI (kg/m^2)	19.31 ± 2.84	11.79 – 28.57	18.18 ± 2.26	11.79 – 22.67	20.44 ± 2.93	14.88 – 28.57	-4.32	< 0.001	11.06
SHt (cm)	73.52 ± 4.81	60.00 – 85.00	72.30 ± 4.67	60.00 – 84.00	74.74 ± 4.68	65.00 – 85.00	-2.61	0.010	3.26
BGW (cm)	11.03 ± 0.87	8.50 – 13.00	11.23 ± 0.91	9.00 – 13.00	10.83 ± 0.80	8.50 – 12.50	2.33	0.022	-3.69
LOMA (cm)	19.38 ± 1.50	16.00 – 23.00	19.00 ± 1.28	16.00 – 22.00	19.76 ± 1.61	16.00 – 23.00	-2.61	0.010	3.85
NL (cm)	11.34 ± 1.43	8.00 – 16.00	11.96 ± 1.34	10.00 – 16.00	10.72 ± 1.25	8.00 – 13.00	4.79	<0.001	-11.57
BALt (cm)	31.22 ± 3.17	22.00 – 37.00	31.16 ± 3.41	23.00 – 37.00	31.28 ± 2.94	22.00 – 37.00	-0.19	0.851	0.38
DSLt (cm)	81.11 ± 5.33	69.00 – 93.00	80.14 ± 6.21	69.00 – 93.00	82.08 ± 4.12	72.00 – 90.00	-1.84	0.069	2.36
HL (cm)	18.23 ± 1.33	15.20 – 21.00	18.32 ± 1.41	15.50 – 21.00	18.14 ± 1.26	15.20 – 21.00	0.69	0.492	-0.99
HB (cm)	9.97 ± 1.01	8.00 – 13.00	10.32 ± 1.15	8.00 – 13.00	9.61 ± 0.68	8.50 – 11.00	3.76	<0.001	-7.39
WRB (cm)	8.14 ± 0.75	7.00 – 10.00	8.32 ± 0.84	7.00 – 10.00	7.96 ± 0.61	7.00 – 9.00	2.45	0.016	-4.52
ThL (cm)	50.76 ± 4.47	35.00 – 59.00	48.62 ± 4.93	35.00 – 57.00	52.90 ± 3.43	44.00 – 59.00	-5.04	<0.001	8.09
LL (cm)	39.08 ± 3.08	30.00 – 46.00	39.06 ± 3.59	30.00 – 46.00	39.10 ± 2.51	34.00 – 46.00	-0.07	0.949	0.10
FL (cm)	24.55 ± 1.77	21.00 – 29.00	24.60 ± 2.02	21.00 – 29.00	24.49 ± 1.50	21.00 – 29.00	0.31	0.758	-0.45
FB (cm)	13.20 ± 0.84	12.00 – 15.00	13.34 ± 0.82	12.00 – 15.00	13.06 ± 0.84	12.00 – 15.00	1.68	0.096	-2.14
AKB (cm)	13.19 ± 0.81	12.00 – 15.00	13.28 ± 0.78	12.00 – 15.00	13.10 ± 0.84	12.00 – 15.00	1.11	0.270	-1.37

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.9: Anthropometric parameters and sexual dimorphism of adolescent age-group (12-17 years) in CSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	14.48 ± 1.76	12.00 – 17.00	14.70 ± 1.64	12.00 – 17.00	14.26 ± 1.85	12.00 – 17.00	1.26	0.212	-3.09
Height (cm)	155.68 ± 10.70	120.00 – 180.00	157.58 ± 12.41	120.00 – 180.20	153.78 ± 8.35	133.00 – 170.00	1.80	0.075	-2.47
Weight (kg)	47.29 ± 9.98	28.00 – 70.00	47.04 ± 10.83	28.00 – 70.00	47.54 ± 9.14	29.00 – 68.00	-0.25	0.804	1.05
BMI (kg/m^2)	19.37 ± 2.92	14.22 – 32.34	18.72 ± 2.49	14.22 – 25.71	20.02 ± 3.19	15.06 – 32.34	-2.27	0.025	6.49
SHt (cm)	75.28 ± 4.44	64.00 – 86.00	75.55 ± 5.19	64.00 – 86.00	75.02 ± 3.58	68.00 – 85.00	0.59	0.555	-0.71
BGW (cm)	10.95 ± 0.88	8.50 – 13.00	10.97 ± 0.84	9.00 – 12.50	10.94 ± 0.92	8.50 – 13.00	0.18	0.856	-0.27
LOMA (cm)	18.60 ± 1.57	15.00 – 23.00	18.44 ± 1.45	15.00 – 23.00	18.76 ± 1.69	16.00 – 22.00	-1.02	0.311	1.71
NL (cm)	12.89 ± 1.54	10.00 – 17.00	13.24 ± 1.39	10.00 – 16.00	12.54 ± 1.62	10.00 – 17.00	2.32	0.023	-5.58
BALt (cm)	33.32 ± 3.39	26.00 – 45.00	32.98 ± 3.29	27.00 – 40.00	33.66 ± 3.48	26.00 – 45.00	-1.00	0.318	2.02
DSLt (cm)	83.00 ± 6.61	68.00 – 101.00	84.69 ± 7.32	71.00 – 101.00	81.31 ± 5.37	68.00 – 92.00	2.63	0.010	-4.16
HL (cm)	18.50 ± 1.42	16.00 – 22.50	18.94 ± 1.65	16.00 – 22.50	18.05 ± 0.98	16.00 – 21.00	3.29	0.001	-4.93
HB (cm)	10.58 ± 0.93	9.00 – 13.00	10.88 ± 0.98	9.00 – 13.00	10.28 ± 0.78	9.00 – 12.00	3.38	0.001	-5.84
WRB (cm)	8.26 ± 0.80	6.00 – 11.00	8.48 ± 0.81	7.00 – 11.00	8.04 ± 0.73	6.00 – 10.00	2.85	0.005	-5.47
ThL (cm)	50.13 ± 4.62	40.00 – 60.00	48.94 ± 4.68	40.00 – 59.00	51.32 ± 4.29	40.00 – 60.00	-2.65	0.009	4.64
LL (cm)	39.99 ± 3.46	33.00 – 48.00	40.48 ± 3.54	33.00 – 48.00	39.50 ± 3.34	34.00 – 46.00	1.42	0.158	-2.48
FL (cm)	25.07 ± 1.78	22.00 – 30.00	25.76 ± 1.90	22.00 – 30.00	24.38 ± 1.33	22.00 – 29.00	4.22	<0.001	-5.66
FB (cm)	13.41 ± 1.15	11.00 – 16.00	13.96 ± 1.11	12.00 – 16.00	12.85 ± 0.91	11.00 – 15.00	5.49	<0.001	-8.64
AKB (cm)	13.55 ± 1.07	11.00 – 16.00	13.98 ± 1.06	12.00 – 16.00	13.12 ± 0.90	11.00 – 15.00	4.38	<0.001	-6.55

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.10: Anthropometric parameters and sexual dimorphism of adolescent age-group (12-17 years) in NSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	14.21 ± 1.74	12.00 – 17.00	14.10 ± 1.80	12.00 – 17.00	14.32 ± 1.70	12.00 – 17.00	-0.76	0.447	1.54
Height (cm)	155.13 ± 10.24	129.00 – 180.00	154.33 ± 12.66	129.00 – 180.00	155.92 ± 7.10	140.00 – 174.00	-0.78	0.440	1.02
Weight (kg)	47.55 ± 9.39	29.00 – 75.00	46.08 ± 10.09	29.00 – 75.00	49.02 ± 8.48	32.00 – 72.00	-1.58	0.118	6.00
BMI (kg/m^2)	19.67 ± 3.00	14.10 – 28.13	19.21 ± 2.84	15.27 – 27.55	20.13 ± 3.11	14.10 – 28.13	-1.55	0.125	4.57
SHt (cm)	74.75 ± 5.84	58.00 – 88.00	73.38 ± 6.95	58.00 – 88.00	76.12 ± 4.10	66.00 – 84.00	-2.40	0.018	3.60
BGW (cm)	11.09 ± 0.94	9.00 – 13.00	11.13 ± 0.94	9.00 – 13.00	11.05 ± 0.94	9.00 – 13.00	0.45	0.657	-0.72
LOMA (cm)	19.14 ± 1.33	16.00 – 22.00	18.92 ± 1.07	16.00 – 21.00	19.36 ± 1.52	16.00 – 22.00	-1.67	0.097	2.27
NL (cm)	11.71 ± 1.50	8.00 – 15.00	12.16 ± 1.49	8.00 – 15.00	11.26 ± 1.38	9.00 – 14.00	3.13	0.002	-7.99
BALt (cm)	32.18 ± 3.47	24.00 – 40.00	31.60 ± 3.87	24.00 – 39.00	32.76 ± 2.94	27.00 – 40.00	-1.69	0.094	3.54
DSLt (cm)	83.64 ± 5.77	68.00 – 98.00	83.28 ± 7.24	68.00 – 98.00	83.99 ± 3.81	72.00 – 91.00	-0.61	0.541	0.85
HL (cm)	18.64 ± 1.27	15.00 – 22.00	18.65 ± 1.58	15.00 – 22.00	18.63 ± 0.88	16.00 – 20.00	0.09	0.932	-0.11
HB (cm)	10.57 ± 0.98	8.00 – 13.00	10.78 ± 1.06	8.00 – 13.00	10.36 ± 0.86	8.00 – 12.00	2.18	0.031	-4.05
WRB (cm)	8.49 ± 0.95	6.00 – 11.00	8.52 ± 0.95	6.00 – 10.00	8.46 ± 0.95	6.00 – 11.00	0.32	0.753	-0.71
ThL (cm)	50.35 ± 4.50	39.00 – 59.00	48.58 ± 4.32	39.00 – 57.00	52.12 ± 3.10	44.00 – 59.00	-4.26	<0.001	6.79
LL (cm)	39.29 ± 4.24	23.00 – 47.00	38.84 ± 5.35	23.00 – 47.00	39.74 ± 2.70	34.00 – 45.00	-1.06	0.291	2.26
FL (cm)	24.66 ± 1.68	20.00 – 28.00	24.85 ± 2.03	20.00 – 28.00	24.47 ± 1.23	22.00 – 26.00	1.13	0.263	-1.55
FB (cm)	13.41 ± 0.99	11.00 – 16.00	13.65 ± 1.09	11.00 – 16.00	13.16 ± 0.82	11.00 – 15.00	2.55	0.012	-3.72
AKB (cm)	13.45 ± 0.95	11.00 – 16.00	13.70 ± 1.06	11.00 – 16.00	13.20 ± 0.76	12.00 – 15.00	2.73	0.008	-3.79

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.11 shows the mean age and mean height of young adult age-group in the SSZ of Cross River State. The mean age and mean height were 21.79 ± 2.94 years and 164.43 ± 8.87 cm. The minimum age of the subjects was 18 years while the maximum age was 30 years. Also, average ages of males to females were 22.18 ± 2.83 and 21.40 ± 3.03 years respectively. The mean height for males to females were 170.48 ± 6.88 cm and 158.38 ± 6.08 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 9.32, $P < 0.001$). The mean anthropometric variables were significantly higher in males when compared to the females in Cross River State Southern Population $P < 0.05$, except for BMI which was significantly higher in the females when compared to the males $P < 0.05$. More so, mandibular arch length (LOMA), biaxillary length (BALt) and thigh length (ThL) were insignificantly higher in the males (t = 0.70, $P = 0.487$; t = 0.54, $P = 0.591$ and t = 0.90, $P = 0.372$) respectively.

Table 4.12 shows the mean age and mean height of young adult age-group in the CSZ of Cross River State. The mean age and mean height were 23.43 ± 3.58 years and 166.79 ± 9.41 cm. The minimum age of the subjects was 18 years while the maximum age was 30 years. Also, average ages of males to females were 23.72 ± 3.46 and 23.14 ± 3.71 years respectively. The mean height for males to females were 172.61 ± 8.06 cm and 160.97 ± 6.71 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 7.85, $P < 0.001$). The mean anthropometric variables were significantly higher in the males when compared to the females in Cross River State Central Population $P < 0.05$. More so, biaxillary length (BALt) and thigh length (ThL) were insignificantly higher in the males (t = 0.40, $P = 0.689$ and t = 0.64, $P = 0.527$) respectively. While, BMI was insignificantly higher in the females when compared to the males (t = -1.26, $P = 0.211$).

Table 4.13 shows the mean age and mean height of young adult age-group in the NSZ of Cross River State. The mean age and mean height were 22.91 ± 3.46 years and 163.79 ± 8.44 cm. The minimum age of the subjects was 18 years while the maximum age was 30 years. Also, average ages of males to females were 22.98 ± 3.38 and 22.84 ± 3.56 years respectively. The mean height for males to females were 169.34 ± 6.92 cm and 158.24 ± 5.76 cm respectively indicating that the males were significantly taller in stature when compared to the females ($t = 8.72$, $P < 0.001$). The mean anthropometric variables were significantly higher in the males when compared to the females in Cross River State Northern Population $P < 0.05$, except for BMI which was significantly higher in the females when compared to the males $P < 0.05$. More so, thigh length (ThL) was insignificantly higher in the males ($t = 1.10$, $P = 0.274$).

Table 4.11: Anthropometric parameters and sexual dimorphism of young adult age-group (18-30 years) in SSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	21.79 ± 2.94	18.00 – 30.00	22.18 ± 2.83	18.00 – 28.00	21.40 ± 3.03	18.00 – 30.00	1.33	0.186	-3.64
Height (cm)	164.43 ± 8.87	146.00 – 187.00	170.48 ± 6.88	148.00 – 187.00	158.38 ± 6.08	146.00 – 174.00	9.32	<0.001	-7.64
Weight (kg)	62.10 ± 9.24	40.00 – 82.00	64.78 ± 7.48	40.00 – 82.00	59.41 ± 10.09	40.00 – 80.00	3.02	0.003	-9.04
BMI (kg/m^2)	22.99 ± 3.28	16.41 – 33.33	22.25 ± 1.96	18.26 – 26.99	23.72 ± 4.09	16.41 – 33.33	-2.29	0.024	6.20
SHt (cm)	80.39 ± 4.74	65.00 – 92.00	81.36 ± 5.71	65.00 – 92.00	79.42 ± 3.31	72.00 – 89.00	2.08	0.040	-2.44
BGW (cm)	11.76 ± 0.99	10.00 – 14.00	12.24 ± 0.86	10.00 – 14.00	11.28 ± 0.87	10.00 – 13.00	5.54	<0.001	-8.51
LOMA (cm)	21.00 ± 1.43	18.00 – 28.00	21.10 ± 1.52	18.00 – 28.00	20.90 ± 1.34	18.00 – 24.00	0.70	0.487	-0.96
NL (cm)	11.89 ± 1.60	8.00 – 15.00	12.96 ± 1.01	11.00 – 15.00	10.82 ± 1.35	8.00 – 13.00	8.98	<0.001	-19.78
BALt (cm)	34.93 ± 2.77	28.00 – 41.00	35.08 ± 2.77	28.00 – 41.00	34.78 ± 2.79	29.00 – 40.00	0.54	0.591	-0.86
DSLt (cm)	88.93 ± 5.98	76.00 – 103.00	92.66 ± 4.80	76.00 – 103.00	85.20 ± 4.56	77.00 – 97.00	7.97	<0.001	-8.76
HL (cm)	19.48 ± 1.67	15.50 – 26.00	20.48 ± 1.48	18.00 – 26.00	18.48 ± 1.20	15.50 – 22.00	7.41	<0.001	-10.82
HB (cm)	10.93 ± 1.38	9.00 – 15.00	11.87 ± 1.15	10.00 – 15.00	9.98 ± 0.85	9.00 – 12.00	9.38	<0.001	-18.94
WRB (cm)	8.88 ± 1.03	7.00 – 12.00	9.44 ± 0.99	8.00 – 12.00	8.32 ± 0.71	7.00 – 10.00	6.48	<0.001	-13.46
ThL (cm)	54.48 ± 3.79	45.00 – 66.00	54.82 ± 4.20	45.00 – 66.00	54.14 ± 3.33	47.00 – 63.00	0.90	0.372	-1.26
LL (cm)	41.71 ± 3.85	32.00 – 52.00	43.44 ± 4.07	34.00 – 52.00	39.98 ± 2.69	32.00 – 47.00	5.01	<0.001	-8.65
FL (cm)	25.53 ± 1.99	20.00 – 32.00	26.47 ± 1.93	20.00 – 32.00	24.59 ± 1.56	21.00 – 28.00	5.35	<0.001	-7.65
FB (cm)	13.70 ± 1.04	11.00 – 16.00	14.20 ± 0.97	12.00 – 16.00	13.19 ± 0.85	11.00 – 15.00	5.54	<0.001	-7.66
AKB (cm)	13.69 ± 1.01	12.00 – 16.00	14.20 ± 0.95	12.00 – 16.00	13.18 ± 0.80	12.00 – 15.00	5.82	<0.001	-7.74

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.12: Anthropometric parameters and sexual dimorphism of young adult age-group (18-30 years) in CSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	23.43 ± 3.58	18.00 – 30.00	23.72 ± 3.46	18.00 – 30.00	23.14 ± 3.71	18.00 – 30.00	0.81	0.421	-2.51
Height (cm)	166.79 ± 9.41	148.00 – 191.00	172.61 ± 8.06	148.00 – 191.00	160.97 ± 6.71	151.00 – 191.00	7.85	<0.001	-7.23
Weight (kg)	63.58 ± 9.80	45.00 – 90.00	66.98 ± 9.07	45.00 – 90.00	60.18 ± 9.40	45.00 – 89.00	3.68	<0.001	-11.30
BMI (kg/m^2)	22.85 ± 2.95	17.21 – 29.67	22.48 ± 2.65	17.21 – 29.37	23.22 ± 3.21	17.47 – 29.67	-1.26	0.211	3.19
SHt (cm)	81.64 ± 3.96	70.80 – 90.00	82.96 ± 3.53	75.00 – 90.00	80.31 ± 3.96	70.80 – 88.00	3.53	<0.001	-3.30
BGW (cm)	11.99 ± 1.24	9.70 – 20.00	12.39 ± 1.45	10.00 – 20.00	11.59 ± 0.84	9.70 – 13.80	3.39	0.001	-6.90
LOMA (cm)	20.10 ± 1.62	15.00 – 24.00	20.72 ± 1.43	18.00 – 24.00	19.48 ± 1.58	15.00 – 23.00	4.11	<0.001	-6.37
NL (cm)	13.05 ± 1.88	9.00 – 19.00	13.77 ± 1.70	11.00 – 19.00	12.32 ± 1.79	9.00 – 16.00	4.15	<0.001	-11.77
BALt (cm)	37.66 ± 3.97	29.00 – 52.00	37.82 ± 3.22	29.00 – 43.00	37.50 ± 4.63	31.00 – 52.00	0.40	0.689	-0.85
DSLt (cm)	88.66 ± 5.88	77.70 – 102.00	92.27 ± 5.50	79.00 – 102.00	85.04 ± 3.61	77.70 – 98.00	7.77	<0.001	-8.50
HL (cm)	19.40 ± 1.47	17.00 – 23.00	20.11 ± 1.34	17.00 – 22.50	18.68 ± 1.24	17.00 – 23.00	5.58	<0.001	-7.66
HB (cm)	11.45 ± 1.11	9.00 – 14.00	12.12 ± 0.95	10.00 – 14.00	10.78 ± 0.83	9.00 – 13.00	7.56	<0.001	-12.43
WRB (cm)	8.76 ± 0.78	7.00 – 10.00	9.14 ± 0.61	8.00 – 10.00	8.38 ± 0.75	7.00 – 10.00	5.56	<0.001	-9.07
ThL (cm)	53.32 ± 3.77	42.00 – 63.00	53.56 ± 3.41	42.00 – 61.00	53.08 ± 4.12	45.00 – 63.00	0.64	0.527	-0.90
LL (cm)	41.71 ± 3.64	33.00 – 52.00	42.64 ± 3.80	33.00 – 50.00	40.78 ± 3.26	35.00 – 52.00	2.63	0.010	-4.56
FL (cm)	26.01 ± 2.27	20.00 – 35.00	27.23 ± 2.25	21.50 – 35.00	24.78 ± 1.52	20.00 – 29.00	6.38	<0.001	-9.89
FB (cm)	14.03 ± 1.13	11.00 – 18.00	14.68 ± 0.10	13.00 – 18.00	13.38 ± 0.85	11.00 – 15.00	7.01	<0.001	-9.72
AKB (cm)	14.03 ± 1.07	11.00 – 17.00	14.56 ± 0.91	13.00 – 17.00	13.50 ± 0.95	11.00 – 16.00	5.70	<0.001	-7.85

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.13: Anthropometric parameters and sexual dimorphism of young adult age-group (18-30 years) in NSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	22.91 ± 3.46	18.00 – 30.00	22.98 ± 3.38	18.00 – 30.00	22.84 ± 3.56	18.00 – 30.00	0.20	0.841	-0.61
Height (cm)	163.79 ± 8.44	144.00 – 187.00	169.34 ± 6.92	153.00 – 187.00	158.24 ± 5.76	144.00 – 170.00	8.72	<0.001	-7.01
Weight (kg)	62.79 ± 8.88	45.00 – 88.00	65.26 ± 8.07	52.00 – 85.00	60.32 ± 9.05	45.00 – 88.00	2.88	0.005	-8.19
BMI (kg/m^2)	23.40 ± 2.91	18.52 – 35.56	22.71 ± 1.98	18.52 – 26.49	24.10 ± 3.50	18.73 – 35.56	-2.43	0.017	5.77
SHt (cm)	80.85 ± 3.10	70.00 – 92.00	82.62 ± 3.78	75.00 – 92.00	79.08 ± 3.40	70.00 – 90.00	4.92	<0.001	-4.48
BGW (cm)	11.93 ± 0.96	10.00 – 14.00	12.30 ± 0.91	10.50 – 14.00	11.57 ± 0.87	10.00 – 14.00	4.10	<0.001	-6.31
LOMA (cm)	20.30 ± 1.51	17.00 – 24.00	20.92 ± 1.34	18.00 – 24.00	19.68 ± 1.44	17.00 – 23.00	4.47	<0.001	-6.30
NL (cm)	12.14 ± 1.76	8.00 – 17.00	13.02 ± 1.62	8.00 – 17.00	11.26 ± 1.43	8.00 – 14.00	5.76	<0.001	-15.63
BALt (cm)	35.47 ± 3.29	29.00 – 45.00	36.46 ± 3.42	29.00 – 45.00	34.48 ± 2.86	29.00 – 41.00	3.14	0.002	-5.74
DSLt (cm)	89.42 ± 5.73	78.00 – 103.00	93.10 ± 4.81	84.00 – 103.00	85.73 ± 3.94	78.00 – 95.00	8.39	<0.001	-8.60
HL (cm)	19.78 ± 1.45	16.50 – 23.00	20.59 ± 1.10	18.00 – 23.00	18.97 ± 1.30	16.50 – 22.50	6.74	<0.001	-8.54
HB (cm)	11.57 ± 1.17	9.00 – 15.00	12.42 ± 0.84	11.00 – 15.00	10.72 ± 0.76	9.00 – 12.00	10.66	<0.001	-15.86
WRB (cm)	9.15 ± 0.93	7.00 – 12.00	9.62 ± 0.83	8.00 – 12.00	8.68 ± 0.77	7.00 – 10.00	5.88	<0.001	-10.83
ThL (cm)	53.30 ± 3.64	45.00 – 63.00	53.70 ± 3.51	46.00 – 62.00	52.90 ± 3.76	45.00 – 63.00	1.10	0.274	-1.51
LL (cm)	41.94 ± 3.58	34.00 – 53.00	43.68 ± 3.46	38.00 – 53.00	40.20 ± 2.78	34.00 – 46.00	5.55	<0.001	-8.66
FL (cm)	25.37 ± 1.64	21.00 – 30.00	26.31 ± 1.54	23.00 – 30.00	24.43 ± 1.13	21.00 – 27.00	6.95	<0.001	-7.70
FB (cm)	13.87 ± 1.14	12.00 – 17.00	14.56 ± 0.97	13.00 – 17.00	13.18 ± 0.85	12.00 – 15.00	7.56	<0.001	-10.47
AKB (cm)	13.94 ± 1.13	12.00 – 17.00	14.58 ± 1.01	13.00 – 17.00	13.30 ± 0.84	12.00 – 15.00	6.89	<0.001	-9.62

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.14 shows the mean age and mean height of adult age-group in the SSZ of Cross River State. The mean age and mean height were 35.46 ± 4.40 years and 164.49 ± 11.14 cm. The minimum age of the subjects was 31 years while the maximum age was 45 years. Also, average ages of males to females were 35.40 ± 4.16 and 35.52 ± 4.67 years respectively. The mean height for males to females were 170.28 ± 12.33 cm and 158.70 ± 5.50 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 6.07, $P < 0.001$). The mean anthropometric variables were significantly higher in the males when compared to the females in Cross River State Southern Population $P < 0.05$, except for BMI which was significantly higher in the females when compared to the males $P < 0.05$. More so, weight (WT) was insignificantly higher in the males (t = 1.40, $P = 0.166$). While, biaxillary length (BALt) was insignificantly higher in the females when compared to the males (t = -0.65, $P = 0.515$).

Table 4.15 shows the mean age and mean height of adult age-group in the CSZ of Cross River State. The mean age and mean height were 35.98 ± 4.14 years and 165.91 ± 8.17 cm. The minimum age of the subjects was 31 years while the maximum age was 45 years. Also, average ages of males to females were 35.70 ± 4.18 and 36.26 ± 4.13 years respectively. The mean height for males to females were 171.12 ± 6.40 cm and 160.70 ± 6.19 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 8.27, $P < 0.001$). The mean anthropometric variables were significantly higher in the males when compared to the females in Cross River State Central Population $P < 0.05$, except for BMI which was significantly higher in the females when compared to the males $P < 0.05$. More so, biaxillary length (BALt), thigh length (ThL) and leg length (LL) were insignificantly higher in the males (t = 1.50, $P = 0.138$; t = 1.20, $P = 0.234$ and t = 1.69, $P = 0.094$)

respectively. While, weight (WT) was insignificantly higher in the females when compared to the males (t = -0.07, *P* = 0.944).

Table 4.16 shows the mean age and mean height of adult age-group in the NSZ of Cross River State. The mean age and mean height were 36.05 ± 4.19 years and 163.58 ± 9.07 cm. The minimum age of the subjects was 31 years while the maximum age was 45 years. Also, average ages of males to females were 35.56 ± 4.20 and 36.54 ± 4.16 years respectively. The mean height for males to females were 169.08 ± 7.92 cm and 158.08 ± 6.47 cm respectively indicating that the males were significantly taller in stature when compared to the females (t = 7.61, *P* < 0.001). The mean anthropometric variables were significantly higher in the males when compared to the females in Cross River State Northern Population *P* < 0.05, except for BMI which was significantly higher in the females when compared to the males *P* < 0.05. More so, LOMA, BALt and thigh length (ThL) were insignificantly higher in the males (t = 1.50, *P* = 0.136; t = 0.48, *P* = 0.632 and t = 1.35, *P* = 0.181) respectively. While, weight (WT) was insignificantly higher in the females when compared to the males (t = -0.74, *P* = 0.460).

Table 4.14: Anthropometric parameters and sexual dimorphism of adult age-group (31-45 years) in SSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	35.46 ± 4.40	31.00 – 45.00	35.40 ± 4.16	31.00 – 45.00	35.52 ± 4.67	31.00 – 45.00	-0.14	0.892	0.34
Height (cm)	164.49 ± 11.14	103.00 – 189.00	170.28 ± 12.33	103.00 – 198.00	158.70 ± 5.50	150.00 – 173.00	6.07	<0.001	-7.30
Weight (kg)	67.25 ± 10.45	40.00 – 92.00	68.70 ± 9.39	40.00 – 90.00	65.80 ± 11.32	45.00 – 92.00	1.40	0.166	-4.41
BMI (kg/m^2)	25.07 ± 4.71	14.03 – 48.07	23.97 ± 4.62	14.03 – 48.07	26.16 ± 4.59	17.58 – 38.29	-2.38	0.019	8.37
SHt (cm)	81.59 ± 3.85	70.00 – 91.00	83.24 ± 4.02	72.00 – 91.00	79.94 ± 2.85	70.00 – 86.00	4.73	<0.001	-4.13
BGW (cm)	12.17 ± 1.15	10.00 – 15.00	12.78 ± 0.91	10.00 – 15.00	11.55 ± 1.04	10.00 – 14.00	6.28	<0.001	-10.65
LOMA (cm)	21.24 ± 1.63	16.00 – 26.00	21.90 ± 1.36	18.00 – 26.00	20.58 ± 1.63	16.00 – 24.00	4.40	<0.001	-6.41
NL (cm)	11.76 ± 1.52	8.00 – 15.00	12.58 ± 0.99	11.00 – 15.00	10.94 ± 1.52	8.00 – 14.00	6.40	<0.001	-14.99
BALt (cm)	36.55 ± 2.59	28.00 – 42.00	36.38 ± 2.51	28.00 – 41.00	36.72 ± 2.69	31.00 – 42.00	-0.65	0.515	0.93
DSLt (cm)	89.45 ± 6.08	75.00 – 101.00	93.72 ± 4.13	81.00 – 101.00	85.18 ± 4.52	75.00 – 98.00	9.86	<0.001	-10.03
HL (cm)	19.41 ± 1.42	16.00 – 25.00	19.95 ± 1.35	17.00 – 25.00	18.88 ± 1.28	16.00 – 22.00	4.07	<0.001	-5.67
HB (cm)	11.13 ± 1.31	8.00 – 14.00	12.00 ± 1.03	10.00 – 14.00	10.26 ± 0.92	8.00 – 13.00	8.90	<0.001	-16.96
WRB (cm)	8.99 ± 0.99	7.00 – 12.00	9.44 ± 0.99	7.00 – 12.00	8.54 ± 0.76	7.00 – 11.00	5.09	<0.001	-10.54
ThL (cm)	54.95 ± 3.89	47.00 – 64.00	55.94 ± 3.52	49.00 – 64.00	53.96 ± 4.02	47.00 – 64.00	2.62	0.010	-3.67
LL (cm)	42.58 ± 3.34	35.00 – 51.00	44.58 ± 2.79	37.00 – 51.00	40.58 ± 2.56	35.00 – 45.00	7.47	<0.001	-9.86
FL (cm)	25.46 ± 1.82	21.00 – 36.00	26.09 ± 2.21	21.00 – 36.00	24.82 ± 0.99	23.00 – 27.00	3.71	<0.001	-5.12
FB (cm)	13.59 ± 1.02	11.00 – 16.00	13.84 ± 1.08	11.00 – 16.00	13.34 ± 0.90	11.00 – 15.00	2.53	0.013	-3.75
AKB (cm)	13.58 ± 0.10	11.00 – 16.00	13.82 ± 1.08	11.00 – 16.00	13.34 ± 0.85	11.00 – 15.00	2.47	0.015	-3.60

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.15: Anthropometric parameters and sexual dimorphism of adult age-group (31-45 years) in CSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	35.98 ± 4.14	31.00 – 45.00	35.70 ± 4.18	31.00 – 45.00	36.26 ± 4.13	31.00 – 45.00	-0.68	0.501	1.54
Height (cm)	165.91 ± 8.17	150.00 – 185.00	171.12 ± 6.40	156.00 – 185.00	160.70 ± 6.19	150.00 – 178.00	8.27	<0.001	-6.48
Weight (kg)	72.67 ± 13.32	45.00 – 113.00	72.57 ± 11.24	55.00 – 101.00	72.76 ± 15.23	45.00 – 113.00	-0.07	0.944	0.26
BMI (kg/m^2)	26.54 ± 5.52	16.56 – 47.65	24.77 ± 3.53	18.99 – 36.73	28.32 ± 6.53	16.56 – 47.65	-3.38	0.001	12.54
SHt (cm)	82.48 ± 4.55	68.00 – 94.00	84.72 ± 3.61	75.00 – 94.00	80.24 ± 4.31	68.00 – 90.00	5.63	<0.001	-5.58
BGW (cm)	12.48 ± 1.13	10.00 – 19.00	12.77 ± 1.32	10.50 – 19.00	12.18 ± 0.82	10.00 – 13.50	2.70	0.008	-4.84
LOMA (cm)	20.67 ± 1.66	16.00 – 26.00	21.20 ± 1.68	18.00 – 26.00	20.13 ± 1.48	16.00 – 23.00	3.38	0.001	-5.32
NL (cm)	12.28 ± 1.76	8.00 – 16.00	13.20 ± 1.41	9.00 – 16.00	11.36 ± 1.59	8.00 – 16.00	6.12	<0.001	-16.20
BALt (cm)	38.58 ± 3.90	30.00 – 48.00	39.16 ± 3.43	30.00 – 48.00	38.00 ± 4.28	31.00 – 48.00	1.50	0.138	-3.05
DSLt (cm)	89.45 ± 5.19	80.00 – 102.00	93.12 ± 3.83	86.00 – 102.00	85.79 ± 3.50	80.00 – 92.50	9.99	<0.001	-8.54
HL (cm)	19.46 ± 1.50	16.50 – 25.00	20.29 ± 1.14	18.00 – 22.50	18.63 ± 1.35	16.50 – 25.00	6.60	<0.001	-8.91
HB (cm)	11.53 ± 1.18	9.00 – 14.00	12.26 ± 0.90	10.00 – 14.00	10.80 ± 0.95	9.00 – 13.00	7.90	<0.001	-13.52
WRB (cm)	9.02 ± 0.85	7.00 – 12.00	9.32 ± 0.68	8.00 – 11.00	8.72 ± 0.90	7.00 – 12.00	3.74	<0.001	-6.88
ThL (cm)	53.33 ± 3.60	45.00 – 61.00	53.76 ± 3.90	45.00 – 61.00	52.90 ± 3.26	46.00 – 60.00	1.20	0.234	-1.63
LL (cm)	41.26 ± 3.11	33.00 – 50.00	41.78 ± 3.76	33.00 – 50.00	40.74 ± 2.19	36.00 – 46.00	1.69	0.094	-2.55
FL (cm)	25.68 ± 1.59	22.00 – 30.00	26.63 ± 1.29	23.00 – 30.00	24.72 ± 1.27	22.00 – 28.00	7.47	<0.001	-7.73
FB (cm)	14.20 ± 1.38	11.00 – 18.00	14.96 ± 1.18	13.00 – 18.00	13.43 ± 1.13	11.00 – 16.00	6.62	<0.001	-11.39
AKB (cm)	14.19 ± 1.21	11.00 – 17.00	14.78 ± 0.95	13.00 – 17.00	13.60 ± 1.16	11.00 – 17.00	5.55	<0.001	-8.68

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

Table 4.16: Anthropometric parameters and sexual dimorphism of adult age-group (31-45 years) in NSZ

Variable	Male + Female (n = 100) Mean + SD	Min - Max	Males (n = 50) Mean + SD	Min - Max	Females (n = 50) Mean + SD	Min - Max	t	*P*	SDI
Age (years)	36.05 ± 4.19	31.00 – 45.00	35.56 ± 4.20	31.00 – 45.00	36.54 ± 4.16	31.00 – 45.00	-1.17	0.244	2.68
Height (cm)	163.58 ± 9.07	145.00 – 188.00	169.08 ± 7.92	154.00 – 188.00	158.08 ± 6.47	145.00 – 172.00	7.61	<0.001	-6.96
Weight (kg)	70.00 ± 13.45	49.00 – 103.00	69.00 ± 11.36	50.00 – 100.00	71.00 ± 15.30	49.00 – 103.00	-0.74	0.460	2.82
BMI (kg/m^2)	26.20 ± 4.86	17.02 – 39.45	24.07 ± 3.13	17.02 – 31.74	28.32 ± 5.36	19.57 – 39.45	-4.84	<0.001	15.01
SHt (cm)	80.92 ± 4.69	68.00 – 92.00	82.80 ± 4.20	75.00 – 92.00	79.04 ± 4.42	68.00 – 88.00	4.36	<0.001	-4.76
BGW (cm)	12.10 ± 0.95	10.00 – 14.00	12.52 ± 0.81	11.00 – 14.00	11.67 ± 0.90	10.00 – 14.00	4.97	<0.001	-7.28
LOMA (cm)	21.17 ± 1.81	16.00 – 26.00	21.44 ± 1.40	19.00 – 24.00	20.90 ± 2.12	16.00 – 26.00	1.50	0.136	-2.58
NL (cm)	11.46 ± 1.79	8.00 – 16.00	12.56 ± 1.58	9.00 – 16.00	10.36 ± 1.23	8.00 – 13.00	7.78	<0.001	-21.24
BALt (cm)	37.37 ± 3.11	30.00 – 48.00	37.52 ± 2.57	31.00 – 42.00	37.22 ± 3.58	30.00 – 48.00	0.48	0.632	-0.81
DSLt (cm)	89.19 ± 5.66	75.00 – 101.00	92.30 ± 5.04	79.00 – 101.00	86.08 ± 4.43	75.00 – 95.00	6.56	<0.001	-7.23
HL (cm)	19.48 ± 1.49	15.50 – 22.50	20.24 ± 1.27	18.00 – 22.50	18.73 ± 1.32	15.50 – 22.00	5.85	<0.001	-8.06
HB (cm)	11.37 ± 1.13	8.00 – 14.00	12.16 ± 0.82	10.00 – 14.00	10.58 ± 0.81	8.00 – 12.00	9.71	<0.001	-14.93
WRB (cm)	9.24 ± 0.75	8.00 – 11.00	9.46 ± 0.76	8.00 – 11.00	9.02 ± 0.69	8.00 – 10.00	3.04	0.003	-4.88
ThL (cm)	53.57 ± 3.65	43.00 – 62.00	54.06 ± 3.67	44.00 – 62.00	53.08 ± 3.61	43.00 – 61.00	1.35	0.181	-1.85
LL (cm)	42.46 ± 3.38	33.00 – 50.00	43.70 ± 3.07	37.00 – 50.00	41.22 ± 3.24	33.00 – 49.00	3.93	<0.001	-6.02
FL (cm)	25.41 ± 1.72	20.00 – 30.00	26.18 ± 1.50	24.00 – 30.00	24.64 ± 1.58	20.00 – 28.00	5.00	<0.001	-6.25
FB (cm)	14.23 ± 1.16	12.00 – 18.00	14.68 ± 1.10	13.00 – 18.00	13.77 ± 1.05	12.00 – 16.00	4.25	<0.001	-6.61
AKB (cm)	14.14 ± 1.11	12.00 – 17.00	14.50 ± 1.09	13.00 – 17.00	13.77 ± 1.02	12.00 – 16.00	3.45	<0.001	-5.30

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone; SDI = Sexual Dimorphism Index; Min = Minimum; Max = Maximum

4.3 One-way Analysis of Variance (ANOVA)

Table 4.17 and 4.18 compares the mean height of children age group from Southern, Central and Northern senatorial zones of Cross River State. In boys, CSZ were insignificant taller in stature than SSZ and NSZ (F = 1.08, *P* = 0.342). In girls, SSZ were significant taller in stature when compared with CSZ and NSZ (F = 6.74, *P* = 0.002).

Table 4.19 and 4.20 compares the mean height of adolescents age group from Southern, Central and Northern senatorial zones of Cross River State. In males, the CSZ were insignificant taller in stature when compared with the SSZ and NSZ, while in females, the NSZ were insignificantly taller in stature when compared with SSZ and CSZ. ANOVA shows no significant difference between SSZ, CSZ and NSZ in both males and females (F = 2.86, *P* = 0.060 and F = 2.30, *P* = 0.104) respectively.

Table 4.21 and 4.22 compares the mean height of young adults age group from Southern, Central and Northern senatorial zones of Cross River State. In males, CSZ were insignificantly taller in stature when compared with SSZ and NSZ (F = 2.57, *P* = 0.080). In females, ANOVA shows a higher significant difference in stature of CSZ when compared with SSZ and NSZ (F = 3.07, *P* = 0.049).

Table 4.23 and 4.24 compares the mean height of adults age group from Southern, Central and Northern senatorial zones of Cross River State. The CSZ were insignificantly taller in stature when compared with the SSZ and NSZ in both males and females. ANOVA shows no significant difference in both males and females (F = 0.62, *P* = 0.541 and F = 2.55, *P* = 0.082) respectively.

Table 4.17: Comparison of anthropometric characteristics of boys (5-11 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	8.84 ± 1.66	8.78 ± 1.88	8.36 ± 2.25	0.91	0.406
Height (cm)	128.84 ± 10.93	129.04 ± 10.36	126.10 ± 12.12	1.08	0.342
Weight (kg)	27.32 ± 5.45	26.76 ± 5.22	26.74 ± 7.16	0.15	0.861
BMI (kg/m^2)	16.36 ± 1.82	15.94 ± 1.50	16.56 ± 2.38	1.34	0.265
SHt (cm)	64.76 ± 6.06	64.42 ± 5.32	62.70 ± 5.04	2.03	0.135
BGW (cm)	10.09 ± 0.10	10.00 ± 1.01	10.12 ± 0.77	0.23	0.796
LOMA (cm)	17.20 ± 1.49	16.88 ± 1.02	17.16 ± 1.27	0.94	0.393
NL (cm)	10.70 ± 1.33^{a}	12.28 ± 1.58^{b}	11.32 ± 1.60^{c}	13.97	<0.001
BALt (cm)	27.22 ± 2.10	27.42 ± 2.88	27.22 ± 2.54	0.08	0.917
DSLt (cm)	67.34 ± 5.94	68.56 ± 6.76	67.42 ± 6.92	0.54	0.583
HL (cm)	15.34 ± 1.32	15.34 ± 1.20	15.35 ± 1.67	0.00	0.997
HB (cm)	8.64 ± 0.92^{ab}	9.10 ± 0.88^{abc}	9.09 ± 1.09^{bc}	3.69	0.027
WRB (cm)	7.06 ± 0.87^{ab}	7.20 ± 0.76^{abc}	7.50 ± 1.02^{bc}	3.22	0.043
ThL (cm)	40.26 ± 3.84	39.38 ± 5.38	39.78 ± 5.08	0.42	0.658
LL (cm)	32.18 ± 4.33	32.28 ± 3.74	31.56 ± 4.34	0.44	0.643
FL (cm)	20.87 ± 2.28	21.46 ± 2.11	20.54 ± 2.12	2.31	0.103
FB (cm)	11.64 ± 1.06	11.54 ± 1.05	11.56 ± 1.11	0.12	0.886
AKB (cm)	11.70 ± 1.07	11.54 ± 1.05	11.62 ± 1.11	0.28	0.760

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscripts are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.18: Comparison of anthropometric characteristics of girls (5-11 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	9.10 ± 1.59^{ab}	8.34 ± 1.80^{abc}	7.76 ± 1.74^{bc}	7.70	<0.001
Height (cm)	131.98 ± 10.07^{ab}	129.74 ± 11.23^{ab}	124.24 ± 11.22^{c}	6.74	0.002
Weight (kg)	27.50 ± 5.56	27.34 ± 6.59	25.38 ± 7.65	1.58	0.211
BMI (kg/m^2)	15.69 ± 1.94	16.05 ± 2.04	16.11 ± 2.32	0.57	0.565
SHt (cm)	65.43 ± 5.95^{ab}	64.72 ± 4.99^{ab}	61.60 ± 4.69^{c}	7.34	<0.001
BGW (cm)	9.89 ± 1.02	10.01 ± 1.08	9.68 ± 0.88	1.40	0.249
LOMA (cm)	18.04 ± 1.46^{a}	16.56 ± 1.40^{b}	17.18 ± 1.72^{c}	11.75	<0.001
NL (cm)	10.46 ± 1.50^{ac}	11.50 ± 1.66^{b}	10.08 ± 1.95^{ac}	9.31	<0.001
BALt (cm)	270.36 ± 2.50	28.32 ± 2.74	27.04 ± 3.46	2.59	0.079
DSLt (cm)	69.48 ± 5.75^{ab}	67.65 ± 6.04^{abc}	$65\ 52 \pm 6.94^{bc}$	5.01	0.008
HL (cm)	15.87 ± 1.36^{ab}	15.41 ± 1.50^{ab}	15.02 ± 1.69^{bc}	4.03	0.020
HB (cm)	$8.65. \pm 0.82$	8.85 ± 0.96	8.72 ± 1.17	0.52	0.594
WRB (cm)	7.16 ± 0.77	6.92 ± 0.78	7.16 ± 1.11	1.19	0.309
ThL (cm)	43.56 ± 4.66^{a}	$40\ 18 \pm 5.12^{bc}$	40.06 ± 5.53^{bc}	7.44	<0.001
LL (cm)	33.66 ± 4.12^{ab}	32.38 ± 4.20^{abc}	31.36 ± 3.74^{bc}	4.10	0.019
FL (cm)	$21.\ 53 \pm 1.84^{ab}$	21.18 ± 2.04^{abc}	20.35 ± 2.32^{bc}	4.27	0.016
FB (cm)	11.64 ± 1.03^{a}	10.84 ± 0.84^{bc}	11.08 ± 1.40^{bc}	6.81	0.001
AKB (cm)	11.68 ± 1.06^{ac}	11.08 ± 0.90^{bc}	11.24 ± 1.33^{abc}	3.91	0.022

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscripts are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.19: Comparison of anthropometric characteristics of adolescent males (12-17 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	14.28 ± 1.67	14.70 ± 1.64	14.10 ± 1.80	1.63	0.199
Height (cm)	151.78 ± 11.37	157.58 ± 12.41	154.33 ± 12.66	2.86	0.060
Weight (kg)	42.20 ± 8.63^{ac}	47.04 ± 10.83^{bc}	46.08 ± 10.09^{abc}	3.36	0.038
BMI (kg/m^2)	18.18 ± 2.26	18.72 ± 2.49	19.21 ± 2.84	2.04	0.133
SHt (cm)	72.30 ± 4.67^{ac}	75.55 ± 5.19^{bc}	73.38 ± 6.95^{abc}	4.23	0.016
BGW (cm)	11.23 ± 0.91	10.97 ± 0.84	11.13 ± 0.94	1.09	0.340
LOMA (cm)	19.00 ± 1.28	18.44 ± 1.45	18.92 ± 1.07	2.83	0.062
NL (cm)	11.96 ± 1.34^{ac}	13.24 ± 1.39^{b}	12.16 ±1.49^{ac}	11.94	<0.001
BALt (cm)	31.16 ± 3.41^{ac}	32.98 ± 3.29^{bc}	31.60 ± 3.87^{abc}	3.61	0.029
DSLt (cm)	80.14 ± 6.21^{ac}	84.69 ± 7.32^{bc}	83.28 ± 7.24^{abc}	5.62	0.004
HL (cm)	18.32 ± 1.41	18.94 ± 1.65	18.65 ± 1.58	2.02	0.136
HB (cm)	10.32 ± 1.15^{ac}	10.88 ± 0.98^{bc}	10.78 ± 1.06^{abc}	3.93	0.022
WRB (cm)	8.32 ± 0.84	8.48 ± 0.81	8.52 ± 0.95	0.74	0.481
ThL (cm)	48.62 ± 4.93	48.94 ± 4.68	48.58 ± 4.32	0.09	0.914
LL (cm)	39.06 ± 3.59	40.48 ± 3.54	38.84 ± 5.35	2.20	0.12
FL (cm)	24.60 ±2.02^{ac}	25.76 ± 1.90^{b}	24.85 ± 2.03^{ac}	4.77	0.010
FB (cm)	13.34 ± 0.82^{ac}	13.96 ± 1.11^{bc}	13.65 ± 1.09^{abc}	4.67	0.011
AKB (cm)	13.28 ± 0.78^{ac}	13.98 ± 1.06^{bc}	13.70 ± 1.06^{abc}	6.54	0.002

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.20: Comparison of anthropometric characteristics of adolescent females (12-17 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	14.24 ± 1.71	14.26 ± 1.85	14.32 ± 1.70	0.03	0.972
Height (cm)	152.72 ± 7.30	153. 78 ± 8.35	155.92 ± 7.10	2.30	0.104
Weight (kg)	47.90 ± 8.69	47.54 ± 9.14	49.02 ± 8.48	0.39	0.680
BMI (kg/m^2)	20.44 ± 2.93	20.02 ± 3.19	20.13 ± 3.11	0.25	0.778
SHt (cm)	74.74 ± 4.68	75.02 ± 3.58	76.12 ± 4.10	1.55	0.216
BGW (cm)	10.83 ± 0.80	10.94 ± 0.92	11.05 ± 0.94	0.73	0.486
LOMA (cm)	19.76 ± 1.61^{ac}	18.76 ± 1.69^{bc}	19.36 ± 1.52^{abc}	4.90	0.009
NL (cm)	10.72 ± 1.25^{ac}	12.54 ± 1.62^{b}	11.26 ± 1.38^{ac}	21.54	<0.001
BALt (cm)	31.28 ± 2.94^{a}	33.66 ± 3.48^{bc}	32.76 ± 2.94^{bc}	7.38	<0.001
DSLt (cm)	82.08 ± 4.12^{abc}	81.31 ± 5.37^{ab}	83.99 ± 3.81^{ac}	4.74	0.010
HL (cm)	18.14 ± 1.26^{ab}	18.05 ± 0.98^{ab}	18.63 ± 0.88^{c}	4.47	0.013
HB (cm)	9.61 ± 0.68^{a}	10.28 ± 0.78^{bc}	10.36 ± 0.86^{bc}	14.05	<0.001
WRB (cm)	7.96 ± 0.61^{ab}	8.04 ± 0.73^{ab}	8.46 ± 0.95^{c}	6.01	0.003
ThL (cm)	52.90 ± 3.43	51.32 ± 4.29	52.12 ± 3.10	2.03	0.135
LL (cm)	39.10 ± 2.51	39.50 ± 3.34	39.74 ± 2.70	0.63	0.532
FL (cm)	24.49 ± 1.50	24.38 ± 1.33	24.47 ± 1.23	0.09	0.911
FB (cm)	13.06 ± 0.84	12.85 ± 0.91	13.16 ± 0.82	1.71	0.185
AKB (cm)	13.10 ± 0.84	13.12 ± 0.90	13.20 ± 0.76	0.20	0.817

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.21: Comparison of anthropometric characteristics of young adult males (18-30 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	22.18 ± 2.83	23.72 ± 3.46	22.98 ± 3.38	2.83	0.062
Height (cm)	170.48 ± 6.88	172.61 ± 8.06	169.34 ± 6.92	2.57	0.080
Weight (kg)	64.78 ± 7.48	66.98 ± 9.07	65.26 ± 8.07	0.99	0.375
BMI (kg/m^2)	22.25 ± 1.96	22.48 ± 2.65	22.71 ± 1.98	0.54	0.586
SHt (cm)	81.36 ± 5.71	82.96 ± 3.53	82.62 ± 3.78	1.80	0.169
BGW (cm)	12.24 ± 0.86	12.39 ± 1.45	12.30 ± 0.91	0.23	0.794
LOMA (cm)	21.10 ± 1.52	20.72 ± 1.43	20.92 ± 1.34	0.89	0.415
NL (cm)	12.96 ± 1.01^{ac}	13.77 ± 1.70^{b}	13.02 ± 1.62^{ac}	4.67	0.011
BALt (cm)	35.08 ± 2.77^{ac}	37.82 ± 3.22^{b}	36.46 ± 3.42^{ac}	9.48	<0.001
DSLt (cm)	92.66 ± 4.80	92.27 ± 5.50	93.10 ± 4.81	0.34	0.713
HL (cm)	20.48 ± 1.48	20.11 ± 1.34	20.59 ± 1.10	1.77	0.174
HB (cm)	11.87 ± 1.15^{ab}	12.12 ± 0.95^{abc}	12.42 ± 0.84^{bc}	3.92	0.022
WRB (cm)	9.44 ± 0.99^{abc}	9.14 ± 0.61^{ab}	9.62 ± 0.83^{ac}	4.32	0.015
ThL (cm)	54.82 ± 4.20	53.56 ± 3.41	53.70 ± 3.51	1.72	0.182
LL (cm)	43.44 ± 4.07	42.64 ± 3.80	43.68 ± 3.46	1.04	0.358
FL (cm)	26.47 ± 1.93^{abc}	27.23 ± 2.25^{abc}	26.31 ± 1.54^{abc}	3.27	0.041
FB (cm)	14.20 ± 0.97^{ac}	14.68 ± 0.10^{bc}	14.56 ± 0.97^{abc}	3.25	0.042
AKB (cm)	14.20 ± 0.95	14.56 ± 0.91	14.58 ± 1.01	2.50	0.086

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.22: Comparison of anthropometric characteristics of young adult females (18-30 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	21.40 ± 3.03^{ac}	23.14 ± 3.71^{bc}	22.84 ± 3.56^{abc}	3.64	0.029
Height (cm)	158.38 ± 6.08^{abc}	160.97 ± 6.71^{abc}	158.24 ± 5.76^{abc}	3.07	0.049
Weight (kg)	59.41 ± 10.09	60.18 ± 9.40	60.32 ± 9.05	0.13	0.876
BMI (kg/m^2)	23.72 ± 4.09	23.22 ± 3.21	24.10 ± 3.50	0.75	0.476
SHt (cm)	79.42 ± 3.31	80.31 ± 3.96	79.08 ± 3.40	1.59	0.207
BGW (cm)	11.28 ± 0.87	11.59 ± 0.84	11.57 ± 0.87	1.10	0.139
LOMA (cm)	20.90 ± 1.34^{a}	19.48 ± 1.58^{bc}	19.68 ± 1.44^{bc}	13.92	<0.001
NL (cm)	10.82 ± 1.35^{ac}	12.32 ± 1.79^{b}	11.26 ± 1.43^{ac}	12.63	<0.001
BALt (cm)	34.78 ± 2.79^{ac}	37.50 ± 4.63^{b}	34.48 ± 2.86^{ac}	11.11	<0.001
DSLt (cm)	85.20 ± 4.56	85.04 ± 3.61	85.73 ± 3.94	0.39	0.675
HL (cm)	18.48 ± 1.20	18.68 ± 1.24	18.97 ± 1.30	1.91	0.151
HB (cm)	9.98 ± 0.85^{a}	10.78 ± 0.83^{bc}	10.72 ± 0.76^{bc}	14.99	<0.001
WRB (cm)	8.32 ± 0.71^{ab}	8.38 ± 0.75^{abc}	8.68 ± 0.77^{bc}	3.35	0.038
ThL (cm)	54.14 ± 3.33	53.08 ± 4.12	52.90 ± 3.76	1.60	0.206
LL (cm)	39.98 ± 2.69	40.78 ± 3.26	40.20 ± 2.78	1.00	0.370
FL (cm)	24.59 ± 1.56	24.78 ± 1.52	24.43 ± 1.13	0.78	0.460
FB (cm)	13.19 ± 0.85	13.38 ± 0.85	13.18 ± 0.85	0.88	0.417
AKB (cm)	13.18 ± 0.80	13.50 ± 0.95	13.30 ± 0.84	1.74	0.179

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.23: Comparison of anthropometric characteristics of adult males (31-45 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	35.40 ± 4.16	35.70 ± 4.18	35.56 ± 4.20	0.07	0.938
Height (cm)	170.28 ± 12.33	171.12 ± 6.40	169.08 ± 7.92	0.62	0.541
Weight (kg)	68.70 ± 9.39	72.57 ± 11.24	69.00 ± 11.36	2.02	0.136
BMI (kg/m^2)	23.97 ± 4.62	24.77 ± 3.53	24.07 ± 3.13	0.65	0.525
SHt (cm)	83.24 ± 4.02^{abc}	84.72 ± 3.61^{ab}	82.80 ± 4.20^{ac}	3.24	0.042
BGW (cm)	12.78 ± 0.91	12.77 ± 1.32	12.52 ± 0.81	1.01	0.368
LOMA (cm)	21.90 ± 1.36	21.20 ± 1.68	21.44 ± 1.40	2.86	0.060
NL (cm)	12.58 ± 0.99^{ac}	13.20 ± 1.41^{bc}	12.56 ± 1.58^{abc}	3.62	0.029
BALt (cm)	36.38 ± 2.51^{a}	39.16 ± 3.43^{b}	37.52 ± 2.57^{c}	11.89	<0.001
DSLt (cm)	93.72 ± 4.13	93.12 ± 3.83	92.30 ± 5.04	1.34	0.266
HL (cm)	19.95 ± 1.35	20.29 ± 1.14	20.24 ± 1.27	1.05	0.353
HB (cm)	12.00 ± 1.03	12.26 ± 0.90	12.16 ± 0.82	1.02	0.364
WRB (cm)	9.44 ± 0.99	9.32 ± 0.68	9.46 ± 0.76	0.42	0.656
ThL (cm)	55.94 ± 3.52^{a}	53.76 ± 3.90^{bc}	54.06 ± 3.67^{bc}	5.10	0.007
LL (cm)	44.58 ± 2.79^{ac}	41.78 ± 3.76^{b}	43.70 ± 3.07^{ac}	9.82	<0.001
FL (cm)	26.09 ± 2.21	26.63 ± 1.29	26.18 ± 1.50	1.42	0.245
FB (cm)	13.84 ± 1.08^{a}	14.96 ± 1.18^{bc}	14.68 ± 1.10^{bc}	13.61	<0.001
AKB (cm)	13.82 ± 1.08^{a}	14.78 ± 0.95^{bc}	14.50 ± 1.09^{bc}	11.16	<0.001

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

Table 4.24: Comparison of anthropometric characteristics of adult females (31-45 years) in relation to senatorial zones

Variables	SSZ (n = 50) Mean + SD	CSZ (n = 50) Mean + SD	NSZ (n = 50) Mean + SD	F	*P*
Age (years)	35.52 ± 4.67	36.26 ± 4.13	36.54 ± 4.16	0.74	0.477
Height (cm)	158.70 ± 5.50	160.70 ± 6.19	158.08 ± 6.47	2.55	0.082
Weight (kg)	65.80 ± 11.32^{ac}	72.76 ± 15.23^{bc}	71.00 ± 15.30^{abc}	3.31	0.039
BMI (kg/m^2)	26.16 ± 4.59	28.32 ± 6.53	28.32 ± 5.36	2.51	0.085
SHt (cm)	79.94 ± 2.85	80.24 ± 4.31	79.04 ± 4.42	1.27	0.285
BGW (cm)	11.55 ± 1.04^{ac}	12.18 ± 0.82^{b}	11.67 ± 0.90^{ac}	6.51	0.002
LOMA (cm)	20.58 ± 1.63	20.13 ± 1.48	20.90 ± 2.12	2.40	0.094
NL (cm)	10.94 ± 1.52^{abc}	11.36 ± 1.59^{ab}	10.36 ± 1.23^{ac}	5.98	0.003
BALt (cm)	36.72 ± 2.69	38.00 ± 4.28	37.22 ± 3.58	1.63	0.200
DSLt (cm)	85.18 ± 4.52	85.79 ± 3.50	86.08 ± 4.43	0.61	0.548
HL (cm)	18.88 ± 1.28	18.63 ± 1.35	18.73 ± 1.32	0.44	0.647
HB (cm)	10.26 ± 0.92^{ac}	10.80 ± 0.95^{bc}	10.58 ± 0.81^{abc}	4.60	0.012
WRB (cm)	8.54 ± 0.76^{ab}	8.72 ± 0.90^{abc}	9.02 ± 0.69^{bc}	4.72	0.010
ThL (cm)	53.96 ± 4.02	52.90 ± 3.26	53.08 ± 3.61	1.21	0.300
LL (cm)	40.58 ± 2.56	40.74 ± 2.19	41.22 ± 3.24	0.76	0.469
FL (cm)	24.82 ± 0.99	24.72 ± 1.27	24.64 ± 1.58	0.24	0.787
FB (cm)	13.34 ± 0.90	13.43 ± 1.13	13.77 ± 1.05	2.43	0.092
AKB (cm)	13.34 ± 0.85	13.60 ± 1.16	13.77 ± 1.02	2.26	0.108

BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; Means with different superscript are significantly different with $P < 0.05$; SSZ = Southern Senatorial Zone; CSZ = Central Senatorial Zone; NSZ = Northern Senatorial Zone

4.4. Correlation between Anthropometric Variables

Table 4.25 – 4.56 shows the correlation matrix of the studied population and their anthropometric characteristics. Pearson's correlation coefficient was used to correlate height to the other parameters. Ninety-five percent (95%) of the parameters correlated at $P < 0.001$, $P < 0.01$ and $P < 0.05$. In the overall population of Cross River State, DSLt showed the strongest correlation with stature (r = 0.94), followed by SHt (r = 0.90), (Table 4.25). In the overall male population, there was no significant correlation with stature in all anthropometric variables' exception of NL which showed a positive linear correlation with BGW (r = 0.22), (Table 4.26). Also, in the overall female population, there was no significant correlation with stature in all anthropometric variables. However, NL length showed a strong to moderate linear correlation with most of the variables including BALt, DSLt, HL, HB, WRB, ThL, LL, FL, FB and AKB (r = 0.16, r = 0.21, r = 0.22, r = 0.22, r = 0.13, r = 0.21, r = 0.23, r = 0.25, r = 0.13 and r = 0.13), respectively. Moreso, SHt and BGW showed strong and moderate correlation with NL (r = 0.23 and r = 0.13), respectively. Furthermore, WT showed a weak correlation with NL (r = 0.09), (Table 4.26).

Table 4.27 – 4.28 shows the correlation matrix of the entire SSZ population and their anthropometric characteristics. In the SSZ population, there was no significant correlation with stature in all anthropometric variables. However, NL showed a strong to moderate linear correlation with LOMA and BMI (r = 0.29 and r = 0.14), respectively. In males, there was no significant correlation among the variables, exception of NL which showed a strong and linear correlation with BMI and BGW (r = 0.42 and r = 0.40) respectively. In females, NL showed a significant linear correlation with stature (r = 0.24).

Table 4.29 – 4.30 shows the correlation matrix of the entire CSZ population and their anthropometric characteristics. In the CSZ population, there was no significant correlation with stature in all anthropometric variables. However, NL showed a strong and linear correlation with WT, SHt and LOMA (r = 0.17, r = 0.28 and r = 0.28) respectively (Table 4.29). In males, NL showed a strong and linear correlation with stature (r = 0.35), while in females, NL also, showed a moderate and linear correlation with stature (r = 0.22), (Table 4.30).

Table 4.31 – 4.32 shows the correlation matrix of the entire NSZ population and their anthropometric characteristics. In the NSZ, there was no significant correlation with stature in all anthropometric variables. However, NL showed a strong and significant linear correlation with WT, BGW and LOMA (r = 0.25, r = 0.28 and r = 0.25) respectively. Moreso, BALt showed a strong and significant linear correlation with NL (r = 0.23), (Table 4.31). In males, there was no significant correlation with stature in all anthropometric variables, exception of NL which showed a strong and significant correlation with WT, BMI, BGW and LOMA (r = 0.43, r = 0.31, r = 0.25 and r = 0.39) respectively, while BALt also showed strong and significant linear correlation with NL (r = 0.31). In females, NL showed a strong and significant linear correlation with stature (r = 0.32), (Table 4.32).

Table 4.25: Correlation matrix of anthropometric parameters of all subjects (n = 1200)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.68	0.81	0.72	0.72	0.62	0.65	0.13[c]	0.72	0.68	0.60	0.58	0.58	0.63	0.60	0.54	0.56	0.56
HT		-	0.84	0.50	0.90[c]	0.67	0.70	0.40	0.75	0.94[c]	0.88[c]	0.78	0.72	0.85[c]	0.85[c]	0.84	0.77	0.78
WT			-	0.88[c]	0.85[c]	0.69	0.74	0.25	0.82	0.84	0.78	0.73	0.72	0.77	0.74	0.72	0.73	0.74
BMI				-	0.61	0.53	0.60	0.06	0.69	0.57	0.52	0.50	0.55	0.55	0.49	0.47	0.53	0.54
SHt					-	0.66	0.70	0.35	0.76	0.88[c]	0.82	0.74	0.70	0.81	0.78	0.78	0.72	0.74
BGW						-	0.59	0.23	0.60	0.68	0.64	0.62	0.55	0.57	0.58	0.59	0.59	0.58
LOMA							-	0.22	0.63	0.72	0.66	0.60	0.63	0.67	0.65	0.63	0.63	0.64
NL								-	0.27	0.39	0.39	0.46	0.38	0.27	0.36	0.42	0.36	0.35
BALt									-	0.75	0.69	0.67	0.65	0.67	0.66	0.67	0.67	0.69
DSLt										-	0.90[c]	0.80	0.74	0.85[c]	0.86[c]	0.85[c]	0.78	0.79
HL											-	0.81	0.75	0.78	0.81	0.84	0.77	0.77
HB												-	0.79	0.64	0.70	0.73	0.75	0.75
WRB													-	0.65	0.67	0.69	0.71	0.72
ThL														-	0.82	0.74	0.68	0.70
LL															-	0.77	0.69	0.69
FL																-	0.77	0.77
FB																	-	0.95[c]
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$

Table 4.26: Correlation matrix of anthropometric parameters of all male and female subjects (n = 600)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.73	0.82	0.73	0.77	0.69	0.75	0.28	0.74	0.75	0.67	0.70	0.62	0.70	0.64	0.60	0.61	0.60
HT	0.64	-	0.90	0.59	0.90	0.69	0.76	0.47	0.80	0.94	0.89	0.83	0.75	0.88	0.84	0.84	0.79	0.80
WT	0.80	0.79	-	0.86	0.89	0.75	0.82	0.43	0.84	0.91	0.86	0.84	0.77	0.84	0.78	0.80	0.78	0.79
BMI	0.74	0.54	0.94	-	0.69	0.65	0.71	0.30	0.70	0.71	0.67	0.68	0.62	0.64	0.57	0.60	0.62	0.63
SHt	0.67	0.89	0.80	0.62	-	0.71	0.77	0.45	0.80	0.90	0.85	0.82	0.74	0.83	0.79	0.80	0.76	0.77
BGW	0.57	0.62	0.64	0.55	0.60	-	0.71	0.22^{c}	0.67	0.70	0.68	0.64	0.55	0.66	0.59	0.61	0.63	0.63
LOMA	0.54	0.61	0.65	0.57	0.60	0.44	-	0.36	0.73	0.80	0.75	0.74	0.68	0.74	0.69	0.67	0.69	0.70
NL	0.01	0.26	0.09^{a}	-0.01	0.23^{c}	0.13^{b}	0.05	-	0.40	0.48	0.45	0.50	0.49	0.41	0.43	0.48	0.42	0.44
BALt	0.69	0.70	0.81	0.73	0.70	0.55	0.53	0.16^{c}	-	0.82	0.78	0.77	0.71	0.73	0.68	0.75	0.75	0.76
DSLt	0.64	0.94	0.79	0.58	0.86	0.61	0.62	0.21^{c}	0.70	-	0.92	0.85	0.77	0.89	0.86	0.85	0.79	0.80
HL	0.54	0.85	0.70	0.50	0.79	0.55	0.55	0.22^{c}	0.61	0.87	-	0.86	0.79	0.84	0.82	0.85	0.80	0.81
HB	0.52	0.69	0.67	0.55	0.68	0.54	0.44	0.22^{c}	0.63	0.71	0.72	-	0.83	0.78	0.75	0.77	0.77	0.78
WRB	0.57	0.65	0.69	0.61	0.66	0.48	0.57	0.13^{b}	0.61	0.68	0.66	0.70	-	0.73	0.69	0.72	0.72	0.73
ThL	0.55	0.87	0.70	0.50	0.79	0.51	0.61	0.21^{c}	0.61	0.86	0.76	0.58	0.61	-	0.87	0.79	0.74	0.75
LL	0.57	0.87	0.70	0.50	0.77	0.53	0.59	0.23^{c}	0.64	0.87	0.79	0.63	0.63	0.78	-	0.76	0.70	0.71
FL	0.51	0.82	0.66	0.48	0.74	0.52	0.57	0.25^{c}	0.60	0.83	0.81	0.62	0.61	0.74	0.78	-	0.80	0.82
FB	0.56	0.73	0.73	0.61	0.70	0.48	0.57	0.13^{b}	0.62	0.75	0.71	0.66	0.66	0.71	0.68	0.69	-	0.96
AKB	0.54	0.73	0.72	0.60	0.70	0.47	0.57	0.13^{b}	0.63	0.74	0.69	0.67	0.66	0.70	0.67	0.68	0.93	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female

Table 4.27: Correlation matrix of anthropometric parameters of SSZ subjects (n = 400)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.68	0.79	0.67	0.71	0.59	0.63	0.28[c]	0.73	0.69	0.59	0.57	0.56	0.63	0.60	0.53	0.49	0.49
HT		-	0.84	0.46	0.84	0.67	0.70	0.47	0.73	0.91	0.82	0.72	0.69	0.83	0.84	0.78	0.70	0.71
WT			-	0.85	0.83	0.68	0.73	0.36	0.82	0.86	0.77	0.68	0.67	0.80	0.75	0.70	0.67	0.67
BMI				-	0.60	0.49	0.57	0.14[b]	0.69	0.59	0.53	0.44	0.45	0.57	0.48	0.47	0.48	0.48
SHt					-	0.63	0.70	0.40	0.73	0.85	0.77	0.69	0.67	0.81	0.77	0.72	0.65	0.65
BGW						-	0.54	0.39	0.57	0.69	0.64	0.65	0.58	0.56	0.60	0.58	0.55	0.54
LOMA							-	0.29[c]	0.70	0.74	0.64	0.56	0.61	0.69	0.67	0.62	0.62	0.63
NL								-	0.35	0.47	0.47	0.56	0.47	0.33	0.43	0.44	0.41	0.41
BALt									-	0.77	0.70	0.65	0.67	0.71	0.68	0.67	0.66	0.67
DSLt										-	0.86	0.76	0.72	0.85	0.87	0.79	0.71	0.72
HL											-	0.80	0.74	0.75	0.80	0.81	0.72	0.71
HB												-	0.81	0.62	0.70	0.68	0.66	0.66
WRB													-	0.62	0.67	0.69	0.63	0.62
ThL														-	0.82	0.70	0.65	0.65
LL															-	0.74	0.64	0.63
FL																-	0.74	0.75
FB																	-	0.97
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; SSZ = Southern Senatorial Zone

Table 4.28: Correlation matrix of anthropometric parameters of SSZ male and female subjects (n = 200)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.74	0.83	0.68	0.78	0.70	0.76	0.46	0.72	0.79	0.65	0.69	0.63	0.73	0.69	0.59	0.54	0.54
HT	0.63	-	0.89	0.47	0.83	0.72	0.76	0.61	0.77	0.90	0.83	0.77	0.73	0.85	0.83	0.79	0.73	0.74
WT	0.76	0.80	-	0.79	0.87	0.79	0.82	0.60	0.81	0.94	0.84	0.82	0.77	0.87	0.82	0.76	0.71	0.72
BMI	0.69	0.56	0.94	-	0.67	0.64	0.65	0.42[c]	0.65	0.71	0.66	0.64	0.57	0.65	0.60	0.56	0.52	0.52
SHt	0.65	0.89	0.77	0.59	-	0.70	0.78	0.59	0.75	0.88	0.80	0.79	0.73	0.83	0.81	0.76	0.69	0.69
BGW	0.51	0.58	0.59	0.49	0.55	-	0.70	0.40[c]	0.66	0.74	0.68	0.68	0.61	0.72	0.65	0.62	0.61	0.62
LOMA	0.48	0.61	0.63	0.53	0.58	0.34[c]	-	0.57	0.74	0.83	0.72	0.71	0.67	0.76	0.76	0.66	0.70	0.70
NL	0.14[a]	0.24[c]	0.15[a]	0.07	0.22[b]	0.21[b]	0.01	-	0.58	0.67	0.64	0.61	0.63	0.59	0.61	0.64	0.53	0.55
BALt	0.74	0.72	0.82	0.73	0.71	0.51	0.66	0.19[b]	-	0.82	0.78	0.76	0.75	0.76	0.76	0.76	0.72	0.73
DSLt	0.59	0.91	0.78	0.58	0.82	0.57	0.62	0.14[a]	0.74	-	0.88	0.82	0.77	0.90	0.89	0.80	0.74	0.75
HL	0.53	0.80	0.69	0.51	0.74	0.54	0.52	0.18[a]	0.63	0.81	-	0.85	0.80	0.84	0.84	0.83	0.77	0.76
HB	0.51	0.61	0.58	0.47	0.61	0.52	0.40[c]	0.28[c]	0.64	0.65	0.70	-	0.87	0.80	0.78	0.74	0.71	0.70
WRB	0.53	0.57	0.58	0.49	0.60	0.47	0.55	0.11	0.63	0.59	0.57	0.61	-	0.75	0.73	0.74	0.71	0.70
ThL	0.51	0.86	0.71	0.52	0.78	0.45	0.58	0.18[a]	0.66	0.82	0.67	0.51	0.50	-	0.89	0.76	0.72	0.72
LL	0.52	0.85	0.67	0.46	0.72	0.47	0.54	0.11	0.60	0.82	0.71	0.50	0.52	0.76	-	0.76	0.67	0.68
FL	0.47	0.75	0.63	0.47	0.66	0.49	0.56	0.13	0.58	0.76	0.76	0.55	0.54	0.65	0.67	-	0.81	0.81
FB	0.45	0.64	0.64	0.54	0.60	0.40[c]	0.52	0.19[b]	0.61	0.64	0.62	0.56	0.46	0.61	0.55	0.61	-	0.98
AKB	0.44	0.63	0.63	0.53	0.60	0.38[c]	0.55	0.18[a]	0.61	0.64	0.59	0.56	0.46	0.61	0.53	0.62	0.94	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; SSZ = Southern Senatorial Zone

Table 4.29: Correlation matrix of anthropometric parameters of CSZ subjects (n = 400)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.68	0.83	0.74	0.73	0.64	0.68	0.04	0.70	0.69	0.61	0.61	0.62	0.63	0.55	0.52	0.59	0.59
HT		-	0.83	0.51	0.91	0.62	0.73	0.33	0.75	0.95	0.89	0.80	0.77	0.86	0.83	0.84	0.79	0.80
WT			-	0.90	0.85	0.66	0.76	0.17[c]	0.83	0.83	0.78	0.76	0.79	0.76	0.68	0.71	0.74	0.76
BMI				-	0.61	0.55	0.60	-0.01	0.71	0.55	0.51	0.55	0.63	0.54	0.44	0.45	0.53	0.55
SHt					-	0.64	0.72	0.28[c]	0.77	0.88	0.84	0.76	0.77	0.80	0.75	0.78	0.76	0.78
BGW						-	0.65	0.07	0.59	0.62	0.61	0.58	0.54	0.54	0.50	0.54	0.58	0.56
LOMA							-	0.28[c]	0.66	0.72	0.70	0.69	0.68	0.64	0.63	0.62	0.65	0.67
NL								-	0.16[c]	0.32	0.29[c]	0.29[c]	0.29[c]	0.26[c]	0.30[c]	0.39	0.28[c]	0.26[c]
BALt									-	0.75	0.71	0.67	0.67	0.66	0.62	0.65	0.66	0.68
DSLt										-	0.91	0.81	0.78	0.84	0.83	0.85	0.81	0.81
HL											-	0.80	0.77	0.76	0.77	0.83	0.80	0.80
HB												-	0.77	0.65	0.65	0.73	0.78	0.78
WRB													-	0.70	0.66	0.71	0.76	0.78
ThL														-	0.81	0.73	0.68	0.70
LL															-	0.75	0.69	0.70
FL																-	0.76	0.76
FB																	-	0.93
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; CSZ = Central Senatorial Zone

Table 4.30: Correlation matrix of anthropometric parameters of CSZ male and female subjects (n = 200)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.73	0.84	0.80	0.79	0.65	0.77	0.19[b]	0.77	0.74	0.69	0.72	0.68	0.68	0.55	0.58	0.66	0.66
HT	0.66	-	0.90	0.65	0.92	0.62	0.77	0.35[c]	0.83	0.94	0.91	0.85	0.83	0.89	0.82	0.86	0.81	0.84
WT	0.81	0.77	-	0.91	0.89	0.69	0.84	0.31[c]	0.87	0.90	0.87	0.85	0.82	0.82	0.71	0.80	0.80	0.82
BMI	0.74	0.50	0.93	-	0.72	0.65	0.75	0.22[b]	0.76	0.72	0.69	0.72	0.69	0.64	0.51	0.64	0.69	0.70
SHt	0.68	0.88	0.80	0.61	-	0.67	0.78	0.31[c]	0.84	0.91	0.87	0.81	0.80	0.83	0.75	0.82	0.78	0.81
BGW	0.65	0.60	0.64	0.56	0.58	-	0.69	0.08	0.65	0.62	0.66	0.59	0.56	0.57	0.46	0.56	0.63	0.62
LOMA	0.59	0.66	0.77	0.57	0.63	0.57	-	0.26[c]	0.79	0.76	0.78	0.78	0.70	0.67	0.60	0.64	0.72	0.73
NL	-0.10	0.22[b]	0.03	-0.08	0.19[b]	-0.05	0.25[c]	-	0.31[c]	0.32[c]	0.27[c]	0.36[c]	0.33[c]	0.31[c]	0.30[c]	0.34[c]	0.28[c]	0.31[c]
BALt	0.63	0.68	0.78	0.70	0.69	0.52	0.53	0.05	-	0.84	0.82	0.79	0.76	0.74	0.63	0.74	0.78	0.80
DSLt	0.68	0.95	0.79	0.56	0.85	0.60	0.65	0.21[b]	0.70	-	0.93	0.84	0.82	0.87	0.81	0.85	0.81	0.84
HL	0.56	0.85	0.70	0.49	0.79	0.50	0.58	0.19[b]	0.61	0.87	-	0.83	0.82	0.82	0.77	0.84	0.83	0.85
HB	0.56	0.71	0.73	0.60	0.70	0.53	0.58	0.03	0.61	0.74	0.72	-	0.81	0.75	0.71	0.76	0.79	0.81
WRB	0.60	0.67	0.78	0.70	0.73	0.51	0.63	0.12	0.60	0.71	0.68	0.70	-	0.77	0.72	0.75	0.77	0.81
ThL	0.58	0.87	0.69	0.48	0.79	0.54	0.62	0.26[c]	0.58	0.87	0.74	0.63	0.68	-	0.85	0.80	0.77	0.78
LL	0.55	0.85	0.66	0.44	0.74	0.54	0.66	0.27[c]	0.60	0.87	0.78	0.59	0.60	0.78	-	0.74	0.73	0.75
FL	0.51	0.81	0.65	0.45	0.74	0.46	0.59	0.32[c]	0.60	0.83	0.78	0.60	0.61	0.73	0.80	-	0.78	0.81
FB	0.60	0.75	0.75	0.61	0.75	0.50	0.55	0.07	0.62	0.78	0.73	0.71	0.72	0.70	0.68	0.67	-	0.94
AKB	0.57	0.74	0.73	0.59	0.75	0.46	0.58	0.06	0.61	0.75	0.70	0.69	0.71	0.70	0.64	0.64	0.90	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; CSZ = Central Senatorial Zone

Table 4.31: Correlation matrix of anthropometric parameters of NSZ subjects (n = 400)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BAL	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.67	0.81	0.74	0.71	0.63	0.67	0.11[a]	0.74	0.67	0.60	0.57	0.56	0.64	0.64	0.57	0.59	0.58
HT		-	0.85	0.55	0.93	0.73	0.71	0.42	0.77	0.96	0.92	0.84	0.74	0.89	0.88	0.89	0.82	0.82
WT			-	0.89	0.86	0.73	0.78	0.25[c]	0.84	0.85	0.79	0.74	0.72	0.79	0.79	0.76	0.77	0.78
BMI				-	0.63	0.56	0.65	0.04	0.71	0.58	0.52	0.50	0.56	0.56	0.54	0.51	0.56	0.58
SHt					-	0.73	0.72	0.37	0.78	0.91	0.87	0.80	0.71	0.83	0.83	0.82	0.76	0.77
BGW						-	0.63	0.28[c]	0.66	0.73	0.69	0.66	0.54	0.64	0.65	0.67	0.62	0.64
LOMA							-	0.25[c]	0.66	0.73	0.68	0.65	0.64	0.69	0.66	0.69	0.67	0.68
NL								-	0.23[c]	0.44	0.47	0.53	0.47	0.33	0.40	0.41	0.42	0.41
BALt									-	0.77	0.70	0.68	0.67	0.72	0.71	0.70	0.70	0.71
DSLt										-	0.93	0.85	0.75	0.89	0.89	0.89	0.81	0.83
HL											-	0.85	0.74	0.84	0.85	0.89	0.80	0.81
HB												-	0.81	0.71	0.78	0.80	0.80	0.80
WRB													-	0.67	0.70	0.73	0.75	0.76
ThL														-	0.83	0.81	0.75	0.76
LL															-	0.82	0.75	0.75
FL																-	0.81	0.82
FB																	-	0.95
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; NSZ = Northern Senatorial Zone

Table 4.32: Correlation matrix of anthropometric parameters of NSZ male and female subjects (n = 200)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.73	0.80	0.71	0.76	0.73	0.76	0.24[c]	0.74	0.74	0.68	0.69	0.57	0.71	0.67	0.63	0.63	0.60
HT	0.63	-	0.91	0.64	0.95	0.77	0.80	0.46	0.82	0.96	0.93	0.88	0.75	0.93	0.87	0.89	0.83	0.84
WT	0.81	0.81	-	0.89	0.90	0.80	0.85	0.43[c]	0.83	0.91	0.88	0.86	0.75	0.86	0.82	0.83	0.81	0.83
BMI	0.79	0.58	0.94	-	0.68	0.66	0.74	0.31[c]	0.68	0.70	0.66	0.67	0.62	0.64	0.61	0.64	0.64	0.66
SHt	0.67	0.91	0.83	0.66	-	0.78	0.80	0.47	0.82	0.92	0.89	0.87	0.72	0.86	0.83	0.83	0.79	0.80
BGW	0.56	0.67	0.69	0.60	0.67	-	0.75	0.25[c]	0.74	0.77	0.73	0.70	0.53	0.74	0.69	0.69	0.67	0.68
LOMA	0.59	0.61	0.71	0.65	0.63	0.49	-	0.39[c]	0.73	0.83	0.77	0.79	0.69	0.79	0.72	0.78	0.74	0.75
NL	-0.00	0.32[c]	0.10	-0.01	0.27[c]	0.18[b]	0.09	-	0.31[c]	0.49	0.51	0.56	0.60	0.46	0.46	0.44[c]	0.45	0.47
BALt	0.74	0.73	0.84	0.78	0.74	0.59	0.59	0.15[a]	-	0.81	0.76	0.76	0.68	0.77	0.72	0.76	0.74	0.74
DSLt	0.63	0.96	0.80	0.60	0.90	0.67	0.61	0.32[c]	0.73	-	0.94	0.89	0.75	0.92	0.87	0.89	0.82	0.83
HL	0.53	0.90	0.72	0.52	0.84	0.61	0.57	0.35[c]	0.64	0.91	-	0.89	0.76	0.89	0.85	0.89	0.81	0.83
HB	0.51	0.78	0.71	0.58	0.77	0.55	0.51	0.31[c]	0.64	0.79	0.80	-	0.83	0.82	0.79	0.83	0.81	0.82
WRB	0.58	0.71	0.71	0.62	0.69	0.51	0.58	0.25[c]	0.67	0.73	0.71	0.78	-	0.69	0.65	0.73	0.74	0.75
ThL	0.57	0.90	0.73	0.53	0.81	0.57	0.61	0.30[c]	0.68	0.89	0.84	0.71	0.68	-	0.87	0.86	0.79	0.81
LL	0.63	0.89	0.77	0.59	0.83	0.59	0.59	0.31[c]	0.72	0.91	0.86	0.79	0.75	0.81	-	0.80	0.74	0.74
FL	0.54	0.88	0.72	0.53	0.80	0.61	0.59	0.31[c]	0.65	0.89	0.89	0.74	0.71	0.81	0.85	-	0.82	0.85
FB	0.60	0.79	0.77	0.65	0.74	0.53	0.62	0.25[c]	0.70	0.80	0.76	0.75	0.74	0.78	0.76	0.78	-	0.95
AKB	0.59	0.79	0.78	0.67	0.74	0.55	0.61	0.22[b]	0.70	0.81	0.76	0.76	0.75	0.77	0.78	0.77	0.95	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; NSZ = Northern Senatorial Zone

Table 4.33 – 4.38 shows the correlation matrix of the entire children in the studied population and their anthropometric characteristics. In the SSZ children, AKB showed the strongest and significant correlation with stature (r = 0.52), followed by FB and WRB (r = 0.51 and r = 0.51), respectively. While BGW showed a weak and significant correlation with stature (r = 0.23). In boys, FL shows the strongest and significant correlation with stature followed by HL and LL (r = 0.73, r = 0.71 and r = 0.71), respectively, while LOMA showed a weak correlation (r = 0.29). In girls, HL showed the strongest and significant correlation with stature (r = 0.74), while NL and AKB showed a weak correlation (r = 0.35 and r = 0.35), respectively (Table 4.33-4.34).

In the CSZ children, BALt showed the strongest and significant correlation with stature (r = 0.56), followed by WRB and FB (r = 0.55 and r = 0.55), respectively. While NL showed a weak and significant correlation with stature (r = 0.23). In boys, DSLt showed the strongest correlation with stature (r = 0.76), followed by SHt (r = 0.75). In girls, SHt showed the strongest correlation with stature (r = 0.72), while NL showed a weak correlation (r = 32), (Table 4.35-4.36).

In the NSZ, BGW showed the strongest and significant correlation with stature (r = 0.53), while NL showed a moderate and significant correlation with stature (r = 0.32). In boys, HB showed the strongest correlation with stature (r = 0.70), while BGW showed a weak correlation (r = 0.44). In girls, SHt showed the strongest correlation with stature (r = 0.75), while LOMA showed a weak correlation (r = 0.34), (Table 4.37-4.38).

Table 4.39 – 4.44 shows the correlation matrix of the entire adolescents in the studied population and their anthropometric characteristics. In the SSZ, ThL showed the strongest and significant correlation with stature (r = 0.57), followed by FL (r = 0.56). While HB showed a moderate and

significant correlation with stature (r = 0.28). In males, WT showed the strongest and significant correlation with stature (r = 0.76), followed by DSLt (r = 0.72), while WRB showed a weak correlation (r = 0.29). In females, DSLt showed the strongest and significant correlation with stature (r = 0.73), while LOMA showed a weak correlation (r = 0.34), (Table 4.39-4.40).

In CSZ, HB showed the strongest and significant correlation with stature (r = 0.58), followed by FB (r = 0.50). In males, SHt, ThL and HL showed the strongest correlation with stature (r = 0.76, r = 0.76 and r = 0.75), respectively. In females, ThL showed the strongest and significant correlation with stature (r = 0.69), followed by HL (r = 0.68), while FL showed a weak correlation (r = 33), (Table 4.41-4.42).

In the NSZ, BALt showed the strongest and significant correlation with stature (r = 0.57), followed by AKB (r = 0.55). While BGW showed a moderate and significant correlation with stature (r = 0.32). In males, FL showed the strongest and significant correlation with stature (r = 0.76). In females, DSLt showed the strongest correlation with staure (r = 0.67), followed by ThL (r = 0.62), while FL and BALt showed a weak correlation (r = 0.28 and r = 0.29), respectively (Table 4.43-4.44).

Table 4.33: Correlation matrix of anthropometric parameters of SSZ children (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.69	0.66	0.14	0.71	0.10	0.42^{c}	0.26^{b}	0.49^{c}	0.76	0.69	0.55^{c}	0.52^{c}	0.65	0.62	0.66	0.52^{c}	0.49^{c}
HT		-	0.79	-0.04	0.72	0.23^{a}	0.37^{c}	0.35^{c}	0.49^{c}	0.86	0.73	0.48^{c}	0.51^{c}	0.72	0.74	0.67	0.51^{c}	0.52^{c}
WT			-	0.58^{c}	0.72	0.27^{b}	0.44^{c}	0.24^{a}	0.52^{c}	0.80	0.63	0.50^{c}	0.52	0.72	0.63	0.64	0.49^{c}	0.51^{c}
BMI				-	0.20^{a}	0.12	0.20^{a}	-0.06	0.23^{a}	0.14	0.05	0.17	0.14	0.20	0.02	0.14	0.12	0.14
SHt					-	0.17	0.47^{c}	0.39^{c}	0.52^{c}	0.78	0.66	0.57^{c}	0.60	0.68	0.67	0.67	0.47^{c}	0.46^{c}
BGW						-	0.20^{a}	-0.04	0.05	0.25^{a}	0.16	0.22^{a}	0.28^{b}	0.12	0.07	0.16	0.00	0.01
LOMA							-	0.13	0.45^{c}	0.52^{c}	0.49^{c}	0.35^{c}	0.38^{c}	0.52^{c}	0.44^{c}	0.47^{c}	0.44^{c}	0.42^{c}
NL								-	0.32^{b}	0.33^{c}	0.22^{a}	0.31^{b}	0.31^{b}	0.27^{b}	0.26^{b}	0.27^{b}	0.19	0.20^{a}
BALt									-	0.60	0.52^{c}	0.50^{c}	0.46^{c}	0.47^{c}	0.42^{c}	0.51^{c}	0.45^{c}	0.49^{c}
DSLt										-	0.82	0.63	0.59^{c}	0.79	0.79	0.75	0.56^{c}	0.54^{c}
HL											-	0.61	0.54^{c}	0.64	0.68	0.77	0.55^{c}	0.48^{c}
HB												-	0.65	0.37^{c}	0.49^{c}	0.54^{c}	0.39^{c}	0.36^{c}
WRB													-	0.42^{c}	0.47^{c}	0.55^{c}	0.31^{b}	0.27^{b}
ThL														-	0.71	0.66	0.48^{c}	0.46^{c}
LL															-	0.61	0.40^{c}	0.36^{c}
FL																-	0.60	0.60
FB																	-	0.94
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; SSZ = Southern Senatorial Zone

Table 4.34: Correlation matrix of anthropometric parameters of SSZ boys and girls (n = 50)

→B ↓G	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.64^{c}	0.74^{c}	0.33^{a}	0.75^{c}	0.13	0.40^{b}	0.34^{a}	0.63^{c}	0.81	0.75^{c}	0.63^{c}	0.56^{c}	0.74^{c}	0.66^{c}	0.74^{c}	0.59^{c}	0.58^{c}
HT	0.75^{c}	-	0.80	-0.04	0.62^{c}	0.27	0.29^{a}	0.39^{b}	0.58^{c}	0.82	0.71^{c}	0.49^{c}	0.57^{c}	0.64^{c}	0.71^{c}	0.73^{c}	0.60^{c}	0.68^{c}
WT	0.59^{c}	0.79	-	0.56^{c}	0.70^{c}	0.28	0.45^{b}	0.29^{a}	0.60^{c}	0.85	0.77	0.64^{c}	0.60^{c}	0.79	0.67^{c}	0.79	0.62^{c}	0.67^{c}
BMI	-0.02	0.01	0.62^{c}	-	0.30^{a}	0.10	0.32^{a}	-0.05	0.23	0.28	0.30^{a}	0.38^{b}	0.19	0.42^{b}	0.11	0.30^{a}	0.24	0.20
SHt	0.68^{c}	0.83	0.74^{c}	0.13	-	0.13	0.48^{c}	0.48^{c}	0.62^{c}	0.81	0.71^{c}	0.69^{c}	0.66^{c}	0.77	0.77	0.80	0.57^{c}	0.55^{c}
BGW	0.09	0.23	0.26	0.11	0.21	-	0.25	-0.20	0.16	0.27	0.21	0.23	0.21	0.19	0.02	0.14	0.19	0.23
LOMA	0.42^{b}	0.41^{b}	0.46^{c}	0.20	0.46^{c}	0.23	-	0.32^{a}	0.52^{c}	0.46^{c}	0.54^{c}	0.38^{b}	0.34^{a}	0.48^{c}	0.43^{b}	0.43^{b}	0.49^{c}	0.42^{b}
NL	0.21	0.35^{a}	0.20	-0.10	0.32^{a}	0.09	0.01	-	0.49^{c}	0.49^{c}	0.43^{b}	0.43^{b}	0.49^{c}	0.42^{b}	0.54^{c}	0.47^{c}	0.31^{a}	0.31^{a}
BALt	0.32^{a}	0.38^{b}	0.44^{b}	0.25	0.41^{b}	-0.07	0.39^{b}	0.16	-	0.73^{c}	0.72^{c}	0.50^{c}	0.58^{c}	0.66^{c}	0.65^{c}	0.71^{c}	0.55^{c}	0.57^{c}
DSLt	0.70^{c}	0.91	0.76^{c}	0.08	0.75^{c}	0.28	0.55^{c}	0.22	0.45^{b}	-	0.85	0.73^{c}	0.70^{c}	0.81	0.81	0.83	0.70^{c}	0.72^{c}
HL	0.64^{c}	0.74^{c}	0.51^{c}	-0.11	0.61^{c}	0.16	0.38^{b}	0.09	0.30^{a}	0.78	-	0.69^{c}	0.63^{c}	0.72^{c}	0.74^{c}	0.80	0.69^{c}	0.65^{c}
HB	0.46^{c}	0.48^{c}	0.34^{a}	-0.03	0.42^{b}	0.22	0.34^{a}	0.21	0.50^{c}	0.54^{c}	0.56^{c}	-	0.80	0.60^{c}	0.70^{c}	0.57^{c}	0.45^{b}	0.41^{b}
WRB	0.46^{c}	0.44^{b}	0.43^{b}	0.13	0.53^{c}	0.38^{b}	0.43^{b}	0.15	0.30^{a}	0.46^{c}	0.44^{b}	0.46^{c}	-	0.62^{c}	0.66^{c}	0.58^{c}	0.44^{b}	0.37^{b}
ThL	0.61^{c}	0.80	0.76^{c}	0.19	0.67^{c}	0.14	0.46^{c}	0.25	0.35^{a}	0.80	0.55^{c}	0.22	0.27	-	0.69^{c}	0.81	0.60^{c}	0.58^{c}
LL	0.56^{c}	0.77	0.59^{c}	-0.00	0.58^{c}	0.17	0.40^{b}	0.05	0.14	0.75^{c}	0.60^{c}	0.27	0.25	0.72^{c}	-	0.74^{c}	0.47^{c}	0.49^{c}
FL	0.55^{c}	0.59^{c}	0.48^{c}	0.04	0.53^{c}	0.23	0.48^{c}	0.10	0.21	0.65^{c}	0.72^{c}	0.52^{c}	0.50^{c}	0.52^{c}	0.41^{b}	-	0.66^{c}	0.67^{c}
FB	0.44^{b}	0.42^{b}	0.36^{a}	0.01	0.38^{b}	-0.20	0.42^{a}	0.08	0.33^{a}	0.42^{a}	0.44^{b}	0.32^{a}	0.15	0.44^{b}	0.34^{a}	0.55^{c}	-	0.94
AKB	0.40^{b}	0.35^{a}	0.35^{a}	0.09	0.37^{b}	-0.22	0.46^{c}	0.11	0.39^{a}	0.37^{a}	0.33^{a}	0.30^{a}	0.17	0.43^{b}	0.23	0.54^{c}	0.95	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; B = Boys; G = Girls; SSZ = Southern Senatorial Zone

Table 4.35: Correlation matrix of anthropometric parameters of CSZ children (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.76	0.70	0.27	0.62	0.47[c]	0.50[c]	0.25[a]	0.42[c]	0.76	0.70	0.44[c]	0.53[c]	0.68	0.69	0.72	0.55[c]	0.61
HT		-	0.85	0.17	0.73	0.47[c]	0.53[c]	0.23[a]	0.56[c]	0.83	0.86	0.54[c]	0.55[c]	0.77	0.80	0.83	0.55[c]	0.60
WT			-	0.65	0.62	0.50[c]	0.52[c]	0.17	0.61	0.75	0.79	0.55[c]	0.59	0.73	0.74	0.77	0.54[c]	0.53[c]
BMI				-	0.14	0.30[b]	0.22[a]	0.01	0.35[c]	0.25[a]	0.28[b]	0.26[b]	0.33[c]	0.27[b]	0.27[b]	0.29[b]	0.30[b]	0.20
SHt					-	0.43[c]	0.35[c]	0.24[a]	0.49[c]	0.64	0.60	0.33[c]	0.46[c]	0.60	0.57[c]	0.67	0.46[c]	0.50[c]
BGW						-	0.45[c]	-0.00	0.37[c]	0.41[c]	0.46[c]	0.37[c]	0.38[c]	0.41[c]	0.44[c]	0.40[c]	0.39[c]	0.39[c]
LOMA							-	0.21[a]	0.24[a]	0.49[c]	0.55[c]	0.36[c]	0.37[c]	0.45[c]	0.60	0.49[c]	0.33[c]	0.37[c]
NL								-	0.09	0.23[a]	0.21[a]	0.01	0.15	0.24[a]	0.22[a]	0.40[c]	0.21[a]	0.11
BALt									-	0.53[c]	0.55[c]	0.42[c]	0.38[c]	0.50[c]	0.46[c]	0.54[c]	0.38[c]	0.41[c]
DSLt										-	0.79	0.51[c]	0.56[c]	0.70	0.75	0.80	0.55[c]	0.58[c]
HL											-	0.58[c]	0.58[c]	0.70	0.72	0.75	0.52[c]	0.53[c]
HB												-	0.40[c]	0.36[c]	0.38[c]	0.49[c]	0.52[c]	0.50[c]
WRB													-	0.59[c]	0.55[c]	0.52[c]	0.51[c]	0.51[c]
ThL														-	0.83	0.72	0.50[c]	0.56[c]
LL															-	0.73	0.55[c]	0.56[c]
FL																-	0.58[c]	0.55[c]
FB																	-	0.86
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; CSZ = Central Senatorial Zone

Table 4.36: Correlation matrix of anthropometric parameters of CSZ boys and girls (n = 50)

→B ↓G	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.76^{c}	0.76^{c}	0.32^{a}	0.63^{c}	0.50^{c}	0.40^{b}	0.05	0.38^{b}	0.72^{c}	0.70^{c}	0.40^{b}	0.38^{b}	0.65^{c}	0.67^{c}	0.70^{c}	0.62^{c}	0.64^{c}
HT	0.77	-	0.87	0.11	0.75^{c}	0.50^{c}	0.51^{c}	0.15	0.54^{c}	0.76^{c}	0.87	0.57	0.54^{c}	0.77	0.80	0.86	0.67^{c}	0.75^{c}
WT	0.67^{c}	0.84	-	0.57^{c}	0.66^{c}	0.45^{b}	0.46^{c}	0.14	0.61^{c}	0.72^{c}	0.79	0.62^{c}	0.56^{c}	0.78	0.73^{c}	0.83	0.69^{c}	0.76^{c}
BMI	0.24	0.21	0.69^{c}	-	0.12	0.11	0.10	0.02	0.31^{a}	0.24	0.21	0.28	0.23	0.28	0.19	0.25	0.30^{a}	0.33^{a}
SHt	0.63^{c}	0.72^{c}	0.59^{c}	0.16	-	0.47^{c}	0.34^{a}	0.16	0.50^{c}	0.64^{c}	0.67^{c}	0.38^{b}	0.39^{b}	0.55^{c}	0.53^{c}	0.70^{c}	0.55^{c}	0.58^{c}
BGW	0.44^{b}	0.44^{b}	0.55^{c}	0.44^{b}	0.39^{b}	-	0.53^{c}	0.10	0.34^{a}	0.44^{b}	0.56^{c}	0.41^{b}	0.31^{a}	0.44^{b}	0.46^{c}	0.44^{b}	0.51^{c}	0.51^{c}
LOMA	0.58^{c}	0.57^{c}	0.58^{c}	0.29^{a}	0.39^{b}	0.41^{b}	-	0.02	0.29^{a}	0.39^{b}	0.58^{c}	0.48^{c}	0.22	0.42^{b}	0.53^{c}	0.38^{b}	0.35^{a}	0.38^{b}
NL	0.40^{b}	0.32^{a}	0.23	0.02	0.36^{a}	-0.09	0.30^{a}	-	0.20	0.11	0.12	0.03	-0.05	0.06	0.09	0.29^{a}	0.07	0.02
BALt	0.53^{c}	0.60^{c}	0.63^{c}	0.38^{b}	0.48^{c}	0.40^{b}	0.26	0.07	-	0.49^{c}	0.56^{c}	0.46^{c}	0.42^{b}	0.39^{b}	0.33^{a}	0.59^{c}	0.46^{c}	0.53^{c}
DSLt	0.81	0.93	0.81	0.27	0.65^{c}	0.39^{b}	0.59^{c}	0.34^{a}	0.62^{c}	-	0.77	0.44^{b}	0.52^{c}	0.65^{c}	0.65^{c}	0.73^{c}	0.55^{c}	0.61^{c}
HL	0.72^{c}	0.85	0.79	0.32^{a}	0.55^{c}	0.38^{b}	0.54^{c}	0.31^{a}	0.55^{c}	0.84	-	0.54^{c}	0.55^{c}	0.73^{c}	0.76^{c}	0.80	0.64^{c}	0.69^{c}
HB	0.47^{c}	0.53^{c}	0.52^{c}	0.27	0.30^{a}	0.34^{a}	0.27	-0.07	0.43^{b}	0.58^{c}	0.63^{c}	-	0.28	0.40^{b}	0.36^{b}	0.56^{c}	0.48^{c}	0.52^{c}
WRB	0.67^{c}	0.59^{c}	0.66^{c}	0.44^{b}	0.56^{c}	0.47^{c}	0.45^{c}	0.27	0.41^{b}	0.60^{c}	0.64^{c}	0.48^{c}	-	0.52^{c}	0.53^{c}	0.50^{c}	0.50^{c}	0.55^{c}
ThL	0.75^{c}	0.77	0.69^{c}	0.27	0.65^{c}	0.38^{b}	0.51^{c}	0.47^{c}	0.62^{c}	0.80	0.69^{c}	0.34^{a}	0.72^{c}	-	0.84	0.70^{c}	0.64^{c}	0.68^{c}
LL	0.73^{c}	0.80	0.75^{c}	0.33^{a}	0.60^{c}	0.42^{b}	0.67^{c}	0.34^{a}	0.59^{c}	0.86	0.70^{c}	0.41^{b}	0.60^{c}	0.84	-	0.68^{c}	0.68^{c}	0.70^{c}
FL	0.74^{c}	0.81	0.75^{c}	0.33^{a}	0.64^{c}	0.35^{a}	0.57^{c}	0.51^{c}	0.52^{c}	0.87	0.73^{c}	0.43^{b}	0.52^{c}	0.76^{c}	0.78	-	0.66^{c}	0.71^{c}
FB	0.47^{c}	0.52^{c}	0.54^{c}	0.38^{b}	0.44^{b}	0.31^{a}	0.29^{a}	0.22	0.48^{c}	0.59^{c}	0.52^{c}	0.56^{c}	0.48^{c}	0.47^{c}	0.52^{c}	0.52^{c}	-	0.93
AKB	0.55^{c}	0.51^{c}	0.38^{b}	0.11	0.44^{b}	0.29^{a}	0.34^{a}	0.11	0.38^{b}	0.55^{c}	0.45^{b}	0.46^{c}	0.42^{b}	0.48^{c}	0.47^{c}	0.37^{b}	0.75^{c}	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; B = Boys; G = Girls; CSZ = Central Senatorial Zone

Table 4.37: Correlation matrix of anthropometric parameters of NSZ children (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.79	0.72	0.38[c]	0.68	0.50[c]	0.36[c]	0.37[c]	0.57[c]	0.79	0.71	0.60	0.53[c]	0.70	0.67	0.74	0.62	0.65
HT		-	0.85	0.35[c]	0.80	0.53[c]	0.40[c]	0.32[b]	0.67	0.91	0.84	0.71	0.60	0.82	0.78	0.84	0.69	0.72
WT			-	0.77	0.77	0.54[c]	0.41[c]	0.37[c]	0.67	0.87	0.82	0.71	0.68	0.75	0.75	0.81	0.73	0.76
BMI				-	0.46[c]	0.33[c]	0.27[b]	0.31[b]	0.40[c]	0.49[c]	0.50[c]	0.43[c]	0.51[c]	0.40[c]	0.45[c]	0.47[c]	0.49[c]	0.53[c]
SHt					-	0.50[c]	0.32[b]	0.33[c]	0.55[c]	0.75	0.71	0.61	0.61	0.65	0.66	0.72	0.58[c]	0.62
BGW						-	0.14	0.27[b]	0.38[c]	0.51[c]	0.40[c]	0.30[b]	0.24[a]	0.42[c]	0.48[c]	0.41[c]	0.35[c]	0.38[c]
LOMA							-	0.18	0.24[a]	0.47[c]	0.43[c]	0.42[c]	0.47[c]	0.45[c]	0.40[c]	0.39[c]	0.38[c]	0.37[c]
NL								-	0.14	0.42[c]	0.48[c]	0.46[c]	0.53[c]	0.30[b]	0.39[c]	0.37[c]	0.41[c]	0.42[c]
BALt									-	0.66	0.54[c]	0.49[c]	0.47[c]	0.59[c]	0.56[c]	0.62	0.53[c]	0.54[c]
DSLt										-	0.89	0.79	0.68	0.84	0.79	0.89	0.74	0.77
HL											-	0.81	0.70	0.78	0.77	0.89	0.76	0.78
HB												-	0.80	0.67	0.67	0.78	0.81	0.83
WRB													-	0.59	0.53[c]	0.71	0.73	0.73
ThL														-	0.76	0.81	0.68	0.72
LL															-	0.76	0.66	0.70
FL																-	0.76	0.79
FB																	-	0.96
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; NSZ = Northern Senatorial Zone

Table 4.38: Correlation matrix of anthropometric parameters of NSZ boys and girls (n = 50)

→B ↓G	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.79	0.74^{c}	0.35^{a}	0.69^{c}	0.41^{b}	0.55^{c}	0.25	0.60^{c}	0.80	0.68^{c}	0.61^{c}	0.46^{c}	0.77	0.64^{c}	0.78	0.61^{c}	0.69^{c}
HT	0.80	-	0.84	0.23	0.84	0.44^{b}	0.49^{c}	0.24	0.63^{c}	0.87	0.80	0.70^{c}	0.47^{c}	0.79	0.68^{c}	0.82	0.61^{c}	0.67^{c}
WT	0.70^{c}	0.87	-	0.71^{c}	0.81	0.39^{b}	0.55^{c}	0.38^{b}	0.61^{c}	0.86	0.85	0.71^{c}	0.60^{c}	0.80	0.71^{c}	0.84	0.71^{c}	0.77
BMI	0.41^{b}	0.47^{c}	0.82	-	0.39^{b}	0.15	0.36^{a}	0.38^{b}	0.29^{a}	0.43^{b}	0.49^{c}	0.34^{a}	0.42^{b}	0.43^{b}	0.44^{b}	0.45^{b}	0.45^{c}	0.50^{c}
SHt	0.66^{c}	0.75^{c}	0.73^{c}	0.52^{c}	-	0.45^{b}	0.43^{b}	0.39^{b}	0.54^{c}	0.76^{c}	0.70^{c}	0.61^{c}	0.48^{c}	0.69^{c}	0.68^{c}	0.73^{c}	0.54^{c}	0.61^{c}
BGW	0.60^{c}	0.62^{c}	0.65^{c}	0.47^{c}	0.54^{c}	-	0.10	-0.13	0.33^{a}	0.36^{a}	0.30^{a}	0.17	-0.08	0.42^{b}	0.43^{b}	0.29^{a}	0.24	0.28^{a}
LOMA	0.21	0.34^{a}	0.32^{a}	0.21	0.24	0.19	-	0.23	0.52^{c}	0.65^{c}	0.51^{c}	0.58^{c}	0.57^{c}	0.59^{c}	0.46^{c}	0.51^{c}	0.43^{b}	0.50^{c}
NL	0.47^{c}	0.39^{b}	0.35^{a}	0.23	0.25	0.45^{b}	0.18	-	-0.01	0.39^{b}	0.42^{b}	0.47^{c}	0.59^{c}	0.34^{a}	0.36^{b}	0.39^{b}	0.31^{a}	0.39^{b}
BALt	0.60^{c}	0.72^{c}	0.72^{c}	0.49^{c}	0.58^{c}	0.42^{b}	0.08	0.23	-	0.65^{c}	0.47^{c}	0.44^{b}	0.37^{b}	0.59^{c}	0.43^{b}	0.64^{c}	0.46^{c}	0.46^{c}
DSLt	0.78	0.95	0.87	0.54^{c}	0.73^{c}	0.61^{c}	0.37^{b}	0.40^{b}	0.68^{c}	-	0.88	0.79	0.61^{c}	0.87	0.70^{c}	0.92	0.67^{c}	0.76^{c}
HL	0.75^{c}	0.88	0.79	0.50^{c}	0.71^{c}	0.47^{c}	0.39^{b}	0.52^{c}	0.59^{c}	0.90	-	0.81	0.62^{c}	0.79	0.73^{c}	0.90	0.72^{c}	0.78
HB	0.57^{c}	0.72^{c}	0.70^{c}	0.50^{c}	0.60^{c}	0.34^{a}	0.33^{a}	0.41^{b}	0.54^{c}	0.78	0.80	-	0.78	0.70^{c}	0.60^{c}	0.81	0.75^{c}	0.79
WRB	0.60^{c}	0.71^{c}	0.73^{c}	0.58^{c}	0.74^{c}	0.43^{b}	0.42^{b}	0.46^{c}	0.54^{c}	0.73^{c}	0.77	0.81	-	0.56^{c}	0.33^{a}	0.66^{c}	0.58^{c}	0.63^{c}
ThL	0.66^{c}	0.85	0.72^{c}	0.38^{b}	0.62^{c}	0.45^{c}	0.36^{a}	0.32^{a}	0.60^{c}	0.84	0.79	0.67^{c}	0.65^{c}	-	0.74^{c}	0.83	0.65^{c}	0.74^{c}
LL	0.73^{c}	0.90	0.80	0.45^{c}	0.63^{c}	0.56^{c}	0.37^{b}	0.46^{c}	0.70^{c}	0.91	0.84	0.76^{c}	0.74^{c}	0.80	-	0.68^{c}	0.58^{c}	0.64^{c}
FL	0.73^{c}	0.86	0.79	0.50^{c}	0.73^{c}	0.51^{c}	0.31^{a}	0.37^{b}	0.62^{c}	0.87	0.90	0.76^{c}	0.75^{c}	0.80	0.85	-	0.74^{c}	0.81
FB	0.64^{c}	0.77	0.75^{c}	0.52^{c}	0.61^{c}	0.37^{b}	0.36^{a}	0.42^{b}	0.57^{c}	0.79	0.80	0.85	0.82	0.74^{c}	0.78	0.79	-	0.96
AKB	0.62^{c}	0.77	0.76^{c}	0.55^{c}	0.64^{c}	0.41^{b}	0.30^{a}	0.39^{b}	0.60^{c}	0.78	0.78	0.86	0.80	0.73^{c}	0.79	0.79	0.95	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; B = Boys; G = Girls; SSZ = Northern Senatorial Zone

Table 4.39: Correlation matrix of anthropometric parameters of SSZ adolescent subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.53[c]	0.52[c]	0.29[b]	0.36[c]	0.30[b]	0.43[c]	0.21[a]	0.33[c]	0.43[c]	0.40[c]	0.28[b]	0.20	0.30[b]	0.31[b]	0.23[a]	0.25[a]	0.23[a]
HT		-	0.68	0.15	0.62	0.42[c]	0.37[c]	0.17	0.48[c]	0.72	0.63	0.28[b]	0.17	0.57[c]	0.64	0.56[c]	0.41[c]	0.43[c]
WT			-	0.83	0.57[c]	0.48[c]	0.45[c]	0.05	0.46[c]	0.64	0.56[c]	0.18	0.10	0.58[c]	0.50[c]	0.36[c]	0.35[c]	0.38[c]
BMI				-	0.30[b]	0.32[b]	0.32[b]	-0.09	0.26[b]	0.30[b]	0.26[b]	0.02	-0.01	0.35[c]	0.16	0.07	0.15	0.18
SHt					-	0.24[a]	0.29[b]	0.06	0.34[c]	0.54[c]	0.46[c]	0.17	0.08	0.50[c]	0.40[c]	0.38[c]	0.33[c]	0.38[c]
BGW						-	0.05	0.17	0.27[b]	0.35[c]	0.42[c]	0.33[c]	0.22[a]	0.20	0.29[b]	0.40[c]	0.40[c]	0.36[c]
LOMA							-	-0.02	0.48[c]	0.37[c]	0.37[c]	0.16	0.30[b]	0.31[b]	0.39[c]	0.30[b]	0.28[b]	0.35[c]
NL								-	0.13	0.13	0.16	0.33[c]	0.32[b]	-0.01	0.17	0.17	0.14	0.21
BALt									-	0.48[c]	0.45[c]	0.32[b]	0.38[c]	0.41[c]	0.40[c]	0.49[c]	0.48[c]	0.53[c]
DSLt										-	0.66	0.24[a]	0.20	0.64	0.71	0.43[c]	0.32[b]	0.36[c]
HL											-	0.52[c]	0.43[c]	0.47[c]	0.58[c]	0.50[c]	0.53[c]	0.54[c]
HB												-	0.69	0.22[a]	0.31[b]	0.33[c]	0.55[c]	0.52[c]
WRB													-	0.18	0.31[b]	0.28[b]	0.40[c]	0.39[c]
ThL														-	0.57[c]	0.40[c]	0.34[c]	0.41[c]
LL															-	0.53[c]	0.35[c]	0.37[c]
FL																-	0.39[c]	0.44[c]
FB																	-	0.91
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; SSZ = Southern Senatorial Zone

Table 4.40: Correlation matrix of anthropometric parameters of SSZ adolescent males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.60^{c}	0.63^{c}	0.32^{a}	0.39^{b}	0.46^{c}	0.56^{c}	0.43^{b}	0.40^{b}	0.47^{c}	0.60^{c}	0.45^{c}	0.34^{a}	0.36^{a}	0.38^{b}	0.46^{c}	0.32^{a}	0.35^{a}
HT	0.47^{c}	-	0.76^{c}	0.13	0.62^{c}	0.49^{c}	0.44^{b}	0.26	0.51^{c}	0.72^{c}	0.69^{c}	0.44^{b}	0.29^{a}	0.59^{c}	0.63^{c}	0.64^{c}	0.42^{b}	0.46^{c}
WT	0.48^{c}	0.65^{c}	-	0.74^{c}	0.61^{c}	0.67^{c}	0.48^{c}	0.29^{a}	0.56^{c}	0.75^{c}	0.79	0.49^{c}	0.33^{a}	0.60^{c}	0.66^{c}	0.52^{c}	0.44^{b}	0.50^{c}
BMI	0.33^{a}	0.19	0.87	-	0.28^{a}	0.54^{c}	0.29^{a}	0.15	0.35^{a}	0.38^{b}	0.47^{c}	0.27	0.16	0.30^{a}	0.34^{a}	0.16	0.27	0.32^{a}
SHt	0.37^{b}	0.68^{c}	0.46^{c}	0.17	-	0.39^{b}	0.34^{a}	0.24	0.43	0.55	0.62	0.40	0.23	0.40^{b}	0.49^{c}	0.61^{c}	0.42^{b}	0.47^{c}
BGW	0.13	0.38^{b}	0.51^{c}	0.41^{b}	0.24	-	0.30^{a}	0.13	0.31^{a}	0.40^{b}	0.48^{c}	0.27	0.10	0.33^{a}	0.33^{a}	0.44^{b}	0.36^{a}	0.38^{b}
LOMA	0.36^{b}	0.34^{a}	0.35^{a}	0.22	0.18	-0.05	-	0.30^{a}	0.46^{c}	0.39^{b}	0.61^{c}	0.51^{c}	0.51^{c}	0.33^{a}	0.45^{c}	0.38^{b}	0.45^{b}	0.49^{c}
NL	0.01	0.16	0.13	0.08	0.15	0.02	-0.07	-	0.25	0.42^{b}	0.29^{a}	0.21	0.32^{a}	0.29^{a}	0.33^{a}	0.27	0.12	0.23
BALt	0.26	0.44^{b}	0.38^{b}	0.22	0.26	0.24	0.54^{c}	0.04	-	0.48^{c}	0.52^{c}	0.39^{b}	0.40^{b}	0.42^{b}	0.48^{c}	0.63^{c}	0.55^{c}	0.63^{c}
DSLt	0.41^{b}	0.73^{c}	0.47^{c}	0.14	0.50^{c}	0.43^{b}	0.31^{a}	-0.05	0.50^{c}	-	0.74^{c}	0.39^{b}	0.28^{a}	0.62^{c}	0.76^{c}	0.45^{b}	0.28^{a}	0.35^{a}
HL	0.18	0.55^{c}	0.43^{b}	0.20	0.37^{b}	0.33^{a}	0.22	-0.03	0.36^{a}	0.62^{c}	-	0.63^{c}	0.47^{c}	0.62^{c}	0.67^{c}	0.60^{c}	0.57^{c}	0.61^{c}
HB	0.07	0.03	0.09	0.11	0.13	0.30^{a}	0.02	0.23	0.28	0.18	0.36^{b}	-	0.67^{c}	0.57^{c}	0.45^{c}	0.47^{c}	0.62^{c}	0.60^{c}
WRB	0.01	-0.03	0.01	0.03	0.04	0.30^{a}	0.28^{a}	0.15	0.40^{b}	0.18	0.35^{a}	0.66^{c}	-	0.46^{c}	0.44^{b}	0.34^{a}	0.49^{c}	0.48^{c}
ThL	0.34^{a}	0.67^{c}	0.42^{b}	0.11	0.53^{c}	0.39^{b}	0.13	0.15	0.51^{c}	0.68^{c}	0.49^{c}	0.21	0.07	-	0.76^{c}	0.51^{c}	0.42^{b}	0.50^{c}
LL	0.22	0.68^{c}	0.37^{b}	0.01	0.31^{a}	0.26	0.38^{b}	-0.00	0.28^{a}	0.62^{c}	0.46^{c}	0.05	0.10	0.36^{b}	-	0.58^{c}	0.34^{a}	0.39^{b}
FL	-0.06	0.42^{b}	0.24	0.03	0.13	0.34^{a}	0.27	0.04	0.28^{a}	0.42^{b}	0.35^{a}	0.07	0.18	0.39^{b}	0.42^{b}	-	0.60^{c}	0.65^{c}
FB	0.19	0.46^{c}	0.41^{b}	0.23	0.36^{b}	0.41^{b}	0.25	0.04	0.41^{b}	0.49^{c}	0.47^{c}	0.45^{b}	0.25	0.57^{c}	0.39^{b}	0.13	-	0.93
AKB	0.13	0.45^{c}	0.39^{b}	0.20	0.39^{b}	0.31^{a}	0.32^{a}	0.13	0.43^{b}	0.47^{c}	0.46^{c}	0.45^{b}	0.25	0.56^{c}	0.37^{b}	0.20	0.89	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Males; F = Females; SSZ = Southern Senatorial Zone

Table 4.41: Correlation matrix of anthropometric parameters of CSZ adolescent subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.60	0.70	0.46^{c}	0.49^{c}	0.26^{b}	0.37^{c}	0.13	0.37^{c}	0.66	0.48^{c}	0.53^{c}	0.41^{c}	0.55^{c}	0.47^{c}	0.32^{b}	0.42^{c}	0.40^{c}
HT		-	0.73	0.13	0.76	0.07	0.34^{c}	0.33^{c}	0.40^{c}	0.88	0.74	0.58^{c}	0.60	0.64	0.69	0.62	0.50^{c}	0.48^{c}
WT			-	0.76	0.69	0.26^{a}	0.46^{c}	0.27^{b}	0.56^{c}	0.76	0.59^{c}	0.54^{c}	0.55^{c}	0.64	0.52^{c}	0.51^{c}	0.47^{c}	0.48^{c}
BMI				-	0.30^{b}	0.31^{b}	0.36^{c}	0.07	0.44^{c}	0.27^{b}	0.16	0.24^{a}	0.25^{a}	0.35^{c}	0.13	0.18	0.22^{a}	0.24^{a}
SHt					-	0.09	0.29^{b}	0.34^{c}	0.40^{c}	0.72	0.62	0.50^{c}	0.56^{c}	0.56^{c}	0.53^{c}	0.53^{c}	0.36^{c}	0.37^{c}
BGW						-	0.23^{a}	-0.04	0.00	0.11	0.09	0.10	0.14	0.16	0.05	0.01	0.13	0.13
LOMA							-	0.33^{c}	0.37^{c}	0.32^{b}	0.30^{b}	0.28^{b}	0.32^{b}	0.33^{c}	0.27^{b}	0.28^{b}	0.19	0.25^{a}
NL								-	0.16	0.37^{c}	0.27^{b}	0.27^{b}	0.28^{b}	0.17	0.34^{c}	0.31^{b}	0.19	0.15
BALt									-	0.43^{c}	0.35^{c}	0.37^{c}	0.39^{c}	0.28^{b}	0.29^{b}	0.26^{b}	0.31^{b}	0.36^{c}
DSLt										-	0.82	0.64	0.62	0.61	0.72	0.71	0.61	0.56^{c}
HL											-	0.55^{c}	0.60	0.41^{c}	0.58^{c}	0.70	0.65	0.62
HB												-	0.58^{c}	0.26^{b}	0.39^{c}	0.52^{c}	0.59	0.59^{c}
WRB													-	0.42^{c}	0.50^{c}	0.52^{c}	0.58^{c}	0.59^{c}
ThL														-	0.56^{c}	0.34^{c}	0.16	0.15
LL															-	0.54^{c}	0.43^{c}	0.34^{c}
FL																-	0.60	0.53^{c}
FB																	-	0.91
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; CSZ = Central Senatorial Zone

Table 4.42: Correlation matrix of anthropometric parameters of CSZ adolescent males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.70^{c}	0.73^{c}	0.45^{c}	0.63^{c}	0.07	0.50^{c}	0.14	0.56^{c}	0.79	0.63^{c}	0.53^{c}	0.54^{c}	0.62^{c}	0.64^{c}	0.55^{c}	0.47^{c}	0.42^{b}
HT	0.49^{c}	-	0.84	0.27	0.76^{c}	0.00	0.57^{c}	0.23	0.58^{c}	0.89	0.75^{c}	0.60^{c}	0.70^{c}	0.76^{c}	0.71^{c}	0.73^{c}	0.53^{c}	0.50^{c}
WT	0.70^{c}	0.60^{c}	-	0.74^{c}	0.77	0.13	0.64^{c}	0.32^{a}	0.65^{c}	0.89	0.78	0.66^{c}	0.69^{c}	0.70^{c}	0.56^{c}	0.79	0.68^{c}	0.66^{c}
BMI	0.54^{c}	0.08	0.84	-	0.47^{c}	0.24	0.44^{b}	0.29^{a}	0.46^{c}	0.51^{c}	0.49^{c}	0.45^{b}	0.40^{b}	0.34^{a}	0.17	0.55^{c}	0.57^{c}	0.56^{c}
SHt	0.35^{a}	0.78	0.56^{c}	0.18	-	0.03	0.45^{b}	0.29^{a}	0.58^{c}	0.81	0.68^{c}	0.56^{c}	0.61^{c}	0.66^{c}	0.65^{c}	0.75^{c}	0.44^{b}	0.41^{b}
BGW	0.42^{b}	0.16	0.40^{b}	0.39^{b}	0.18	-	0.24	-0.23	-0.01	0.04	0.13	-0.03	0.10	0.06	-0.04	0.03	0.08	0.09
LOMA	0.30^{a}	0.15	0.29^{a}	0.28^{a}	0.13	0.22	-	0.33^{a}	0.57^{c}	0.65^{c}	0.63^{c}	0.56^{c}	0.48^{c}	0.29^{a}	0.41^{b}	0.57^{c}	0.52^{c}	0.54^{c}
NL	0.08	0.42^{b}	0.25	0.02	0.41^{b}	0.10	0.39^{b}	-	0.37^{b}	0.33^{a}	0.12	0.36^{b}	0.33^{a}	0.10	0.30^{a}	0.27	0.25	0.27
BALt	0.24	0.24	0.46^{c}	0.42^{b}	0.20	0.01	0.20	0.05	-	0.70^{c}	0.64^{c}	0.58^{c}	0.64^{c}	0.42^{b}	0.38^{b}	0.57^{c}	0.62^{c}	0.62^{c}
DSLt	0.53^{c}	0.85	0.63^{c}	0.21	0.56^{c}	0.21	0.04	0.36^{a}	0.21	-	0.86	0.67^{c}	0.72^{c}	0.74^{c}	0.75^{c}	0.82	0.66^{c}	0.63^{c}
HL	0.29^{a}	0.68^{c}	0.35^{a}	-0.03	0.53^{c}	0.04	0.01	0.39^{b}	0.08	0.71^{c}	-	0.56^{c}	0.66^{c}	0.65^{c}	0.57^{c}	0.78	0.67^{c}	0.67^{c}
HB	0.51^{c}	0.49^{c}	0.46^{c}	0.25	0.42^{b}	0.25	0.11	0.06	0.26	0.49^{c}	0.40^{b}	-	0.56^{c}	0.41^{b}	0.53^{c}	0.65^{c}	0.62^{c}	0.65^{c}
WRB	0.27	0.42^{b}	0.44^{b}	0.28^{a}	0.50^{c}	0.20	0.26	0.14	0.22	0.40^{b}	0.41^{b}	0.52^{c}	-	0.61^{c}	0.61^{c}	0.68^{c}	0.66^{c}	0.65^{c}
ThL	0.60^{c}	0.69^{c}	0.61^{c}	0.29^{a}	0.50^{c}	0.28^{a}	0.34^{a}	0.37^{b}	0.11	0.72^{c}	0.38^{b}	0.34^{a}	0.43^{b}	-	0.71^{c}	0.64^{c}	0.42^{b}	0.38^{b}
LL	0.29^{a}	0.66^{c}	0.49^{c}	0.18	0.36^{a}	0.13	0.19	0.34^{a}	0.24	0.69^{c}	0.59^{c}	0.16	0.33^{a}	0.53^{c}	-	0.63^{c}	0.41^{b}	0.35^{a}
FL	-0.02	0.33^{a}	0.20	0.04	0.13	-0.03	0.11	0.22	0.01	0.41^{b}	0.36^{b}	0.08	0.12	0.27	0.42^{b}	-	0.66^{c}	0.65^{c}
FB	0.37^{b}	0.38^{b}	0.38^{b}	0.23	0.29^{a}	0.20	0.02	-0.06	0.19	0.44^{b}	0.47^{c}	0.39^{b}	0.37^{b}	0.24	0.42^{b}	0.25	-	0.98
AKB	0.35^{a}	0.38^{b}	0.36^{b}	0.21	0.35^{a}	0.18	0.11	-0.14	0.24	0.33^{a}	0.40^{b}	0.36^{a}	0.40^{b}	0.18	0.27	0.11	0.78	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; CSZ = Central Senatorial Zone

Table 4.43: Correlation matrix of anthropometric parameters of NSZ adolescent subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.63	0.55^{c}	0.17	0.58^{c}	0.32^{b}	0.22^{a}	0.13	0.43^{c}	0.56^{c}	0.51^{c}	0.45^{c}	0.29^{b}	0.46^{c}	0.51^{c}	0.32^{b}	0.36^{c}	0.34^{c}
HT		-	0.66	0.01	0.82	0.32^{b}	0.39^{c}	0.41^{c}	0.57^{c}	0.88	0.80	0.69	0.49^{c}	0.70	0.64	0.62	0.52^{c}	0.55^{c}
WT			-	0.75	0.66	0.48^{c}	0.46^{c}	0.15	0.64	0.66	0.55^{c}	0.51^{c}	0.45^{c}	0.48^{c}	0.42^{c}	0.46^{c}	0.53^{c}	0.55^{c}
BMI				-	0.15	0.33^{c}	0.28^{b}	-0.15	0.34^{c}	0.10	0.04	0.07	0.19	0.03	-0.01	0.05	0.24^{a}	0.23^{a}
SHt					-	0.33^{c}	0.41^{c}	0.26^{b}	0.53^{c}	0.80	0.70	0.61	0.40^{c}	0.59	0.62	0.50^{c}	0.38^{c}	0.39^{c}
BGW						-	0.23^{a}	0.11	0.35^{c}	0.29^{b}	0.31^{b}	0.29^{b}	0.13	0.07	0.16	0.29^{b}	0.30^{b}	0.33^{c}
LOMA							-	0.08	0.32^{b}	0.41^{c}	0.28^{b}	0.30^{b}	0.32^{b}	0.38^{c}	0.24^{a}	0.37^{c}	0.36^{c}	0.30^{b}
NL								-	0.16	0.39^{c}	0.38^{c}	0.47^{c}	0.44^{c}	0.21^{a}	0.28^{b}	0.33^{c}	0.28^{b}	0.27^{b}
BALt									-	0.57^{c}	0.45^{c}	0.46^{c}	0.45^{c}	0.41^{c}	0.36^{c}	0.40^{c}	0.48^{c}	0.53^{c}
DSLt										-	0.78	0.59	0.45^{c}	0.68	0.64	0.67	0.53^{c}	0.56^{c}
HL											-	0.71	0.43^{c}	0.56^{c}	0.61	0.71	0.52^{c}	0.56^{c}
HB												-	0.59	0.36^{b}	0.48^{c}	0.48^{c}	0.53^{c}	0.58^{c}
WRB													-	0.37^{c}	0.40^{c}	0.39^{c}	0.49^{c}	0.51^{c}
ThL														-	0.59	0.41^{c}	0.35^{c}	0.35^{c}
LL															-	0.45^{c}	0.41^{c}	0.36^{c}
FL																-	0.59^{c}	0.62
FB																	-	0.93
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; NSZ = Northern Senatorial Zone

Table 4.44: Correlation matrix of anthropometric parameters of NSZ adolescent males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.78	0.70^{c}	0.15	0.74^{c}	0.47^{c}	0.43^{b}	0.39^{b}	0.49^{c}	0.74^{c}	0.69^{c}	0.63^{c}	0.36^{a}	0.66^{c}	0.62^{c}	0.52^{c}	0.50^{c}	0.45^{c}
HT	0.42^{b}	-	0.77	0.02	0.91	0.54^{c}	0.56^{c}	0.51^{c}	0.69^{c}	0.95	0.88	0.81	0.59^{c}	0.82	0.68^{c}	0.76^{c}	0.65^{c}	0.68^{c}
WT	0.36^{a}	0.46^{c}	-	0.64^{c}	0.72^{c}	0.62^{c}	0.53^{c}	0.31^{a}	0.65^{c}	0.80	0.72^{c}	0.60^{c}	0.53^{c}	0.60^{c}	0.42^{b}	0.63^{c}	0.60^{c}	0.62^{c}
BMI	0.18	-0.02	0.88	-	0.03	0.30^{a}	0.16	-0.09	0.17	0.11	0.07	-0.04	0.14	-0.03	-0.16	0.07	0.15	0.13
SHt	0.35^{a}	0.59^{c}	0.53^{c}	0.26	-	0.54^{c}	0.56^{c}	0.43^{b}	0.60^{c}	0.87	0.81	0.79	0.52^{c}	0.71^{c}	0.62^{c}	0.66^{c}	0.57^{c}	0.57^{c}
BGW	0.18	-0.02	0.33^{a}	0.39^{b}	0.08	-	0.31^{a}	0.28^{a}	0.61^{c}	0.51^{c}	0.54^{c}	0.52^{c}	0.33^{a}	0.41^{b}	0.32^{a}	0.43^{b}	0.51^{c}	0.56^{c}
LOMA	0.07	0.25	0.40^{b}	0.32^{a}	0.26	0.21	-	0.45^{b}	0.35^{a}	0.59^{c}	0.44^{b}	0.46^{c}	0.44^{b}	0.49^{c}	0.35^{a}	0.54^{c}	0.42^{b}	0.34^{a}
NL	-0.09	0.39^{b}	0.07	-0.14	0.25	-0.10	-0.09	-	0.29^{a}	0.48^{c}	0.50^{c}	0.56^{c}	0.67^{c}	0.42^{b}	0.38^{b}	0.39^{b}	0.30^{a}	0.28
BALt	0.35^{a}	0.29^{a}	0.60^{c}	0.51^{c}	0.33^{a}	0.05	0.28^{a}	0.14	-	0.69^{c}	0.63^{c}	0.62^{c}	0.53^{c}	0.52^{c}	0.36^{a}	0.57^{c}	0.62^{c}	0.69^{c}
DSLt	0.29^{a}	0.67^{c}	0.40^{b}	0.07	0.64^{c}	-0.07	0.28	0.37^{b}	0.27	-	0.86	0.78	0.58^{c}	0.77	0.66^{c}	0.74^{c}	0.61^{c}	0.65^{c}
HL	0.26	0.55^{c}	0.25	-0.02	0.47^{c}	-0.07	0.17	0.22	0.08	0.50^{c}	-	0.78	0.60^{c}	0.73^{c}	0.64^{c}	0.80	0.65^{c}	0.71^{c}
HB	0.31^{a}	0.56^{c}	0.51^{c}	0.28^{a}	0.53^{c}	-0.00	0.27	0.28^{a}	0.33^{a}	0.30^{a}	0.65^{c}	-	0.64^{c}	0.63^{c}	0.49^{c}	0.63^{c}	0.58^{c}	0.66^{c}
WRB	0.22	0.36^{a}	0.39^{b}	0.25	0.27	-0.07	0.26	0.22	0.37^{b}	0.26	0.15	0.56^{c}	-	0.44^{b}	0.41^{b}	0.56^{c}	0.57^{c}	0.63^{c}
ThL	0.27	0.62^{c}	0.27	-0.03	0.33^{a}	-0.24	0.26	0.33^{a}	0.19	0.65^{c}	0.43^{b}	0.34^{a}	0.38^{b}	-	0.74^{c}	0.63^{c}	0.50^{c}	0.53^{c}
LL	0.36^{a}	0.48^{c}	0.41^{b}	0.19	0.61^{c}	-0.11	0.13	0.26	0.33^{a}	0.56^{c}	0.53^{c}	0.62^{c}	0.44^{b}	0.38^{b}	-	0.52^{c}	0.52^{c}	0.44^{b}
FL	0.04	0.28^{a}	0.21	0.09	0.20	0.09	0.30^{a}	0.19	0.12	0.50^{c}	0.49^{c}	0.18	0.13	0.29^{a}	0.31^{a}	-	0.66^{c}	0.72^{c}
FB	0.26	0.37^{b}	0.59^{c}	0.47^{c}	0.26	0.04	0.46^{c}	0.13	0.43^{b}	0.48^{c}	0.28^{a}	0.38^{b}	0.40^{b}	0.51^{c}	0.30^{a}	0.41^{b}	-	0.92
AKB	0.27	0.40^{b}	0.63^{c}	0.49^{c}	0.29^{a}	0.00	0.43^{b}	0.11	0.44^{b}	0.48^{c}	0.28^{a}	0.39^{b}	0.38^{b}	0.49^{c}	0.32^{a}	0.38^{b}	0.94	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; NSZ = Northern Senatorial Zone

Table 4.45 – 4.50 shows the correlation matrix of the entire young adults age group in the studied population and their anthropometric characteristics. In the SSZ, ThL showed the strongest and significant correlation with stature (r = 0.59), followed by AKB (r = 0.54). While LOMA showed a moderate and significant correlation with stature (r = 0.29). However, BMI showed a weak, significant and inverse correlation with stature (r = -0.25). In males, WT showed the strongest correlation with stature (r = 0.67), followed by ThL (r = 0.54), while FL, NL and HL showed weak correlations (r = 0.38, r = 0.39 and r = 0.39), respectively. In females, LL showed the strongest and significant correlation with stature (r = 0.68), followed by HL and SHt (r = 0.67 and r = 0.66), respectively, while HB showed a weak correlation (r = 0.32), (Table 4.45-4.46).

In the CSZ, WT showed the strongest and significant correlation with stature (r = 0.57), followed by FB (r = 0.56). While BALt showed a weak and significant correlation with stature (r = 0.25). In males, DSLt showed the strongest correlation with stature (r = 0.66), while WRB and LL showed weak correlation with stature (r = 0.29 and r = 0.29) respectively. In females, DSLt also showed the strongest correlation with stature (r = 0.68), while HB and AKB showed a weak correlation with stature (r = 0.29 and r = 0.29) respectively (Table 4.47-4.48).

In the NSZ, FB showed the strongest and significant correlation with stature (r = 0.58), followed by WT and ThL (r = 0.56 and r = 0.55), respectively, while BALT showed a moderate and significant correlation with stature (r = 0.31). However, BMI showed a weak, significant and inverse correlation with stature (r = -0.21). In males, HL showed

the strongest correlation with stature (r = 0.71) followed by WT (r = 0.69), while FL showed a weak correlation with stature (r = 0.30). In females, FL showed the strongest correlation with stature (r = 0.71), while AKB showed a weak correlation with stature (r = 0.33), (Table 4.49-4.50).

Table 4.51 – 4.56 shows the correlation matrix of the entire adults age group in the studied population and their anthropometric characteristics. In the SSZ, BMI showed the strongest, significant and inverse correlation with stature (r = -0.56), followed by DSLt which showed a strong, significant and linear correlation with stature (r = 0.52). While HL, FB and AKB showed moderate and significant correlation with stature (r = 0.27, r = 0.27 and r = 0.27), respectively. (Table 4.51). In males, BMI showed the strongest and inverse correlation with stature (r = -0.71), while WT showed a weak correlation (r = 0.39). In females, LL showed the strongest correlation with stature (r = 0.62), while FL and BALt showed weak correlation with stature (r = 0.30 and r = 0.31), respectively (Table 4.52).

In the CSZ, HB showed the strongest and significant correlation with stature (r = 0.53), followed by AKB (r = 0.50). While, BMI showed a strong, significant and inverse correlation with stature (r = -0.39). However, LOMA showed a moderate and significant correlation with stature (r = 0.27), (Table 4.53). In males, DSLt showed the strongest correlation with stature (r = 0.68), while ThL showed a weak correlation (r = 0.34). In females, DSLt also showed the strongest correlation with stature (r = 0.66), while ThL

and LL showed weak correlation with stature (r = 0.31 and r = 0.31), respectively (Table 4.54).

In the NSZ, ThL showed the strongest and significant correlation with stature (r = 0.59), followed by FB and AKB (r = 0.56 and r = 0.54), respectively. While BMI showed a weak, significant and inverse correlation with stature (r = -0.21), (Table 4.55). In males, ThL showed the strongest and significant correlation with stature (r = 0.74), followed by SHt (r = 0.73), while HB showed a weak and significant correlation with stature (r = 0.30). In females, FL showed the strongest and significant correlation with stature (r = 0.68), followed by LL (r = 0.65), while HB showed a weak and significant correlation with stature (r = 0.33), (Table 4.56).

Table 4.45: Correlation matrix of anthropometric parameters of SSZ young adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.02	0.09	0.11	0.11	0.13	0.13	0.05	0.03	-0.01	-0.12	0.05	0.09	-0.10	-0.07	-0.12	-0.03	-0.02
HT		-	0.49[c]	-0.25[a]	0.49[c]	0.46[c]	0.29[b]	0.61	0.09	0.84	0.70	0.60	0.47[c]	0.46[c]	0.68	0.59[c]	0.51[c]	0.54[c]
WT			-	0.72	0.41[c]	0.45[c]	0.30[b]	0.20[a]	0.29[b]	0.51[c]	0.46[c]	0.35[c]	0.35[c]	0.36[c]	0.41[c]	0.36[c]	0.43[c]	0.39[c]
BMI				-	0.05	0.13	0.11	-0.26[b]	0.25[a]	-0.09	-0.05	-0.09	0.01	0.03	-0.08	-0.07	0.07	0.01
SHt					-	0.27[b]	0.23[a]	0.23[a]	-0.06	0.44[c]	0.34[c]	0.33[c]	0.24[a]	0.34[c]	0.31[b]	0.28[b]	0.18	0.16
BGW						-	0.16	0.39[c]	0.14	0.46[c]	0.49[c]	0.46[c]	0.32[b]	0.19	0.35[c]	0.41[c]	0.43[c]	0.46[c]
LOMA							-	0.01	0.14	0.30[b]	0.13	-0.02	0.13	0.24[a]	0.29[b]	0.14	0.23[a]	0.22[a]
NL								-	0.08	0.50[c]	0.52[c]	0.67	0.47[c]	0.15	0.35[c]	0.46[c]	0.46[c]	0.50[c]
BALt									-	0.22[a]	0.23[a]	0.30[b]	0.39[c]	0.12	0.16	0.20[a]	0.30[b]	0.32[b]
DSLt										-	0.67	0.56[c]	0.47[c]	0.38[c]	0.64	0.54[c]	0.51[c]	0.54[c]
HL											-	0.70	0.65	0.36[c]	0.61	0.80	0.62	0.62
HB												-	0.73	0.20	0.44[c]	0.53[c]	0.51[c]	0.52[c]
WRB													-	0.21[a]	0.43[c]	0.53[c]	0.46[c]	0.48[c]
ThL														-	0.53[c]	0.28[b]	0.26[a]	0.28[b]
LL															-	0.52[c]	0.39[c]	0.41[c]
FL																-	0.61	0.59[c]
FB																	-	0.94
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; SSZ = Southern Senatorial Zone

Table 4.46: Correlation matrix of anthropometric parameters of SSZ young adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.03	0.01	-0.02	0.30[a]	0.10	0.12	-0.08	-0.25	-0.04	-0.26	0.00	-0.11	-0.00	-0.14	-0.34[a]	-0.28[a]	-0.23
HT	-0.36[a]	-	0.67[c]	0.02	0.41[b]	0.14	0.41[b]	0.39[b]	-0.01	0.80	0.39[b]	0.21	0.16	0.54[c]	0.52[c]	0.38[b]	0.18	0.21
WT	0.08	0.21	-	0.75[c]	0.51[c]	0.34[a]	0.41[b]	0.19	0.04	0.63[c]	0.34[a]	0.15	0.15	0.50[c]	0.44[b]	0.33[a]	0.27	0.27
BMI	0.23	-0.23	0.90	-	0.31[a]	0.34[a]	0.19	-0.10	0.05	0.15	0.12	0.02	0.04	0.21	0.14	0.11	0.21	0.19
SHt	-0.24	0.66[c]	0.28	-0.03	-	0.14	0.30[a]	0.17	-0.17	0.41[b]	0.10	0.26	0.20	0.33[a]	0.16	0.14	0.04	0.02
BGW	0.06	0.24	0.39[b]	0.28[a]	0.33[a]	-	0.20	-0.03	-0.01	0.13	0.19	0.12	0.01	0.29	0.16	0.23	0.18	0.19
LOMA	0.13	0.24	0.21	0.11	0.07	0.09	-	0.15	-0.05	0.43[b]	-0.08	-0.19	-0.15	0.20	0.28[a]	-0.01	0.17	0.20
NL	-0.03	0.20	-0.09	-0.17	0.10	0.19	-0.22	-	0.05	0.18	0.37[b]	0.45[b]	0.41[b]	0.08	0.09	0.37[b]	0.15	0.18
BALt	0.28[a]	0.17	0.48[c]	0.40[b]	0.09	0.26	0.35[a]	0.07	-	0.15	0.23	0.27	0.39[b]	0.01	0.11	0.20	0.22	0.22
DSLt	-0.20	0.64[c]	0.31[a]	0.03	0.44[b]	0.33[a]	0.22	0.10	0.35[a]	-	0.34[a]	0.09	0.12	0.60[c]	0.54[c]	0.28	0.23	0.25
HL	-0.24	0.67[c]	0.42[b]	0.12	0.64[c]	0.41[b]	0.38[b]	0.06	0.26	0.65[c]	-	0.56[c]	0.62[c]	0.46[c]	0.45[c]	0.72[c]	0.47[c]	0.47[c]
HB	-0.12	0.32[a]	0.29[a]	0.15	0.29[a]	0.31[a]	0.03	0.37[b]	0.48[c]	0.42[b]	0.40[b]	-	0.72[c]	0.10	0.15	0.39[b]	0.18	0.18
WRB	0.20	0.16	0.35[a]	0.28	0.06	0.17	0.52[c]	-0.09	0.50[c]	0.31[a]	0.23	0.32[a]	-	0.19	0.21	0.43[b]	0.29	0.30[a]
ThL	-0.25	0.56[c]	0.23	-0.03	0.35[a]	0.02	0.29[a]	0.16	0.24	0.17	0.26	0.34[a]	0.21	-	0.68[c]	0.44[b]	0.27	0.27
LL	-0.18	0.68[c]	0.24	-0.05	0.49[c]	0.18	0.30[a]	0.06	0.22	0.51[c]	0.51[c]	0.30[a]	0.31[a]	0.32[a]	-	0.36[a]	0.17	0.18
FL	-0.06	0.45[c]	0.21	0.02	0.37[b]	0.23	0.31[a]	0.09	0.20	0.45[b]	0.73[c]	0.19	0.24	0.02	0.44[b]	-	0.61[c]	0.59[c]
FB	0.07	0.40[b]	0.42[b]	0.25	0.20	0.32[a]	0.29[a]	0.26	0.41[b]	0.38[b]	0.48[c]	0.43[b]	0.22	0.21	0.29[a]	0.32[a]	-	0.98
AKB	0.05	0.42[b]	0.33[a]	0.14	0.16	0.39[b]	0.25	0.31[a]	0.47[c]	0.44[b]	0.44[b]	0.43[b]	0.26	0.27	0.31[a]	0.26	0.85	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; SSZ = Southern Senatorial Zone

Table 4.47: Correlation matrix of anthropometric parameters of CSZ young adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.04	0.21[a]	0.30[b]	-0.00	0.05	0.20[a]	-0.07	0.08	-0.07	0.04	0.20	0.19	-0.28[b]	-0.19	-0.13	0.06	0.03
HT		-	0.57[c]	-0.18	0.62	0.28	0.47[c]	0.35[c]	0.25[a]	0.79	0.70	0.60	0.48[c]	0.41[c]	0.47[c]	0.59	0.56[c]	0.51[c]
WT			-	0.70	0.45[c]	0.27[b]	0.38[c]	0.12	0.40[c]	0.54[c]	0.53[c]	0.58[c]	0.52[c]	0.16	0.20[a]	0.42[c]	0.49[c]	0.50[c]
BMI				-	0.01	0.07	0.05	-0.19	0.27[b]	-0.06	0.02	0.17	0.22[a]	-0.19	-0.18	-0.03	0.09	0.15
SHt					-	0.31[b]	0.30[b]	0.07	0.21[a]	0.50[c]	0.57[c]	0.42[c]	0.39[c]	0.33[c]	0.28[b]	0.40[c]	0.38[c]	0.39[c]
BGW						-	0.34[c]	-0.00	0.23[a]	0.31[b]	0.35[c]	0.24[a]	0.13	-0.02	0.09	0.29[b]	0.36[c]	0.31[b]
LOMA							-	0.29[b]	0.16	0.41[c]	0.42[c]	0.47[c]	0.46[c]	0.12	0.27	0.22	0.43[c]	0.44[c]
NL								-	-0.06	0.31[b]	0.23[a]	0.31[b]	0.28[b]	0.20[a]	0.21[a]	0.34[c]	0.16	0.17
BALt									-	0.29[b]	0.29[b]	0.25[a]	0.08	-0.06	0.12	0.16	0.15	0.21[a]
DSLt										-	0.78	0.60	0.48[c]	0.38[c]	0.51[c]	0.60	0.57[c]	0.51[c]
HL											-	0.67	0.50[c]	0.30[b]	0.44[c]	0.53[c]	0.60	0.58[c]
HB												-	0.69	0.18	0.28[b]	0.47[c]	0.69	0.69
WRB													-	0.25[a]	0.29[b]	0.36[c]	0.59[c]	0.63
ThL														-	0.36[c]	0.25[a]	0.18	0.23[a]
LL															-	0.40[c]	0.40[c]	0.30[b]
FL																-	0.48[c]	0.41[c]
FB																	-	0.87
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; CSZ = Central Senatorial Zone

Table 4.48: Correlation matrix of anthropometric parameters of CSZ young adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.14	0.19	0.34[a]	-0.09	-0.04	0.38[b]	0.06	0.03	-0.17	-0.06	0.24	0.11	-0.37[b]	-0.29[a]	-0.28	-0.17	-0.20
HT	-0.10	-	0.51c	-0.16	0.61[c]	0.14	0.38[b]	0.09	0.43[b]	0.66[c]	0.61[c]	0.40[b]	0.29[a]	0.49[c]	0.29[a]	0.33[a]	0.36[b]	0.31[a]
WT	0.20	0.46[c]	-	0.77	0.38[b]	0.25	0.23	0.14	0.47[c]	0.59[c]	0.50[c]	0.58[c]	0.37[b]	0.22	0.09	0.36[a]	0.39[b]	0.40[b]
BMI	0.30[a]	-0.11	0.83	-	-0.02	0.18	-0.01	0.09	0.22	0.18	0.12	0.37[b]	0.23	-0.12	-0.11	0.15	0.17	0.21
SHt	0.02	0.50[c]	0.37[b]	0.10	-	0.35[a]	0.38[b]	-0.09	0.38[b]	0.51[c]	0.46[c]	0.24	0.12	0.38[b]	0.20	0.26	0.21	0.20
BGW	0.13	0.04	0.06	0.05	0.06	-	0.26	-0.15	0.27	0.16	0.42[b]	0.11	-0.02	0.01	-0.05	0.18	0.34[a]	0.38[b]
LOMA	0.02	0.28	0.33[a]	0.20	0.06	0.24	-	0.00	0.27	0.15	0.35[a]	0.35[a]	0.21	0.04	-0.08	-0.16	0.28	0.20
NL	-0.26	0.23	-0.16	-0.34[a]	-0.05	-0.15	0.30[a]	-	-0.03	-0.00	-0.02	0.32[a]	0.30[a]	0.10	-0.10	0.03	-0.01	0.09
BALt	0.11	0.19	0.38[b]	0.31[a]	0.10	0.23	0.09	-0.12	-	0.47[c]	0.46[c]	0.36[a]	0.22	0.06	0.02	0.08	0.25	0.43[b]
DSLt	-0.16	0.68[c]	0.25	-0.16	0.29[a]	0.11	0.38[b]	0.26	0.24	-	0.76[c]	0.37[b]	0.20	0.44[b]	0.35[a]	0.35[a]	0.37[b]	0.34[a]
HL	0.05	0.54[c]	0.38[b]	0.07	0.52[c]	-0.10	0.23	0.12	0.21	0.60[c]	-	0.52[c]	0.28[a]	0.34[a]	0.25	0.25	0.45[c]	0.46[c]
HB	0.13	0.29[a]	0.41[b]	0.27	0.33[a]	-0.05	0.30[a]	-0.13	0.23	0.37[b]	0.55[c]	-	0.63[c]	0.20	0.16	0.20	0.46[c]	0.48[c]
WRB	0.23	0.24	0.48[c]	0.40[b]	0.39[b]	-0.08	0.43[b]	-0.03	-0.01	0.36[a]	0.39[b]	0.52[b]	-	0.28	0.34[a]	0.11	0.38[b]	0.41[b]
ThL	-0.22	0.49[c]	0.08	-0.22	0.28[a]	-0.14	0.15	0.27	-0.14	0.47[c]	0.28[a]	0.15	0.23	-	0.56[c]	0.34[a]	0.34[a]	0.25
LL	-0.14	0.59[c]	0.16	-0.20	0.23	0.13	0.47[c]	0.37[b]	0.20	0.68[c]	0.54[c]	0.15	0.07	0.17	-	0.17	0.41[b]	0.33[a]
FL	-0.13	0.49[c]	0.22	-0.08	0.32[a]	0.04	0.26	0.39[b]	0.27	0.53[c]	0.55[c]	0.24	0.17	0.17	0.58[c]	-	0.24	0.22
FB	0.21	0.26	0.35[a]	0.24	0.29[a]	-0.02	0.27	-0.16	0.08	0.29[a]	0.45[b]	0.61[c]	0.49[c]	0.02	0.20	0.24	-	0.86
AKB	0.15	0.29[a]	0.40[b]	0.27	0.34[a]	-0.12	0.39[b]	-0.13	0.09	0.26	0.42[b]	0.64[c]	0.58[c]	0.22	0.08	0.17	0.78	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; CSZ = Central Senatorial Zone

Table 4.49: Correlation matrix of anthropometric parameters of NSZ young adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.05	0.34^{c}	0.36^{c}	0.25^{a}	0.22^{a}	0.20^{a}	-0.10	0.25^{a}	0.06	0.01	0.05	0.12	0.03	0.15	-0.08	0.01	0.05
HT		-	0.56^{c}	-0.21^{a}	0.68	0.49^{c}	0.40^{c}	0.47^{c}	0.31^{b}	0.86	0.79	0.71	0.48^{c}	0.55^{c}	0.68	0.66	0.58^{c}	0.63
WT			-	0.69	0.55^{c}	0.44^{c}	0.42^{c}	0.08	0.51^{c}	0.51^{c}	0.44^{c}	0.50^{c}	0.47^{c}	0.31^{b}	0.49^{c}	0.46^{c}	0.39^{c}	0.50^{c}
BMI				-	0.05	0.08	0.14	-0.31^{b}	0.32^{b}	-0.15	-0.17	-0.02	0.14	-0.13	-0.02	-0.04	-0.05	0.04
SHt					-	0.35^{c}	0.47^{c}	0.24^{a}	0.35^{c}	0.59^{c}	0.57^{c}	0.54^{c}	0.37^{c}	0.30^{b}	0.47^{c}	0.46^{c}	0.42^{c}	0.50^{c}
BGW						-	0.35^{c}	0.13	0.25^{a}	0.47^{c}	0.43^{c}	0.42^{c}	0.17	0.16	0.32^{c}	0.35^{c}	0.26^{b}	0.35^{c}
LOMA							-	0.27^{b}	0.33^{c}	0.47^{c}	0.42^{c}	0.46^{c}	0.42^{c}	0.23^{a}	0.26^{b}	0.56^{c}	0.48^{c}	0.49^{c}
NL								-	0.05	0.50^{c}	0.47^{c}	0.51^{c}	0.43^{c}	0.20^{a}	0.44^{c}	0.35^{c}	0.42^{c}	0.36^{c}
BALt									-	0.28^{b}	0.19	0.32^{c}	0.28^{b}	0.12	0.23^{a}	0.34^{c}	0.31^{b}	0.41^{c}
DSLt										-	0.84	0.74	0.54^{c}	0.48^{c}	0.72	0.69	0.56^{c}	0.62
HL											-	0.72	0.55^{c}	0.47^{c}	0.66	0.66	0.54^{c}	0.56^{c}
HB												-	0.71	0.23^{a}	0.64	0.63	0.63	0.63
WRB													-	0.18	0.42^{c}	0.46^{c}	0.55^{c}	0.60
ThL														-	0.36^{c}	0.43^{c}	0.30^{b}	0.35^{c}
LL															-	0.50^{c}	0.43^{c}	0.46^{c}
FL																-	0.53^{c}	0.57^{c}
FB																	-	0.88
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; NSZ = Northern Senatorial Zone

Table 4.50: Correlation matrix of anthropometric parameters of NSZ young adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.09	0.27	0.31[a]	0.29[a]	0.52[c]	0.22	-0.08	0.14	0.15	0.01	-0.02	-0.13	0.09	0.12	-0.21	-0.05	0.05
HT	-0.00	-	0.69[c]	0.05	0.57[c]	0.25	0.27	0.46[c]	0.21	0.80	0.71[c]	0.47[c]	0.22	0.66[c]	0.60[c]	0.30[a]	0.35[a]	0.47[c]
WT	0.41[b]	0.35[a]	-	0.75[c]	0.62[c]	0.45[b]	0.43[b]	0.29[a]	0.44[b]	0.67[c]	0.57[c]	0.50[c]	0.30[a]	0.48[c]	0.54[c]	0.41[b]	0.27	0.42[b]
BMI	0.42[b]	-0.15	0.87	-	0.33[a]	0.41[b]	0.36[a]	-0.02	0.40[b]	0.19	0.14	0.26	0.22	0.06	0.20	0.29[a]	0.04	0.14
SHt	0.25	0.54[c]	0.37[b]	0.10	-	0.29[a]	0.31[a]	0.10	0.31[a]	0.41[b]	0.29[a]	0.30[a]	0.10	0.22	0.29[a]	0.16	0.17	0.35[a]
BGW	-0.05	0.45[b]	0.30[a]	0.07	0.15	-	0.52[c]	-0.01	0.25	0.34[a]	0.28[a]	0.18	-0.15	0.20	0.19	0.13	0.12	0.23
LOMA	0.20	0.08	0.28	0.24	0.40[b]	-0.05	-	0.24	0.33[a]	0.43[b]	0.35[a]	0.43[b]	0.30[a]	0.13	0.12	0.57[c]	0.30[a]	0.44[b]
NL	-0.19	-0.14	-0.44[b]	-0.39[b]	-0.10	-0.15	-0.09	-	-0.04	0.48[c]	0.58[c]	0.57[c]	0.54[c]	0.32[a]	0.40[b]	0.27	0.32[a]	0.30[a]
BALt	0.40[b]	0.06	0.50[c]	0.49[c]	0.18	0.04	0.14	-0.24	-	0.24	0.12	0.20	0.11	0.19	0.15	0.39[b]	0.18	0.35[a]
DSLt	-0.03	0.68[c]	0.21	-0.13	0.49[c]	0.27	0.15	-0.05	-0.05	-	0.82	0.57[c]	0.27	0.62[c]	0.64[c]	0.44[b]	0.29[a]	0.39[b]
HL	-0.02	0.66[c]	0.20	-0.13	0.57[c]	0.27	0.17	-0.04	-0.08	0.70[c]	-	0.63[c]	0.39[b]	0.57[c]	0.58[c]	0.37[b]	0.36[b]	0.41[b]
HB	0.14	0.39[b]	0.43[b]	0.24	0.41[b]	0.26	0.07	-0.18	0.10	0.45[b]	0.47[c]	-	0.56[c]	0.27	0.41[b]	0.40[b]	0.41[b]	0.41[b]
WRB	0.38[b]	0.21	0.49[c]	0.40[b]	0.29[a]	0.11	0.22	-0.13	0.20	0.37[b]	0.36[b]	0.58[c]	-	0.10	0.05	0.21	0.42[b]	0.41[b]
ThL	-0.03	0.62[c]	0.13	-0.19	0.36[b]	0.07	0.26	0.01	-0.02	0.46[c]	0.44[b]	0.17	0.19	-	0.51[c]	0.44[b]	0.33[a]	0.42[b]
LL	0.22	0.47[c]	0.30[a]	0.07	0.36[a]	0.14	0.02	0.04	0.01	0.53[c]	0.50[c]	0.57[c]	0.48[c]	0.18	-	0.21	0.22	0.24
FL	0.01	0.71[c]	0.35[a]	0.01	0.44[b]	0.24	0.29[a]	-0.20	-0.07	0.63[c]	0.67[c]	0.33[a]	0.28	0.49[c]	0.48[c]	-	0.27	0.43[b]
FB	0.04	0.25	0.31[a]	0.18	0.28	-0.07	0.35[a]	-0.04	0.15	0.28	0.25	0.24	0.28	0.27	0.16	0.28	-	0.85
AKB	0.04	0.33[a]	0.46[c]	0.30[a]	0.32[a]	0.09	0.23	-0.19	0.25	0.41[b]	0.31[a]	0.36[a]	0.47[c]	0.27	0.27	0.23	0.78	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; NSZ = Northern Senatorial Zone

Table 4.51: Correlation matrix of anthropometric parameters of SSZ adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.19	0.15	0.01	0.10	0.14	0.15	0.13	0.13	0.07	0.06	-0.01	0.07	-0.04	-0.03	0.25[a]	0.15	0.15
HT		-	0.31[b]	-0.56[c]	0.42[c]	0.40[c]	0.31[b]	0.38[c]	0.11	0.52[c]	0.27[b]	0.43[c]	0.38[c]	0.38[c]	0.49[c]	0.36[c]	0.27[b]	0.27[b]
WT			-	0.58[c]	0.23[a]	0.19	0.36[c]	0.23[a]	0.51[c]	0.38[c]	0.28[b]	0.31[b]	0.34[c]	0.29[b]	0.22[a]	0.38[c]	0.40[c]	0.39[c]
BMI				-	-0.09	-0.12	0.12	-0.06	0.39	-0.03	0.07	-0.06	-0.03	-0.04	-0.14	0.09	0.17	0.17
SHt					-	0.43[c]	0.30[b]	0.34[c]	0.18	0.51[c]	0.42[c]	0.50[c]	0.43[c]	0.42[c]	0.45[c]	0.34[c]	0.36[c]	0.36[c]
BGW						-	0.26[b]	0.46[c]	0.13	0.48[c]	0.34[c]	0.56[c]	0.35[c]	0.19	0.41[c]	0.28[b]	0.32[b]	0.30[b]
LOMA							-	0.27[b]	0.34[c]	0.50[c]	0.18	0.36[c]	0.38[c]	0.34[c]	0.35[c]	0.36[c]	0.44[c]	0.47[c]
NL								-	0.20	0.48[c]	0.46[c]	0.50[c]	0.34[c]	0.16	0.40[c]	0.37[c]	0.29[b]	0.21[a]
BALt									-	0.24[a]	0.25[a]	0.19	0.26[b]	0.15	0.17	0.33[c]	0.40[c]	0.39[c]
DSLt										-	0.56[c]	0.68	0.47[c]	0.49[c]	0.71	0.58[c]	0.35[c]	0.37[c]
HL											-	0.68	0.41[c]	0.24[a]	0.48[c]	0.40[c]	0.21[a]	0.19
HB												-	0.62	0.31[b]	0.54[c]	0.42[c]	0.38[c]	0.38[c]
WRB													-	0.25[a]	0.39[c]	0.47[c]	0.40[c]	0.40[c]
ThL														-	0.54[c]	0.13	0.15	0.15
LL															-	0.28[b]	0.19	0.21[a]
FL																-	0.53[c]	0.56[c]
FB																	-	0.97
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; SSZ = Southern Senatorial Zone

Table 4.52: Correlation matrix of anthropometric parameters of SSZ adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.24	0.10	-0.08	0.25	0.11	0.18	0.06	0.12	0.20	0.07	-0.02	0.08	-0.07	-0.17	0.38[b]	0.33[a]	0.33[a]
HT	0.28	-	0.39[b]	-0.71[c]	0.26	0.14	0.15	0.09	0.13	0.17	-0.01	0.13	0.24	0.23	0.13	0.20	0.28	0.28
WT	0.20	0.18	-	0.31[a]	0.46[c]	0.31[a]	0.29[a]	0.32[a]	0.44[b]	0.65[c]	0.37[b]	0.55[c]	0.61[c]	0.42[b]	0.16	0.48[c]	0.43[b]	0.40[b]
BMI	0.08	-0.22	0.92	-	0.16	0.13	0.14	0.18	0.29[a]	0.39[b]	0.34[a]	0.26	0.17	0.08	0.05	0.23	0.13	0.11
SHt	-0.06	0.25	-0.11	-0.21	-	0.42[b]	0.30[a]	0.06	0.34[a]	0.49[c]	0.37[b]	0.34[a]	0.32[a]	0.46[c]	0.37[b]	0.28	0.45[b]	0.47[c]
BGW	0.23	0.25	0.00	-0.10	0.09	-	0.33[a]	0.06	0.30[a]	0.25	0.08	0.34[a]	0.28	0.28	0.19	0.14	0.36[b]	0.38[b]
LOMA	0.16	0.11	0.37[b]	0.32[a]	0.00	-0.14	-	0.26	0.36[a]	0.56[c]	0.10	0.31[a]	0.38[b]	0.34[a]	0.33[a]	0.35[a]	0.62[c]	0.60[c]
NL	0.23	0.26	0.12	0.02	0.24	0.34[a]	-0.04	-	0.25	0.52[c]	0.30[a]	0.24	0.30[a]	0.10	0.22	0.43[b]	0.20	0.19
BALt	0.13	0.31[a]	0.60[c]	0.47[c]	0.10	0.11	0.43[b]	0.30[a]	-	0.41[b]	0.36[a]	0.41[b]	0.46[c]	0.08	0.21	0.44[b]	0.58[c]	0.58[c]
DSLt	0.03	0.47[c]	0.22	0.03	0.12	0.11	0.16	-0.04	0.40[b]	-	0.51[c]	0.49[c]	0.45[c]	0.51[c]	0.44[b]	0.57[c]	0.47[c]	0.46[c]
HL	0.08	0.34[a]	0.15	-0.00	0.22	0.26	-0.03	0.36[a]	0.24	0.38[b]	-	0.57[c]	0.41[b]	0.29[a]	0.43[b]	0.29[a]	0.20	0.20
HB	0.03	0.16	0.07	-0.01	0.28	0.30[a]	-0.02	0.23	0.21	0.30[a]	0.67[c]	-	0.66[c]	0.46[c]	0.36[b]	0.26	0.37[b]	0.37[b]
WRB	0.10	0.08	0.00	-0.03	0.25	-0.01	0.10	-0.01	0.19	-0.02	0.13	0.23	-	0.28	0.17	0.51[c]	0.49[c]	0.47[c]
ThL	-0.02	0.51[c]	0.16	-0.03	0.25	-0.10	0.22	-0.02	0.24	0.41[b]	0.05	-0.07	0.02	-	0.51[c]	0.00	0.25	0.24
LL	0.10	0.62[c]	0.18	-0.07	0.10	0.08	-0.03	0.03	0.33[a]	0.57[c]	0.24	0.06	0.14	0.49[c]	-	-0.01	0.17	0.18
FL	0.14	0.30[a]	0.26	0.13	0.04	0.11	0.16	0.03	0.35[a]	0.48[c]	0.40[b]	0.34[a]	0.02	0.12	0.35[a]	-	0.59[c]	0.59[c]
FB	-0.01	-0.09	0.34[a]	0.38[b]	0.02	0.09	0.17	0.20	0.26	0.01	0.04	0.19	0.09	-0.07	-0.11	0.30[a]	-	0.99
AKB	-0.03	-0.11	0.36[b]	0.40[b]	-0.02	0.03	0.25	0.03	0.24	0.10	-0.00	0.22	0.09	-0.07	-0.06	0.39[b]	0.92	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; SSZ = Southern Senatorial Zone

Table 4.53: Correlation matrix of anthropometric parameters of CSZ adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.01	0.11	0.11	-0.10	0.09	0.12	-0.11	0.17	-0.00	-0.05	-0.05	0.00	0.08	-0.02	0.11	0.01	0.06
HT		-	0.11	-0.39[c]	0.64	0.09	0.27[b]	0.43[c]	0.19	0.82	0.61	0.53[c]	0.36[c]	0.33[c]	0.35[c]	0.69	0.43[c]	0.50[c]
WT			-	0.87	0.34[c]	0.11	0.39[c]	0.02	0.59[c]	0.22[a]	0.27[b]	0.36[c]	0.62	0.13	0.03	0.36[c]	0.33[c]	0.47[c]
BMI				-	0.00	0.05	0.21[a]	-0.19	0.45[c]	-0.21[a]	-0.07	0.08	0.41[c]	-0.05	-0.15	-0.03	0.08	0.18
SHt					-	0.09	0.39[c]	0.41[c]	0.36[c]	0.65	0.57[c]	0.50[c]	0.54[c]	0.16	0.19	0.64	0.49[c]	0.63
BGW						-	0.37[c]	-0.03	0.09	0.13	0.27[b]	0.23[a]	0.10	-0.06	-0.11	0.18	0.21[a]	0.11
LOMA							-	0.27[b]	0.28[b]	0.34[c]	0.39[c]	0.45[c]	0.38[c]	0.04	0.13	0.40[c]	0.35[c]	0.44[c]
NL								-	0.17	0.38[c]	0.20	0.35[c]	0.29[b]	0.10	0.17	0.38[c]	0.31[b]	0.32[b]
BALt									-	0.30[b]	0.27[b]	0.24[a]	0.41[c]	0.08	-0.04	0.42[c]	0.33[c]	0.38[c]
DSLt										-	0.72	0.64	0.45[c]	0.33[c]	0.38[c]	0.73	0.50[c]	0.58[c]
HL											-	0.54[c]	0.47[c]	0.09	0.18	0.67	0.50[c]	0.51[c]
HB												-	0.58[c]	0.13	0.22[a]	0.54[c]	0.49[c]	0.51[c]
WRB													-	0.17	0.05	0.56[c]	0.51[c]	0.56[c]
ThL														-	0.34[c]	0.22[a]	0.28[b]	0.28[b]
LL															-	0.24[a]	0.12	0.23[a]
FL																-	0.54[c]	0.65
FB																	-	0.81
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; CSZ = Central Senatorial Zone

Table 4.54: Correlation matrix of anthropometric parameters of CSZ adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	0.03	0.26	0.28	0.09	0.16	0.29	-0.06	0.33[a]	0.11	0.07	0.01	0.09	0.15	-0.05	0.26	0.10	0.26
HT	0.06	-	0.41[b]	0.07	0.62[c]	-0.15	0.11	0.27	0.25	0.68[c]	0.43[b]	0.36[a]	0.44[b]	0.34[a]	0.35[a]	0.57[c]	0.06	0.36[a]
WT	0.00	-0.05	-	0.88	0.37	0.26	0.61[c]	-0.01	0.49[c]	0.50[c]	0.51[c]	0.33[a]	0.51[c]	0.29[a]	0.14	0.64[c]	0.30[a]	0.53[c]
BMI	-0.01	-0.37[b]	0.94	-	0.10	0.35[a]	0.63[c]	-0.15	0.41[b]	0.19	0.32[a]	0.19	0.34[a]	0.12	-0.04	0.40[b]	0.29[a]	0.40[b]
SHt	-0.22	0.37[b]	0.41[b]	0.25	-	0.06	0.32[a]	0.14	0.33[a]	0.50[c]	0.42[b]	0.21	0.45[b]	0.00	0.09	0.45[b]	0.17	0.52[c]
BGW	0.03	-0.05	-0.04	-0.01	-0.19	-	0.41b	-0.30[a]	0.18	-0.06	0.26	0.02	0.08	-0.08	-0.18	0.16	0.22	0.12
LOMA	-0.01	0.06	0.26	0.23	0.25	0.16	-	0.03	0.53[c]	0.33[a]	0.49[c]	0.36[a]	0.34[a]	0.06	0.10	0.44[b]	0.38[b]	0.60[c]
NL	-0.12	0.02	0.05	0.04	0.24	-0.08	0.23	-	0.05	0.05	-0.11	0.10	0.14	0.22	0.19	0.04	0.05	0.15
BALt	0.07	0.02	0.66[c]	0.61[c]	0.33[a]	-0.11	0.00	0.16	-	0.38[b]	0.33[a]	0.17	0.20	0.10	-0.04	0.54[c]	0.42[b]	0.41[b]
DSLt	0.02	0.66[c]	0.19	-0.06	0.50[c]	-0.12	-0.04	-0.03	0.20	-	0.51[c]	0.45[c]	0.41[b]	0.37[b]	0.38[b]	0.53[c]	0.07	0.38[b]
HL	-0.08	0.39[b]	0.22	0.07	0.41[b]	0.03	0.05	-0.15	0.16	0.61[c]	-	0.39[b]	0.52[b]	-0.06	0.04	0.64[c]	0.29	0.45[b]
HB	-0.02	0.07	0.57[c]	0.50[c]	0.34[a]	0.20	0.32[a]	-0.02	0.21	0.27	0.24	-	0.56[c]	0.11	0.29[a]	0.34[a]	0.24	0.38[b]
WRB	-0.02	-0.02	0.75[c]	0.70[c]	0.44[b]	-0.07	0.29[a]	0.13	0.50[c]	0.22	0.24	0.46[c]	-	0.17	0.02	0.55[c]	0.25	0.46[c]
ThL	0.02	0.31[a]	0.01	-0.10	0.24	-0.12	-0.07	-0.13	0.02	0.33[a]	0.12	0.01	0.12	-	0.48[c]	0.18	0.12	0.11
LL	0.08	0.31[a]	-0.09	-0.19	0.19	-0.10	0.08	-0.03	-0.11	0.39[b]	0.22	-0.08	-0.07	0.02	-	0.10	0.00	0.20
FL	0.12	0.43[b]	0.32[a]	0.14	0.52[c]	-0.18	0.09	0.14	0.33[a]	0.55[c]	0.40[b]	0.20	0.39[b]	0.19	0.33[a]	-	0.35[a]	0.57[c]
FB	0.01	0.16	0.49[c]	0.38[b]	0.40[b]	-0.15	0.02	-0.01	0.20	0.31[a]	0.28	0.21	0.54[c]	0.42[b]	0.08	0.25	-	0.65[c]
AKB	-0.01	0.21	0.56[c]	0.43[b]	0.51[c]	-0.22	0.10	0.02	0.32[a]	0.38[b]	0.25	0.24	0.49[c]	0.39[b]	0.17	0.47[c]	0.82	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; CSZ = Central Senatorial Zone

Table 4.55: Correlation matrix of anthropometric parameters of NSZ adult subjects (n = 100)

	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.14	0.06	0.15	-0.09	0.06	0.14	-0.31[b]	0.15	-0.12	-0.14	-0.07	-0.04	-0.14	-0.10	-0.04	-0.09	-0.08
HT		-	0.36[c]	-0.21[a]	0.74	0.44[c]	0.38[c]	0.46[c]	0.16	0.78	0.72	0.60	0.38[c]	0.59[c]	0.67	0.69	0.56[c]	0.54[c]
WT			-	0.83	0.44[c]	0.24[a]	0.59[c]	0.01	0.43[c]	0.34[c]	0.31[b]	0.28[b]	0.34[c]	0.40[c]	0.34[c]	0.31[b]	0.45[c]	0.53[c]
BMI				-	0.03	-0.01	0.40[c]	-0.26[b]	0.37[c]	-0.12	-0.10	-0.07	0.14	0.08	-0.04	-0.09	0.14	0.22
SHt					-	0.44[c]	0.40[c]	0.46[c]	0.24[a]	0.57[c]	0.60	0.55[c]	0.25[a]	0.38[c]	0.42[c]	0.54[c]	0.46[c]	0.42[c]
BGW						-	0.40[c]	0.19	0.20	0.45[c]	0.40[c]	0.44[c]	0.18	0.33[c]	0.26[b]	0.46[c]	0.29[b]	0.28[b]
LOMA							-	0.09	0.22[a]	0.40[c]	0.34[c]	0.27[b]	0.29[b]	0.47[c]	0.35[c]	0.43[c]	0.35[c]	0.46[c]
NL								-	0.07	0.44[c]	0.42[c]	0.58[c]	0.26[a]	0.15	0.28[b]	0.35[c]	0.35[c]	0.32[b]
BALt									-	0.13	0.14	0.18	0.30[b]	0.20	0.26[a]	0.12	0.25[a]	0.21[a]
DSLt										-	0.70	0.60	0.37[c]	0.56[c]	0.69	0.66	0.47[c]	0.48[c]
HL											-	0.59[c]	0.37[c]	0.42[c]	0.56[c]	0.65	0.41[c]	0.44[c]
HB												-	0.52[c]	0.19	0.40[c]	0.52[c]	0.52[c]	0.48[c]
WRB													-	0.12	0.36[c]	0.42[c]	0.40[c]	0.44[c]
ThL														-	0.50[c]	0.35[c]	0.31[b]	0.38[c]
LL															-	0.62	0.32[b]	0.36[c]
FL																-	0.51[c]	0.50[c]
FB																	-	0.87
AKB																		-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; NSZ = Northern Senatorial Zone

Table 4.56: Correlation matrix of anthropometric parameters of NSZ adult males and females (n = 50)

→M ↓F	Age	HT	WT	BMI	SHt	BGW	LOMA	NL	BALt	DSLt	HL	HB	WRB	ThL	LL	FL	FB	AKB
Age	-	-0.16	-0.16	-0.09	-0.17	0.19	0.05	-0.41[b]	-0.11	-0.03	-0.09	-0.12	-0.24	-0.14	-0.20	-0.00	-0.29[a]	-0.28
HT	0.01	-	0.60[c]	0.04	0.73[c]	0.41[b]	0.35[a]	0.15	0.20	0.61[c]	0.59[c]	0.30[a]	0.25	0.74[c]	0.58[c]	0.52[c]	0.38[b]	0.47[c]
WT	0.21	0.47[c]	-	0.82	0.48[c]	0.34[a]	0.58[c]	0.18	0.21	0.54[c]	0.46[c]	0.49[c]	0.30[a]	0.48[c]	0.43[b]	0.46[c]	0.45[b]	0.62[c]
BMI	0.23	0.11	0.93	-	0.10	0.12	0.46[c]	0.12	0.13	0.24	0.16	0.40[b]	0.20	0.08	0.15	0.20	0.27	0.41[b]
SHt	0.08	0.63[c]	0.54[c]	0.35[a]	-	0.37[b]	0.36[b]	0.37[b]	0.24	0.47[c]	0.66[c]	0.35[a]	0.14	0.48[c]	0.32[a]	0.44[b]	0.40[b]	0.45[b]
BGW	0.07	0.05	0.29[a]	0.31[a]	0.26	-	0.54[c]	-0.26	0.12	0.39[b]	0.31[a]	0.13	-0.03	0.44[b]	0.23	0.52[c]	0.15	0.19
LOMA	0.24	0.42[b]	0.63[c]	0.55[c]	0.39[b]	0.28	-	0.02	-0.13	0.48[c]	0.33[a]	0.31[a]	0.06	0.52[c]	0.26	0.48[c]	0.36[a]	0.48[c]
NL	-0.17	0.11	-0.03	-0.07	0.20	0.02	-0.02	-	-0.05	0.12	0.10	0.34[a]	0.24	0.15	0.06	-0.03	0.28	0.32[a]
BALt	0.35[a]	0.15	0.55[c]	0.57[c]	0.25	0.25	0.38[b]	0.14	-	-0.05	0.11	0.01	0.15	0.11	0.19	-0.00	0.20	0.17
DSLt	-0.10	0.77	0.41[b]	0.14	0.45[b]	0.15	0.33[a]	0.20	0.26	-	0.45[b]	0.28	0.08	0.63[c]	0.53[c]	0.42[b]	0.24	0.36[a]
HL	-0.10	0.60[c]	0.37[b]	0.16	0.35[a]	0.16	0.31[a]	0.21	0.16	0.73[c]	-	0.40[b]	0.10	0.41[b]	0.34[a]	0.40[b]	0.17	0.29[a]
HB	0.14	0.33[a]	0.46[c]	0.38[b]	0.46[c]	0.24	0.19	0.16	0.36[b]	0.47[c]	0.35[a]	-	0.47[c]	0.15	0.08	0.25	0.31[a]	0.37[b]
WRB	0.26	0.28	0.46[c]	0.41[b]	0.17	0.14	0.42[b]	-0.08	0.43[b]	0.50[c]	0.46[c]	0.46[c]	-	-0.03	0.14	0.16	0.25	0.36[a]
ThL	-0.11	0.53[c]	0.37[b]	0.20	0.24	0.17	0.43[b]	0.00	0.26	0.55[c]	0.42[b]	0.11	0.21	-	0.60[c]	0.35[a]	0.20	0.31[a]
LL	0.08	0.65[c]	0.38[b]	0.15	0.31[a]	0.01	0.37[b]	0.10	0.31[a]	0.74[c]	0.59[c]	0.33[a]	0.44[b]	0.38[b]	-	0.42[b]	0.00	0.12
FL	0.04	0.68[c]	0.35[a]	0.11	0.44[b]	0.15	0.38[b]	0.24	0.18	0.69[c]	0.68[c]	0.37[b]	0.53[c]	0.30[a]	0.65[c]	-	0.39[b]	0.45[b]
FB	0.21	0.50[c]	0.60[c]	0.46[c]	0.31[a]	0.12	0.30[a]	-0.04	0.31[a]	0.45[b]	0.37[b]	0.43[b]	0.41[b]	0.38[b]	0.40[b]	0.42[b]	-	0.82
AKB	0.20	0.44[b]	0.59[c]	0.48[c]	0.21	0.12	0.43[b]	-0.06	0.24	0.40[b]	0.38[b]	0.36[b]	0.40[b]	0.40[b]	0.43[b]	0.40[b]	0.90	-

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; a = $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$; M = Male; F = Female; NSZ = Northern Senatorial Zone

4.5 Linear Regression Models for the Anthropometric Variables

Table 4.57 shows derived equations that can be used in the estimation of height from measurement of body proportions in the entire population of Cross River State. The range of correlation coefficient was (0.40 - 0.94). Demispan length has the strongest prediction ability and small standard error of estimate than all the other parameters (r = 0.94, SEE = 6.22, t = 93.95, $P < 0.001$). A weak to moderate correlation was observed in BMI, bigonial width and neck length, strong correlation was observed in most of the parameters, but stronger correlation was observed with sitting height and hand length (Table 4.57). Males presented with statistically significant higher mean values compared to females with regards to height and all measurement of the body proportions (Table 4.58 and Table 4.59). In males, the range of correlation coefficient was (0.47 - 0.94), while in females, the range of correlation coefficient was (0.26 - 0.94). Demispan length has the strongest estimation ability and the smallest standard error of estimate than the rest of the parameters in both males and females (r = 0.94, SEE = 7.12, t = 64.78, $P < 0.001$ and r = 0.94, SEE = 5.17, t = 66.86, $P < 0.001$) respectively. It was evident from this research that height can be estimated from all of the measured parameters in males of Cross River State, with stronger correlation with weight, sitting height, hand length and thigh length, but strongest and more prediction ability with demispan length (Table 4.58). In females, a weak to moderate correlation was observed in neck length, BMI, bigonial width, length of mandibular arch, hand and wrist breadths. Most parameters showed strong correlation, but stronger correlation was observed with sitting height, thigh length, leg length, hand length and foot length. While strongest correlation and more prediction ability was observed with demispan length when compared to the other parameters in females of Cross River State (Table 4.59).

Table 4.57: Linear regression equations for estimation of height from anthropometric parameters of Cross River State (n = 1200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 129.94 + (1.138 * Age)	0.68	0.46	13.24	31.82	<0.001
Weight (kg)	HT = 112.71 + (0.783 * WT)	0.84	0.70	9.84	52.97	<0.001
Body mass index (kg/m^2)	HT = 115.21 + (1.791 * BMI)	0.50	0.25	15.54	20.19	<0.001
Sitting height (cm)	HT = 12.27 + (1.871 * SHt.)	0.90	0.80	8.00	69.65	<0.001
Bigonial width (cm)	HT = 51.36 + (9.016 * BGW)	0.67	0.45	13.33	31.34	<0.001
Length of mandibular arch (cm)	HT = 40.74 + (5.783 * LOMA)	0.70	0.48	12.93	33.46	<0.001
Neck length (cm)	HT = 105.72 + (4.012 * NL)	0.40	0.16	16.48	15.11	<0.001
Biaxillary length (cm)	HT = 65.67 + (2.625 * BALt)	0.75	0.56	11.97	38.81	<0.001
Demispan length (cm)	HT = 22.85 + (1.585 * DSLt)	0.94	0.88	6.22	93.95	<0.001
Hand length (cm)	HT = 24.04 + (7.086 * HL)	0.88	0.77	8.60	63.56	<0.001
Hand breadth (cm)	HT = 56.35 + (9.242 * HB)	0.78	0.61	11.28	42.97	<0.001
Wrist breadth (cm)	HT = 60.17 + (11.102 * WRB)	0.72	0.52	12.49	35.86	<0.001
Thigh length (cm)	HT = 43.73 + (2.202 * ThL)	0.85	0.73	9.36	56.76	<0.001
Leg length (cm)	HT = 43.50 + (2.818 * LL)	0.85	0.72	9.44	56.10	<0.001
Foot length (cm)	HT = 17.39 + (5.602 * FL)	0.84	0.70	9.79	53.34	<0.001
Foot breadth (cm)	HT = 34.42 + (9.026 * FB)	0.77	0.59	11.48	41.75	<0.001
Ankle breadth (cm)	HT = 27.80 + (9.504 * AKB.)	0.78	0.61	11.29	42.92	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth

Table 4.58: Linear regression equations for estimation of height from anthropometric parameters of Cross River State males (n = 600)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 127.33 + (1.401 * Age)	0.73	0.54	13.68	26.46	<0.001
Weight (kg)	HT = 107.54 + (0.930 * WT)	0.90	0.81	8.86	49.93	<0.001
Body mass index (kg/m^2)	HT = 97.55 + (2.854 * BMI)	0.59	0.35	16.31	17.75	<0.001
Sitting height (cm)	HT = 8.12 + (1.947 * SHt.)	0.90	0.81	8.72	50.92	<0.001
Bigonial width (cm)	HT = 43.82 + (9.706 * BGW)	0.69	0.48	14.59	23.29	<0.001
Length of mandibular arch (cm)	HT = 21.17 + (6.883 * LOMA)	0.76	0.58	13.01	28.92	<0.001
Neck length (cm)	HT = 84.79 + (5.697 * NL)	0.47	0.22	17.83	12.88	<0.001
Biaxillary length (cm)	HT = 52.46 + (3.103 * BALt)	0.80	0.64	12.06	32.76	<0.001
Demispan length (cm)	HT = 22.11 + (1.592 * DSLt)	0.94	0.88	7.12	64.78	<0.001
Hand length (cm)	HT = 19.67 + (7.311 * HL)	0.89	0.79	9.25	47.35	<0.001
Hand breadth (cm)	HT = 45.50 + (10.062 * HB)	0.83	0.68	11.36	35.82	<0.001
Wrist breadth (cm)	HT = 49.55 + (12.329 * WRB)	0.75	0.57	13.23	28.08	<0.001
Thigh length (cm)	HT = 36.05 + (2.431 * ThL)	0.88	0.78	9.50	45.77	<0.001
Leg length (cm)	HT = 45.43 + (2.795 * LL)	0.84	0.71	10.95	37.79	<0.001
Foot length (cm)	HT = 16.28 + (5.641 * FL)	0.84	0.71	10.83	38.37	<0.001
Foot breadth (cm)	HT = 22.30 + (9.858 * FB)	0.79	0.62	12.46	31.08	<0.001
Ankle breadth (cm)	HT = 14.35 + (10.467 * AKB)	0.80	0.64	12.02	32.90	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth

Table 4.59: Linear regression equations for estimation of height from anthropometric parameters of Cross River State females (n = 600)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 132.28 + (0.887 * Age)	0.64	0.41	11.56	20.35	<0.001
Weight (kg)	HT = 118.38 + (0.623 * WT)	0.79	0.62	9.24	31.41	<0.001
Body mass index (kg/m^2)	HT = 119.39 + (1.413 * BMI)	0.54	0.29	12.66	15.71	<0.001
Sitting height (cm)	HT = 21.31 + (1.728 * SHt)	0.89	0.80	6.73	48.89	<0.001
Bigonial width (cm)	HT = 63.85 + (7.844 * BGW)	0.62	0.38	11.83	19.21	<0.001
Length of mandibular arch (cm)	HT = 65.91 + (4.377 * LOMA)	0.61	0.37	11.98	18.56	<0.001
Neck length (cm)	HT = 124.26 + (2.337 * NL)	0.26	0.07	14.52	6.61	<0.001
Biaxillary length (cm)	HT = 80.26 + (2.106 * BALt)	0.70	0.50	10.68	24.24	<0.001
Demispan length (cm)	HT = 23.13 + (1.584 * DSLt)	0.94	0.88	5.17	66.86	<0.001
Hand length (cm)	HT = 30.10 + (6.756 * HL)	0.85	0.73	7.87	39.83	<0.001
Hand breadth (cm)	HT = 61.01 + (8.958 * HB)	0.69	0.48	10.82	23.60	<0.001
Wrist breadth (cm)	HT = 74.17 + (9.382 * WRB)	0.65	0.42	11.49	20.67	<0.001
Thigh length (cm)	HT = 51.11 + (1.983 * ThL)	0.87	0.76	7.38	43.43	<0.001
Leg length (cm)	HT = 43.30 + (2.796 * LL)	0.87	0.75	7.52	42.33	<0.001
Foot length (cm)	HT = 18.50 + (5.561 * FL)	0.82	0.67	8.64	34.84	<0.001
Foot breadth (cm)	HT = 45.58 + (8.217 * FB)	0.73	0.54	10.21	26.44	<0.001
Ankle breadth (cm)	HT = 43.14 + (8.344 * AKB)	0.73	0.53	10.29	26.05	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth

Table 4.60 shows derived equations for the estimation of height from measurement of body proportions in the SSZ of Cross River State. The range of correlation coefficient was (0.46 - 0.91). Demispan length has the strongest prediction ability and small standard error of estimate than all the other parameters (r = 0.91, SEE = 7.19, t = 43.26, $P < 0.001$). A weak to moderate correlation was observed in BMI, neck length, bigonial width and wrist breadth, strong correlation was observed in most of the parameters, but stronger correlation was observed with sitting height, leg length, weight, thigh length and hand length (Table 4.60). Males presented with statistically significant higher mean values compared to females with regards to height and all measurement of the body proportions (Table 4.61 and Table 4.62). In males, the range of correlation coefficient was (0.47 - 0.90), while in females, the range of correlation coefficient was (0.24 - 0.91). Demispan length has the strongest estimation ability and the smallest standard error of estimate than the rest of the parameters in both males and females (r = 0.90, SEE = 8.59, t = 29.84, $P < 0.001$ and r = 0.91, SEE = 5.49, t = 30.91, $P < 0.001$), respectively. It was evident from this research that height can be estimated from all of the measured parameters in males and females in the SSZ of Cross River State, with stronger correlation in weight, thigh length, sitting height, hand length and leg length, but strongest and more prediction ability with demispan length (Table 4.61). In females, a weak to moderate correlation was observed in neck length, BMI, bigonial width, length of mandibular arch, hand, wrist, foot and ankle breadths. Most parameters showed strong correlation, but stronger correlation was observed with sitting height, thigh length, leg length, weight and hand length. While strongest correlation and more prediction ability was observed with demispan length when compared to the other parameters in females in the SSZ of Cross River State (Table 4.62).

Table 4.63 shows derived equations for the estimation of height from measurement of body proportions in the CSZ of Cross River State. The range of correlation coefficient was (0.33 - 0.95). Demispan length has the strongest prediction ability and small standard error of estimate than all the other parameters (r = 0.95, SEE = 5.82, t = 58.52, $P < 0.001$). A weak to moderate correlation was observed in neck length, BMI and bigonial width, strong correlation was observed in most of the parameters, but stronger correlation was observed with sitting height, hand length, thigh length, foot length, weight, leg length, and hand and ankle breadths (Table 4.63). Males presented with statistically significant higher mean values compared to females with regards to height and all measurement of the body proportions (Table 4.64 and Table 4.65). In males, the range of correlation coefficient was (0.35 - 0.94), while in females, the range of correlation coefficient was (0.22 - 0.95). Demispan length has the strongest estimation ability and the smallest standard error of estimate than the rest of the parameters in both males and females (r = 0.94, SEE = 6.63, t = 40.07, $P < 0.001$ and r = 0.95, SEE = 4.81, t = 42.49, $P < 0.001$), respectively. It was evident from this research that height can be estimated from all of the measured parameters in males and females in the CSZ of Cross River State. Most of the parameters showed strong correlation with height, but a stronger correlation was observed with sitting height, hand length and weight. While, the strongest and more prediction ability was observed with demispan length (Table 4.64). In females, most parameters showed strong correlation with stature, but stronger correlation was observed with sitting height, thigh length, leg length, hand length and foot length. While strongest correlation and more prediction ability was observed with demispan length when compared to the other parameters in females in the CSZ of Cross River State (Table 4.65).

Table 4.66 shows derived equations for the estimation of height from measurement of body proportions in the NSZ of Cross River State. The range of correlation coefficient was (0.42 - 0.96).

Demispan length has the strongest prediction ability and small standard error of estimate than all the other parameters (r= 0.96, SEE = 5.21, t = 68.79, $P < 0.001$). A weak to moderate correlation was observed in neck length and BMI, strong correlation was observed in most of the parameters, but stronger correlation was observed with sitting height and hand length (Table 4.66). Males presented with statistically significant higher mean values compared to females with regards to height and all measurement of the body proportions (Table 4.67 and Table 4.68). In males, the range of correlation coefficient was (0.46 - 0.96), while in females, the range of correlation coefficient was (0.32 - 0.96). Demispan length has the strongest estimation ability and the smallest standard error of estimate than the rest of the parameters in both males and females (r = 0.96, SEE = 5.66, t = 48.76, $P < 0.001$ and r = 0.96, SEE = 4.73, t = 46.90, $P < 0.001$) respectively. It was evident from this research that height can be estimated from all of the measured parameters in males and females in the NSZ of Cross River State. In males, most of the parameters showed strong correlation with height, but a stronger correlation was observed with sitting height, hand length, thigh length and weight. While, the strongest and more prediction ability was observed with demispan length (Table 4.67). In females, most parameters showed strong correlation with stature, but stronger correlation was observed with sitting height, thigh length and hand length. While strongest correlation and more prediction ability was observed with demispan length when compared to the other parameters in females in the NSZ of Cross River State (Table 4.68).

Table 4.69 – 4.104 shows derived equations for the estimation of height from measurement of body proportions in children, adolescents, young adults and adult age groups of the SSZ, CSZ and NSZ of the studied population. DSLt has the strongest prediction ability and small standard error of estimate than all the other parameters, exception of the CSZ children (HL), boys (HL and WT);

SSZ adolescent males (WT); SSZ young adult females (LL); SSZ adults (BMI), males (BMI), females (LL) and NSZ adult males (ThL).

Table 4.60: Linear regression equations for estimation of height from anthropometric parameters of SSZ (n = 400)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 130.40 + (1.118 * Age)	0.68	0.46	12.66	18.32	<0.001
Weight (kg)	HT = 112.39 + (0.803 * WT)	0.84	0.70	9.36	30.73	<0.001
Body mass index (kg/m^2)	HT = 118.91 + (1.630 * BMI)	0.46	0.21	15.28	10.24	<0.001
Sitting height (cm)	HT = 20.35 + (1.764 * SHt)	0.84	0.71	9.22	31.38	<0.001
Bigonial width (cm)	HT = 53.52 + (8.843 * BGW)	0.67	0.45	12.73	18.07	<0.001
Length of mandibular arch (cm)	HT = 40.30 + (5.684 * LOMA)	0.70	0.48	12.33	19.34	<0.001
Neck length (cm)	HT = 94.39 + (5.135 * NL)	0.47	0.22	15.16	10.65	<0.001
Biaxillary length (cm)	HT = 63.66 + (2.746 * BALt)	0.73	0.53	11.78	21.16	<0.001
Demispan length (cm)	HT = 28.95 + (1.512 * DSLt)	0.91	0.83	7.19	43.26	<0.001
Hand length (cm)	HT = 32.90 + (6.599 * HL)	0.82	0.67	9.81	28.68	<0.001
Hand breadth (cm)	HT = 70.03 + (8.151 * HB)	0.72	0.52	11.91	20.75	<0.001
Wrist breadth (cm)	HT = 69.02 + (10.130 * WRB)	0.69	0.48	12.40	19.14	<0.001
Thigh length (cm)	HT = 46.72 + (2.102 * ThL)	0.83	0.68	9.68	29.25	<0.001
Leg length (cm)	HT = 45.76 + (2.742 * LL)	0.84	0.71	9.32	30.91	<0.001
Foot length (cm)	HT = 29.04 + (5.122 * FL)	0.78	0.60	10.81	24.65	<0.001
Foot breadth (cm)	HT = 30.48 + (9.394 * FB)	0.70	0.49	12.22	19.72	<0.001
Ankle breadth (cm)	HT = 27.67 + (9.605 * AKB)	0.71	0.50	12.19	19.82	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.61: Linear regression equations for estimation of height from anthropometric parameters of SSZ males (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 126.46 + (1.432 * Age)	0.74	0.55	13.55	15.48	<0.001
Weight (kg)	HT = 106.62 + (0.960 * WT)	0.89	0.79	9.14	27.65	<0.001
Body mass index (kg/m^2)	HT = 109.51 + (2.270 * BMI)	0.47	0.23	17.73	7.58	<0.001
Sitting height (cm)	HT = 15.84 + (1.850 * SHt)	0.83	0.69	11.18	21.10	<0.001
Bigonial width (cm)	HT = 34.03 + (10.472 * BGW)	0.72	0.51	14.04	14.47	<0.001
Length of mandibular arch (cm)	HT = 25.05 + (6.580 * LOMA)	0.76	0.58	13.14	16.36	<0.001
Neck length (cm)	HT = 53.50 + (8.452 * NL)	0.61	0.37	15.95	10.86	<0.001
Biaxillary length (cm)	HT = 47.03 + (3.337 * BALt)	0.77	0.59	12.94	16.79	<0.001
Demispan length (cm)	HT = 28.87 + (1.515 * DSLt)	0.90	0.82	8.59	29.84	<0.001
Hand length (cm)	HT = 29.40 + (6.800 * HL)	0.83	0.68	11.39	20.52	<0.001
Hand breadth (cm)	HT = 59.32 + (8.968 * HB)	0.77	0.60	12.80	17.09	<0.001
Wrist breadth (cm)	HT = 61.74 + (10.929 * WRB)	0.73	0.54	13.70	15.16	<0.001
Thigh length (cm)	HT = 41.56 + (2.280 * ThL)	0.85	0.72	10.63	22.64	<0.001
Leg length (cm)	HT = 46.86 + (2.725 * LL)	0.83	0.69	11.19	21.06	<0.001
Foot length (cm)	HT = 28.78 + (5.164 * FL)	0.79	0.62	12.48	17.83	<0.001
Foot breadth (cm)	HT = 15.57 + (10.545 * FB)	0.73	0.53	13.78	14.99	<0.001
Ankle breadth (cm)	HT = 10.84 + (10.906 * AKB)	0.74	0.55	13.55	15.47	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.62: Linear regression equations for estimation of height from anthropometric parameters of SSZ females (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 134.34 + (0.803 * Age)	0.63	0.40	10.27	11.47	<0.001
Weight (kg)	HT = 119.66 + (0.614 * WT)	0.80	0.64	7.96	18.73	<0.001
Body mass index (kg/m^2)	HT = 120.51 + (1.392 * BMI)	0.56	0.31	11.01	9.40	<0.001
Sitting height (cm)	HT = 29.76 + (1.612 * SHt.)	0.89	0.79	6.02	27.58	<0.001
Bigonial width (cm)	HT = 76.89 + (6.755 * BGW)	0.58	0.33	10.83	9.90	<0.001
Length of mandibular arch (cm)	HT = 64.76 + (4.323 * LOMA)	0.61	0.37	10.48	10.88	<0.001
Neck length (cm)	HT = 126.51 + (2.230 * NL)	0.24	0.06	12.87	3.44	<0.001
Biaxillary length (cm)	HT = 81.11 + (2.131 * BALt)	0.72	0.52	9.14	14.77	<0.001
Demispan length (cm)	HT = 30.09 + (1.495 * DSLt)	0.91	0.83	5.49	30.91	<0.001
Hand length (cm)	HT = 40.76 + (6.147 * HL)	0.80	0.64	7.93	18.84	<0.001
Hand breadth (cm)	HT = 74.85 + (7.854 * HB)	0.61	0.37	10.54	10.70	<0.001
Wrist breadth (cm)	HT = 81.77 + (8.590 * WRB)	0.57	0.33	10.85	9.86	<0.001
Thigh length (cm)	HT = 50.93 + (1.946 * ThL)	0.86	0.75	6.67	24.16	<0.001
Leg length (cm)	HT = 45.28 + (2.744 * LL)	0.85	0.72	6.99	22.64	<0.001
Foot length (cm)	HT = 33.62 + (4.897 * FL)	0.75	0.56	8.81	15.79	<0.001
Foot breadth (cm)	HT = 54.02 + (7.529 * FB)	0.64	0.41	10.14	11.83	<0.001
Ankle breadth (cm)	HT = 54.26 + (7.500 * AKB)	0.63	0.40	10.29	11.41	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.63: Linear regression equations for estimation of height from anthropometric parameters of CSZ (n = 400)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 130.86 + (1.144 * Age)	0.68	0.47	13.15	18.72	<0.001
Weight (kg)	HT = 115.35 + (0.743 * WT)	0.83	0.69	10.12	29.43	<0.001
Body mass index (kg/m^2)	HT = 117.64 + (1.737 * BMI)	0.51	0.26	15.50	11.86	<0.001
Sitting height (cm)	HT = 8.21 + (1.924 * SHt)	0.91	0.82	7.66	42.50	<0.001
Bigonial width (cm)	HT = 66.69 + (7.727 * BGW)	0.62	0.38	14.19	15.65	<0.001
Length of mandibular arch (cm)	HT = 39.35 + (6.051 * LOMA)	0.73	0.53	12.40	21.06	<0.001
Neck length (cm)	HT = 112.84 + (3.322 * NL)	0.33	0.11	17.05	6.89	<0.001
Biaxillary length (cm)	HT = 70.66 + (2.439 * BALt)	0.75	0.56	11.97	22.50	<0.001
Demispan length (cm)	HT = 20.55 + (1.627 * DSLt)	0.95	0.90	5.82	58.52	<0.001
Hand length (cm)	HT = 21.47 + (7.314 * HL)	0.89	0.80	8.14	39.43	<0.001
Hand breadth (cm)	HT = 49.65 + (9.855 * HB)	0.80	0.64	10.82	26.59	<0.001
Wrist breadth (cm)	HT = 50.45 + (12.567 * WRB)	0.77	0.59	11.58	23.82	<0.001
Thigh length (cm)	HT = 47.21 + (2.182 * ThL)	0.86	0.73	9.35	32.92	<0.001
Leg length (cm)	HT = 42.29 + (2.889 * LL)	0.83	0.70	9.96	30.13	<0.001
Foot length (cm)	HT = 16.32 + (5.634 * FL)	0.84	0.71	9.67	31.41	<0.001
Foot breadth (cm)	HT = 43.02 + (8.438 * FB)	0.79	0.62	11.14	25.40	<0.001
Ankle breadth (cm)	HT = 33.98 + (9.078 * AKB)	0.80	0.64	10.82	26.59	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.64: Linear regression equations for estimation of height from anthropometric parameters of CSZ males (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 129.11 + (1.374 * Age)	0.73	0.53	13.66	15.04	<0.001
Weight (kg)	HT = 110.79 + (0.877 * WT)	0.90	0.80	8.92	28.25	<0.001
Body mass index (kg/m^2)	HT = 95.50 + (3.032 * BMI)	0.65	9.43	15.15	12.13	<0.001
Sitting height (cm)	HT = 3.00 + (2.010 * SHt)	0.92	0.85	7.66	33.94	<0.001
Bigonial width (cm)	HT = 69.84 + (7.608 * BGW)	0.62	0.38	15.75	10.10	<0.001
Length of mandibular arch (cm)	HT = 25.88 + (6.821 * LOMA)	0.77	9.59	12.82	16.85	<0.001
Neck length (cm)	HT = 100.48 + (4.352 * NL)	0.35	0.12	18.73	5.27	<0.001
Biaxillary length (cm)	HT = 56.22 + (2.952 * BALt)	0.83	0.69	11.13	21.01	<0.001
Demispan length (cm)	HT = 19.52 + (1.631 * DSLt)	0.94	0.89	6.63	40.07	<0.001
Hand length (cm)	HT = 16.27 + (7.570 * HL)	0.91	0.83	8.20	31.29	<0.001
Hand breadth (cm)	HT = 38.47 + (10.741 * HB)	0.85	0.72	10.68	22.27	<0.001
Wrist breadth (cm)	HT = 29.22 + (15.041 * WRB)	0.83	0.69	11.22	20.75	<0.001
Thigh length (cm)	HT = 38.89 + (2.427 * ThL)	0.89	0.79	9.20	27.16	<0.001
Leg length (cm)	HT = 41.01 + (2.967 * LL)	0.82	0.68	11.35	20.41	<0.001
Foot length (cm)	HT = 11.13 + (5.796 * FL)	0.86	0.74	10.17	23.81	<0.001
Foot breadth (cm)	HT = 28.65 + (9.353 * FB)	0.81	0.66	11.73	19.44	<0.001
Ankle breadth (cm)	HT = 16.99 + (10.251 * AKB)	0.84	0.70	10.97	21.45	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.65: Linear regression equations for estimation of height from anthropometric parameters of CSZ females (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 132.37 + (0.923 * Age)	0.66	0.44	11.44	12.50	<0.001
Weight (kg)	HT = 120.58 + (0.591 * WT)	0.77	0.59	9.79	16.90	<0.001
Body mass index (kg/m^2)	HT = 123.74 + (1.258 * BMI)	0.50	0.25	13.24	8.14	<0.001
Sitting height (cm)	HT = 19.39 + (1.757 * SHt)	0.88	0.77	7.30	25.91	<0.001
Bigonial width (cm)	HT = 67.34 + (7.510 * BGW)	0.60	0.36	12.25	10.52	<0.001
Length of mandibular arch (cm)	HT = 59.10 + (4.922 * LOMA)	0.66	0.43	11.52	12.29	<0.001
Neck length (cm)	HT = 127.86 + (1.965 * NL)	0.22	0.05	14.91	3.21	0.002
Biaxillary length (cm)	HT = 86.10 + (1.897 * BALt)	0.68	0.46	11.25	12.97	<0.001
Demispan length (cm)	HT = 18.37 + (1.663 * DSLt)	0.95	0.90	4.81	42.49	<0.001
Hand length (cm)	HT = 27.33 + (7.007 * HL)	0.85	0.72	8.06	22.71	<0.001
Hand breadth (cm)	HT = 57.82 + (9.185 * HB)	0.71	0.51	10.73	14.30	<0.001
Wrist breadth (cm)	HT = 72.22 + (9.866 * WRB)	0.67	0.45	11.32	12.77	<0.001
Thigh length (cm)	HT = 55.59 + (1.939 * ThL)	0.87	0.75	7.62	24.47	<0.001
Leg length (cm)	HT = 47.29 + (2.712 * LL)	0.85	0.73	7.95	23.13	<0.001
Foot length (cm)	HT = 16.23 + (5.683 * FL)	0.81	0.65	9.04	19.20	<0.001
Foot breadth (cm)	HT = 49.15 + (8.091 * FB)	0.75	0.56	10.15	15.86	<0.001
Ankle breadth (cm)	HT = 49.61 + (7.929 * AKB)	0.74	0.54	10.36	15.29	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.66: Linear regression equations for estimation of height from anthropometric parameters of NSZ (n = 400)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 128.63 + (1.147 * Age)	0.67	0.45	13.86	18.10	<0.001
Weight (kg)	HT = 110.17 + (0.809 * WT)	0.85	0.72	9.91	31.96	<0.001
Body mass index (kg/m^2)	HT = 108.80 + (2.015 * BMI)	0.55	0.30	15.69	12.96	<0.001
Sitting height (cm)	HT = 9.18 + (1.912 * SHt)	0.93	0.86	6.93	50.02	<0.001
Bigonial width (cm)	HT = 30.20 + (10.815 * BGW)	0.73	0.54	12.71	21.55	<0.001
Length of mandibular arch (cm)	HT = 32.56 + (6.138 * LOMA)	0.71	0.50	13.23	19.94	<0.001
Neck length (cm)	HT = 101.83 + (4.354 * NL)	0.42	0.18	16.97	9.25	<0.001
Biaxillary length (cm)	HT = 57.24 + (2.866 * BALt)	0.77	0.60	11.85	24.36	<0.001
Demispan length (cm)	HT = 19.59 + (1.610 * DSLt)	0.96	0.92	5.21	68.79	<0.001
Hand length (cm)	HT = 18.28 + (7.314 * HL)	0.92	0.85	7.31	46.98	<0.001
Hand breadth (cm)	HT = 43.21 + (10.252 * HB)	0.84	0.70	10.27	30.36	<0.001
Wrist breadth (cm)	HT = 54.27 + (11.417 * WRB)	0.73	0.54	12.69	21.61	<0.001
Thigh length (cm)	HT = 34.82 + (2.376 * ThL)	0.89	0.80	8.37	39.90	<0.001
Leg length (cm)	HT = 42.29 + (2.826 * LL)	0.88	0.78	8.86	37.11	<0.001
Foot length (cm)	HT = 7.57 + (6.022 * FL)	0.89	0.79	8.67	38.16	<0.001
Foot breadth (cm)	HT = 26.60 + (9.490 * FB)	0.82	0.67	10.82	28.12	<0.001
Ankle breadth (cm)	HT = 19.76 + (9.982 * AKB)	0.82	0.68	10.60	29.01	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.67: Linear regression equations for estimation of height from anthropometric parameters of NSZ males (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 126.51 + (1.393 * Age)	0.73	0.54	13.86	15.20	<0.001
Weight (kg)	HT = 104.92 + (0.962 * WT)	0.91	0.83	8.42	31.04	<0.001
Body mass index (kg/m^2)	HT = 85.10 + (3.329 * BMI)	0.64	0.42	15.61	11.85	<0.001
Sitting height (cm)	HT = 5.58 + (1.978 * SHt)	0.95	0.89	6.70	40.48	<0.001
Bigonial width (cm)	HT = 14.77 + (12.150 * BGW)	0.77	0.59	13.04	16.93	<0.001
Length of mandibular arch (cm)	HT = 4.97 + (7.636 * LOMA)	0.80	0.63	12.35	18.50	<0.001
Neck length (cm)	HT = 85.84 + (5.615 * NL)	0.46	0.22	18.07	7.37	<0.001
Biaxillary length (cm)	HT = 47.94 + (3.216 * BALt)	0.82	0.67	11.75	19.98	<0.001
Demispan length (cm)	HT = 17.78 + (1.630 * DSLt)	0.96	0.92	5.66	48.76	<0.001
Hand length (cm)	HT = 13.07 + (7.571 * HL)	0..93	0.87	7.33	36.55	<0.001
Hand breadth (cm)	HT = 32.61 + (10.988 * HB)	0.88	0.78	9.66	26.19	<0.001
Wrist breadth (cm)	HT = 46.56 + (12.325 * WRB)	0.75	0.56	13.62	15.70	<0.001
Thigh length (cm)	HT = 24.96 + (2.646 * ThL)	0.93	0.86	7.72	34.43	<0.001
Leg length (cm)	HT = 46.13 + (2.753 * LL)	0.87	0.76	9.92	25.28	<0.001
Foot length (cm)	HT = 5.39 + (6.102 * FL)	0.89	0.79	9.40	27.09	<0.001
Foot breadth (cm)	HT = 14.77 + (10.280 * FB)	0.83	0.69	11.40	20.88	<0.001
Ankle breadth (cm)	HT = 9.14 + (10.704 * AKB)	0.84	0.71	11.06	21.82	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.68: Linear regression equations for estimation of height from anthropometric parameters of NSZ females (n = 200)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 130.31 + (0.924 * Age)	0.63	0.40	12.81	11.39	<0.001
Weight (kg)	HT = 114.96 + (0.664 * WT)	0.81	0.65	9.74	19.18	<0.001
Body mass index (kg/m^2)	HT = 113.30 + (1.616 * BMI)	0.58	0.33	13.45	9.96	<0.001
Sitting height (cm)	HT = 16.59 + (1.792 * SHt)	0.91	0.83	6.79	31.14	<0.001
Bigonial width (cm)	HT = 47.16 + (9.276 * BGW)	0.67	0.45	12.18	12.82	<0.001
Length of mandibular arch (cm)	HT = 60.68 + (4.587 * LOMA)	0.61	0.37	13.10	10.74	<0.001
Neck length (cm)	HT = 114.07 + (3.263 * NL)	0.32	0.10	15.63	4.69	<0.001
Biaxillary length (cm)	HT = 68.68 + (2.447 * BALt)	0.73	0.54	11.22	15.13	<0.001
Demispan length (cm)	HT = 21.51 + (1.589 * DSLt)	0.96	0.92	4.73	46.90	<0.001
Hand length (cm)	HT = 23.82 + (7.025 * HL)	0.90	0.81	7.26	28.69	<0.001
Hand breadth (cm)	HT = 42.08 + (10.603 * HB)	0.78	0.61	10.27	17.65	<0.001
Wrist breadth (cm)	HT = 63.65 + (10.261 * WRB)	0.71	0.50	11.63	14.13	<0.001
Thigh length (cm)	HT = 43.66 + (2.129 * ThL)	0.90	0.81	7.14	29.24	<0.001
Leg length (cm)	HT = 38.59 + (2.899 * LL)	0.89	0.79	7.56	27.25	<0.001
Foot length (cm)	HT = 9.77 + (5.937 * FL)	0.88	0.77	7.90	25.75	<0.001
Foot breadth (cm)	HT = 35.15 + (8.906 * FB)	0.79	0.63	10.04	18.32	<0.001
Ankle breadth (cm)	HT = 28.84 + (9.340 * AKB)	0.79	0.63	10.01	18.40	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.69: Linear regression equations for estimation of height from anthropometric parameters of children in SSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 89.87 + (4.520 * Age)	0.69	0.48	7.68	9.47	<0.001
Weight (kg)	HT = 88.83 + (1.517 * WT)	0.79	0.62	6.57	12.58	<0.001
Body mass index (kg/m^2)	HT = 133.91 - (0.218 * BMI)	0.04	0.00	10.62	-0.39	0.698
Sitting height (cm)	HT = 48.07 + (1.266 * SHt.)	0.72	0.51	7.42	10.16	<0.001
Bigonial width (cm)	HT = 105.88 + (2.455 * BGW)	0.23	0.06	10.33	2.39	0.019
Length of mandibular arch (cm)	HT = 85.31 + (2.560 * LOMA)	0.37	0.14	9.88	3.93	<0.001
Neck length (cm)	HT = 102.93 + (2.597 * NL)	0.35	0.12	9.96	3.67	<0.001
Biaxillary length (cm)	HT = 78.22 + (1.912 * BALt)	0.49	0.24	9.27	5.54	<0.001
Demispan length (cm)	HT = 24.99 + (1.541 * DSLt)	0.86	0.74	5.38	16.85	<0.001
Hand length (cm)	HT = 41.38 + (5.704 * HL)	0.73	0.54	7.22	10.68	<0.001
Hand breadth (cm)	HT = 79.97 + (5.835 * HB)	0.48	0.23	9.33	5.41	<0.001
Wrist breadth (cm)	HT = 83.24 + (6.635 * WRB)	0.51	0.26	9.13	5.89	<0.001
Thigh length (cm)	HT = 60.88 + (1.659 * ThL)	0.72	0.51	7.42	10.14	<0.001
Leg length (cm)	HT = 69.76 + (1.842 * LL)	0.74	0.55	7.10	11.03	<0.001
Foot length (cm)	HT = 58.23 + (3.405 * FL)	0.67	0.45	7.87	8.97	<0.001
Foot breadth (cm)	HT = 70.08 + (5.183 * FB)	0.51	0.26	9.14	5.87	<0.001
Ankle breadth (cm)	HT = 70.31 + (5.141 * AKB)	0.52	0.27	9.10	5.96	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.70: Linear regression equations for estimation of height from anthropometric parameters of boys in SSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 91.85 + (4.184 * Age)	0.64	0.40	8.53	5.69	<0.001
Weight (kg)	HT = 84.99 + (1.605 * WT)	0.80	0.64	6.61	9.27	<0.001
Body mass index (kg/m^2)	HT = 132.66 - (0.233 * BMI)	0.04	0.00	11.03	-0.27	0.788
Sitting height (cm)	HT = 56.95 + (1.110 * SHt)	0.62	0.38	8.70	5.41	<0.001
Bigonial width (cm)	HT = 98.53 + (3.004 * BGW)	0.27	0.08	10.62	1.98	0.054
Length of mandibular arch (cm)	HT = 92.27 + (2.126 * LOMA)	0.29	0.08	10.57	2.09	0.042
Neck length (cm)	HT = 94.38 + (3.221 * NL)	0.39	0.15	10.16	2.95	0.005
Biaxillary length (cm)	HT = 69.63 + (2.175 * BALt)	0.58	0.34	9.00	4.92	<0.001
Demispan length (cm)	HT = 27.83 + (1.500 * DSLt)	0.82	0.67	6.39	9.76	<0.001
Hand length (cm)	HT = 38.40 + (5.897 * HL)	0.71	0.51	7.74	7.05	<0.001
Hand breadth (cm)	HT = 78.67 + (5.807 * HB)	0.49	0.24	9.63	3.89	<0.001
Wrist breadth (cm)	HT = 78.32 + (7.156 * WRB)	0.57	0.32	9.09	4.78	<0.001
Thigh length (cm)	HT = 55.92 + (1.811 * ThL)	0.64	0.41	8.52	5.71	<0.001
Leg length (cm)	HT = 71.26 + (1.789 * LL)	0.71	0.50	7.79	6.95	<0.001
Foot length (cm)	HT = 56.22 + (3.479 * FL)	0.73	0.53	7.61	7.29	<0.001
Foot breadth (cm)	HT = 57.32 + (6.144 * FB)	0.60	0.36	8.85	5.18	<0.001
Ankle breadth (cm)	HT = 47.75 + (6.931 * AKB)	0.68	0.46	8.09	6.44	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.71: Linear regression equations for estimation of height from anthropometric parameters of girls in SSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 88.44 + (4.784 * Age)	0.75	0.57	6.71	7.89	<0.001
Weight (kg)	HT = 92.84 + (1.423 * WT)	0.79	0.62	6.29	8.79	<0.001
Body mass index (kg/m^2)	HT = 130.97 + (0.065 * BMI)	0.01	0.00	10.17	0.09	0.932
Sitting height (cm)	HT = 40.02 + (1.407 * SHt)	0.83	0.69	5.65	10.37	<0.001
Bigonial width (cm)	HT = 109.41 + (2.282 * BGW)	0.23	0.05	9.89	1.65	0.106
Length of mandibular arch (cm)	HT = 81.28 + (2.810 * LOMA)	0.41	0.17	9.29	3.08	0.003
Neck length (cm)	HT = 107.78 + (2.314 * NL)	0.35	0.12	9.55	2.55	0.014
Biaxillary length (cm)	HT = 90.31 + (1.523 * BALt)	0.38	0.14	9.42	2.83	0.007
Demispan length (cm)	HT = 21.51 + (1.590 * DSLt)	0.91	0.83	4.25	15.05	<0.001
Hand length (cm)	HT = 44.44 + (5.513 * HL)	0.74	0.55	6.82	7.67	<0.001
Hand breadth (cm)	HT = 81.41 + (5.846 * HB)	0.48	0.23	8.94	3.77	<0.001
Wrist breadth (cm)	HT = 90.81 + (5.751 * WRB)	0.44	0.19	9.15	3.37	0.001
Thigh length (cm)	HT = 56.32 + (1.737 * ThL)	0.80	0.65	6.05	9.37	<0.001
Leg length (cm)	HT = 68.61 + (1.883 * LL)	0.77	0.60	6.47	8.39	<0.001
Foot length (cm)	HT = 63.05 + (3.202 * FL)	0.59	0.34	8.25	4.10	<0.001
Foot breadth (cm)	HT = 83.71 + (4.147 * FB)	0.42	0.18	9.22	3.23	0.002
Ankle breadth (cm)	HT = 93.10 + (3.329 * AKB)	0.35	0.12	9.53	2.59	0.013

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.72: Linear regression equations for estimation of height from anthropometric parameters of children in CSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 91.62 + (4.413 * Age)	0.76	0.57	7.07	11.46	<0.001
Weight (kg)	HT = 87.47 + (1.550 * WT)	0.85	0.73	5.63	16.21	<0.001
Body mass index (kg/m^2)	HT = 112.75 + (1.040 * BMI)	0.17	0.03	10.65	1.73	0.087
Sitting height (cm)	HT = 30.45 + (1.532 * SHt)	0.73	0.53	7.38	10.60	<0.001
Bigonial width (cm)	HT = 81.02 + (4.834 * BGW)	0.47	0.22	9.56	5.22	<0.001
Length of mandibular arch (cm)	HT = 52.23 + (4.615 * LOMA)	0.53	0.28	9.18	6.16	<0.001
Neck length (cm)	HT = 111.95 + (1.467 * NL)	0.23	0.05	10.53	2.30	0.024
Biaxillary length (cm)	HT = 69.82 + (2.137 * BALt)	0.56	0.32	8.93	6.75	<0.001
Demispan length (cm)	HT = 33.88 + (1.402 * DSLt)	0.83	0.70	5.97	14.95	<0.001
Hand length (cm)	HT = 24.63 + (6.815 * HL)	0.86	0.73	5.58	16.43	<0.001
Hand breadth (cm)	HT = 73.25 + (6.256 * HB)	0.54	0.29	9.11	6.32	<0.001
Wrist breadth (cm)	HT = 75.93 + (7.573 * WRB)	0.55	0.30	9.50	6.46	<0.001
Thigh length (cm)	HT = 66.52 + (1.581 * ThL)	0.77	0.59	6.90	11.95	<0.001
Leg length (cm)	HT = 59.14 + (2.173 * LL)	0.80	0.64	6.49	13.18	<0.001
Foot length (cm)	HT = 37.64 + (4.303 * FL)	0.83	0.69	6.05	14.66	<0.001
Foot breadth (cm)	HT = 64.61 + (5.789 * FB)	0.55	0.30	9.06	6.43	<0.001
Ankle breadth (cm)	HT = 56.54 + (6.442 * AKB)	0.60	0.36	8.65	7.43	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.73: Linear regression equations for estimation of height from anthropometric parameters of boys in CSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 92.08 + (4.210 * Age)	0.76	0.58	6.77	8.18	<0.001
Weight (kg)	HT = 82.75 + (1.730 * WT)	0.87	0.76	5.12	12.34	<0.001
Body mass index (kg/m^2)	HT = 116.66 + (0.777 * BMI)	0.11	0.01	10.40	0.78	0.437
Sitting height (cm)	HT = 35.58 + (1.451 * SHt)	0.75	0.56	6.98	7.73	<0.001
Bigonial width (cm)	HT = 78.11 + (5.092 * BGW)	0.50	0.25	9.08	3.96	<0.001
Length of mandibular arch (cm)	HT = 42.75 + (5.112 * LOMA)	0.51	0.26	9.30	4.05	<0.001
Neck length (cm)	HT = 116.62 + (1.012 * NL)	0.15	0.02	10.34	1.08	0.285
Biaxillary length (cm)	HT = 76.05 + (1.933 * BALt)	0.54	0.29	8.83	4.41	<0.001
Demispan length (cm)	HT = 49.72 + (1.157 * DSLt)	0.76	0.57	6.86	7.99	<0.001
Hand length (cm)	HT = 13.92 + (7.507 * HL)	0.87	0.76	5.12	12.35	<0.001
Hand breadth (cm)	HT = 67.62 + (6.750 * HB)	0.57	0.33	8.57	4.86	<0.001
Wrist breadth (cm)	HT = 76.18 + (7.342 * WRB)	0.54	0.29	8.83	4.40	<0.001
Thigh length (cm)	HT = 70.34 + (1.491 * ThL)	0.77	0.60	6.63	8.46	<0.001
Leg length (cm)	HT = 58.03 + (2.200 * LL)	0.80	0.63	6.35	9.08	<0.001
Foot length (cm)	HT = 38.18 + (4.234 * FL)	0.86	0.75	5.28	11.85	<0.001
Foot breadth (cm)	HT = 52.65 + (6.620 * FB)	0.67	0.45	7.73	6.32	<0.001
Ankle breadth (cm)	HT = 44.59 + (7.318 * AKB)	0.75	0.56	6.98	7.73	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.74: Linear regression equations for estimation of height from anthropometric parameters of girls in CSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 89.58 + (4.815 * Age)	0.77	0.60	7.20	8.44	<0.001
Weight (kg)	HT = 90.43 + (1.438 * WT)	0.84	0.71	6.09	10.90	<0.001
Body mass index (kg/m^2)	HT = 110.89 + (1.175 * BMI)	0.21	0.05	11.09	1.51	0.137
Sitting height (cm)	HT = 24.67 + (1.623 * SHt)	0.72	0.52	7.87	7.20	<0.001
Bigonial width (cm)	HT = 83.65 + (4.603 * BGW)	0.44	0.19	10.19	3.40	0.001
Length of mandibular arch (cm)	HT = 54.71 + (4.531 * LOMA)	0.57	0.32	9.36	4.75	<0.001
Neck length (cm)	HT = 105.05 + (2.147 * NL)	0.32	0.10	10.76	2.31	0.025
Biaxillary length (cm)	HT = 60.71 + (2.437 * BALt)	0.60	0.36	9.12	5.14	<0.001
Demispan length (cm)	HT = 12.35 + (1.735 * DSLt)	0.93	0.87	4.09	17.95	<0.001
Hand length (cm)	HT = 31.68 + (6.365 * HL)	0.85	0.72	6.01	11.09	<0.001
Hand breadth (cm)	HT = 75.29 + (6.153 * HB)	0.53	0.28	9.65	4.28	<0.001
Wrist breadth (cm)	HT = 71.23 + (8.456 * WRB)	0.59	0.34	9.20	5.01	<0.001
Thigh length (cm)	HT = 61.90 + (1.688 * ThL)	0.77	0.59	7.24	8.36	<0.001
Leg length (cm)	HT = 60.12 + (2.150 * LL)	0.80	0.65	6.75	9.36	<0.001
Foot length (cm)	HT = 35.65 + (4.443 * FL)	0.81	0.65	6.70	9.48	<0.001
Foot breadth (cm)	HT = 55.14 + (6.882 * FB)	0.52	0.27	9.72	4.17	<0.001
Ankle breadth (cm)	HT = 59.93 + (6.301 * AKB)	0.51	0.23	9.80	4.05	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.75: Linear regression equations for estimation of height from anthropometric parameters of children in NSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 88.38 + (4.565 * Age)	0.79	0.63	7.14	12.88	<0.001
Weight (kg)	HT = 90.14 + (1.344 * WT)	0.85	0.73	6.11	16.21	<0.001
Body mass index (kg/m^2)	HT = 97.08 + (1.720 * BMI)	0.35	0.12	10.99	3.66	<0.001
Sitting height (cm)	HT = 5.81 + (1.921 * SHt)	0.80	0.64	6.99	13.32	<0.001
Bigonial width (cm)	HT = 53.37 + (7.249 * BGW)	0.53	0.28	9.93	6.19	<0.001
Length of mandibular arch (cm)	HT = 72.53 + (3.066 * LOMA)	0.40	0.16	10.76	4.27	<0.001
Neck length (cm)	HT = 103.54 + (2.021 * NL)	0.32	0.11	11.08	3.39	0.001
Biaxillary length (cm)	HT = 55.35 + (2.574 * BALt)	0.67	0.45	8.73	8.86	<0.001
Demispan length (cm)	HT = 24.40 + (1.516 * DSLt)	0.91	0.82	4.98	21.07	<0.001
Hand length (cm)	HT = 37.05 + (5.803 * HL)	0.84	0.70	6.44	15.05	<0.001
Hand breadth (cm)	HT = 60.30 + (7.286 * HB)	0.71	0.51	8.25	9.99	<0.001
Wrist breadth (cm)	HT = 77.80 + (6.463 * WRB)	0.60	0.35	9.41	7.34	<0.001
Thigh length (cm)	HT = 53.43 + (1.797 * ThL)	0.82	0.66	6.79	13.92	<0.001
Leg length (cm)	HT = 54.60 + (2.243 * LL)	0.78	0.60	7.39	12.18	<0.001
Foot length (cm)	HT = 34.57 + (4.431 * FL)	0.84	0.71	6.35	15.36	<0.001
Foot breadth (cm)	HT = 53.91 + (6.295 * FB)	0.69	0.48	8.48	9.45	<0.001
Ankle breadth (cm)	HT = 47.45 + (6.800 * AKB)	0.72	0.52	8.14	10.25	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.76: Linear regression equations for estimation of height from anthropometric parameters of boys in NSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 90.34 + (4.278 * Age)	0.79	0.63	7.46	9.02	<0.001
Weight (kg)	HT = 88.23 + (1.416 * WT)	0.84	0.70	6.72	10.56	<0.001
Body mass index (kg/m^2)	HT = 107.12 + (1.147 * BMI)	0.23	0.05	11.94	1.60	0.116
Sitting height (cm)	HT = -0.95 + (2.026 * SHt)	0.84	0.71	6.62	10.80	<0.001
Bigonial width (cm)	HT = 55.50 + (6.974 * BGW)	0.44	0.20	10.98	3.42	0.001
Length of mandibular arch (cm)	HT = 46.50 + (4.639 * LOMA)	0.49	0.24	10.71	3.84	<0.001
Neck length (cm)	HT = 105.30 + (1.838 * NL)	0.24	0.06	11.89	1.73	0.090
Biaxillary length (cm)	HT = 44.43 + (3.000 * BALt)	0.63	0.40	9.52	5.61	<0.001
Demispan length (cm)	HT = 23.34 + (1.524 * DSLt)	0.87	0.76	6.04	12.22	<0.001
Hand length (cm)	HT = 36.98 + (5.804 * HL)	0.80	0.64	7.38	9.18	<0.001
Hand breadth (cm)	HT = 54.94 + (7.828 * HB)	0.70	0.49	8.73	6.82	<0.001
Wrist breadth (cm)	HT = 83.69 + (5.655 * WRB)	0.47	0.22	10.79	3.73	<0.001
Thigh length (cm)	HT = 50.81 + (1.893 * ThL)	0.79	0.63	7.45	9.04	<0.001
Leg length (cm)	HT = 65.95 + (1.906 * LL)	0.68	0.47	8.96	6.46	<0.001
Foot length (cm)	HT = 29.35 + (4.710 * FL)	0.82	0.68	6.96	10.04	<0.001
Foot breadth (cm)	HT = 49.08 + (6.663 * FB)	0.61	0.37	9.71	5.33	<0.001
Ankle breadth (cm)	HT = 40.85 + (7.337 * AKB)	0.67	0.45	9.11	6.23	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.77: Linear regression equations for estimation of height from anthropometric parameters of girls in NSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 84.44 + (5.129 * Age)	0.80	0.64	6.83	9.18	<0.001
Weight (kg)	HT = 91.74 + (1.280 * WT)	0.87	0.76	5.52	12.43	<0.001
Body mass index (kg/m^2)	HT = 87.58 + (2.276 * BMI)	0.47	0.22	9.99	3.70	<0.001
Sitting height (cm)	HT = 13.07 + (1.805 * SHt)	0.75	0.57	7.44	7.96	<0.001
Bigonial width (cm)	HT = 48.29 + (7.843 * BGW)	0.62	0.38	8.92	5.42	<0.001
Length of mandibular arch (cm)	HT = 86.09 + (2.221 * LOMA)	0.34	0.12	10.65	2.52	0.015
Neck length (cm)	HT = 101.49 + (2.257 * NL)	0.39	0.15	10.44	2.91	0.005
Biaxillary length (cm)	HT = 61.18 + (2.332 * BALt)	0.72	0.52	7.82	7.17	<0.001
Demispan length (cm)	HT = 24.10 + (1.528 * DSLt)	0.95	0.89	3.69	20.10	<0.001
Hand length (cm)	HT = 37.03 + (5.808 * HL)	0.88	0.77	5.49	12.51	<0.001
Hand breadth (cm)	HT = 63.82 + (6.929 * HB)	0.72	0.52	7.86	7.20	<0.001
Wrist breadth (cm)	HT = 72.82 + (7.182 * WRB)	0.71	0.51	7.94	7.05	<0.001
Thigh length (cm)	HT = 55.05 + (1.727 * ThL)	0.85	0.73	5.94	11.25	<0.001
Leg length (cm)	HT = 39.99 + (2.687 * LL)	0.90	0.80	5.02	14.00	<0.001
Foot length (cm)	HT = 39.18 + (4.180 * FL)	0.86	0.75	5.71	11.89	<0.001
Foot breadth (cm)	HT = 55.45 + (6.209 * FB)	0.77	0.60	7.18	8.46	<0.001
Ankle breadth (cm)	HT = 51.07 + (6.510 * AKB)	0.77	0.60	7.17	8.48	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.78: Linear regression equations for estimation of height from anthropometric parameters of adolescents in SSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 109.23 + (3.017 * Age)	0.53	0.28	8.10	6.23	<0.001
Weight (kg)	HT = 120.34 + (0.708 * WT)	0.68	0.46	7.05	9.08	<0.001
Body mass index (kg/m^2)	HT = 142.30 + (0.515 * BMI)	0.15	0.02	9.45	1.54	0.127
Sitting height (cm)	HT = 62.03 + (1.227 * SHt)	0.62	0.38	7.51	7.82	<0.001
Bigonial width (cm)	HT = 101.84 + (4.570 * BGW)	0.42	0.18	8.68	4.57	<0.001
Length of mandibular arch (cm)	HT = 106.46 + (2.363 * LOMA)	0.37	0.14	8.88	3.96	<0.001
Neck length (cm)	HT = 139.28 + (1.144 * NL)	0.17	0.03	9.42	1.73	0.087
Biaxillary length (cm)	HT = 107.35 + (1.438 * BALt)	0.48	0.23	8.40	5.40	<0.001
Demispan length (cm)	HT = 48.24 + (1.282 * DSLt)	0.72	0.52	6.66	10.21	<0.001
Hand length (cm)	HT = 70.56 + (4.481 * HL)	0.63	0.39	7.45	7.97	<0.001
Hand breadth (cm)	HT = 125.54 + (2.680 * HB)	0.28	0.08	9.17	2.92	0.004
Wrist breadth (cm)	HT = 134.60 + (2.168 * WRB)	0.17	0.03	9.42	1.72	0.088
Thigh length (cm)	HT = 94.29 + (1.142 * ThL)	0.57	0.32	7.87	6.85	<0.001
Leg length (cm)	HT = 74.70 + (1.984 * LL)	0.64	0.41	7.33	8.31	<0.001
Foot length (cm)	HT = 78.20 + (3.017 * FL)	0.56	0.32	7.92	6.71	<0.001
Foot breadth (cm)	HT = 90.59 + (4.671 * FB)	0.41	0.17	8.71	4.49	<0.001
Ankle breadth (cm)	HT = 85.43 + (5.066 * AKB)	0.43	0.19	8.62	4.75	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.79: Linear regression equations for estimation of height from anthropometric parameters of adolescent males in SSZ (n= 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 93.22 + (4.101 * Age)	0.60	0.36	9.18	5.21	<0.001
Weight (kg)	HT = 109.82 + (0.994 * WT)	0.76	0.57	7.53	7.97	<0.001
Body mass index (kg/m^2)	HT = 140.07 + (0.644 * BMI)	0.13	0.02	11.39	0.89	0.377
Sitting height (cm)	HT = 42.35 + (1.514 * SHt)	0.62	0.39	8.99	5.50	<0.001
Bigonial width (cm)	HT = 82.75 + (6.147 * BGW)	0.49	0.24	10.02	3.89	<0.001
Length of mandibular arch (cm)	HT = 77.68 + (3.900 * LOMA)	0.44	0.19	10.32	3.38	0.001
Neck length (cm)	HT = 125.72 + (2.179 * NL)	0.26	0.07	11.10	1.84	0.072
Biaxillary length (cm)	HT = 99.22 + (1.687 * BALt)	0.51	0.26	9.90	4.07	<0.001
Demispan length (cm)	HT = 46.23 + (1.317 * DSLt)	0.72	0.52	7.98	7.17	<0.001
Hand length (cm)	HT = 49.43 + (5.587 * HL)	0.69	0.48	8.28	6.66	<0.001
Hand breadth (cm)	HT = 107.48 + (4.293 * HB)	0.44	0.19	10.34	3.34	0.002
Wrist breadth (cm)	HT = 119.45 + (3.885 * WRB)	0.29	0.08	10.10	2.09	0.042
Thigh length (cm)	HT = 85.74 + (1.358 * ThL)	0.59	0.35	9.28	5.05	<0.001
Leg length (cm)	HT = 74.09 + (1.989 * LL)	0.63	0.40	8.93	5.60	<0.001
Foot length (cm)	HT = 63.76 + (3.578 * FL)	0.64	0.40	8.86	5.71	<0.001
Foot breadth (cm)	HT = 73.98 + (5.832 * FB)	0.42	0.18	10.41	3.23	0.002
Ankle breadth (cm)	HT = 63.89 + (6.618 * AKB)	0.46	0.21	10.22	3.55	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.80: Linear regression equations for estimation of height from anthropometric parameters of adolescent females in SSZ (= 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 124.33 + (1.994 * Age)	0.47	0.22	6.53	3.65	<0.001
Weight (kg)	HT = 126.58 + (0.546 * WT)	0.65	0.42	5.61	5.92	<0.001
Body mass index (kg/m^2)	HT = 143.14 + (0.469 * BMI)	0.19	0.04	7.25	1.33	0.191
Sitting height (cm)	HT = 73.60 + (1.059 * SHt)	0.68	0.46	5.43	6.39	<0.001
Bigonial width (cm)	HT = 115.55 + (3.432 * BGW)	0.38	0.14	6.84	2.81	0.007
Length of mandibular arch (cm)	HT = 122.62 + (1.523 * LOMA)	0.34	0.11	6.95	2.47	0.017
Neck length (cm)	HT = 142.99 + (0.908 * NL)	0.16	0.02	7.29	1.09	0.283
Biaxillary length (cm)	HT = 118.41 + (1.097 * BALt)	0.44	0.19	6.62	3.40	0.001
Demispan length (cm)	HT = 46.56 + (1.293 * DSLt)	0.73	0.53	5.05	7.37	<0.001
Hand length (cm)	HT = 94.79 + (3.194 * HL)	0.55	0.30	6.17	4.55	<0.001
Hand breadth (cm)	HT = 149.95 + (0.289 * HB)	0.03	0.00	7.38	0.19	0.853
Wrist breadth (cm)	HT = 155.19 - (0.310 * WRB)	0.03	0.00	7.38	-0.18	0.859
Thigh length (cm)	HT = 77.24 + (1.427 * ThL)	0.67	0.45	5.48	6.25	<0.001
Leg length (cm)	HT = 75.61 + (1.972 * LL)	0.68	0.46	5.43	6.38	<0.001
Foot length (cm)	HT = 103.10 + (2.026 * FL)	0.42	0.17	6.71	3.16	0.003
Foot breadth (cm)	HT = 100.27 + (4.016 * FB)	0.46	0.22	6.54	3.62	<0.001
Ankle breadth (cm)	HT =100.93 + (3.954 * AKB)	0.45	0.21	6.58	3.53	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.81: Linear regression equations for estimation of height from anthropometric parameters of adolescents in CSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 102.91 + (3.644 * Age)	0.60	0.36	8.62	7.38	<0.001
Weight (kg)	HT = 118.60 + (0.784 * WT)	0.73	0.54	7.34	10.61	<0.001
Body mass index (kg/m^2)	HT = 146.70 + (0.464 * BMI)	0.13	0.02	10.67	1.26	0.210
Sitting height (cm)	HT = 17.26 + (1.839 * SHt)	0.76	0.58	6.95	11.69	<0.001
Bigonial width (cm)	HT = 146.36 + (0.851 * BGW)	0.07	0.01	10.73	0.69	0.491
Length of mandibular arch (cm)	HT = 112.12 + (2.342 * LOMA)	0.34	0.12	10.10	3.62	<0.001
Neck length (cm)	HT = 126.19 + (2.288 * NL)	0.33	0.11	10.15	3.46	<0.001
Biaxillary length (cm)	HT = 113.55 + (1.264 * BALt)	0.40	0.16	9.85	4.33	<0.001
Demispan length (cm)	HT = 37.77 + (1.421 * DSLt)	0.88	0.77	5.15	18.13	<0.001
Hand length (cm)	HT = 52.78 + (5.564 * HL)	0.74	0.55	7.24	10.86	<0.001
Hand breadth (cm)	HT = 85.53 + (6.630 * HB)	0.58	0.34	8.77	7.03	<0.001
Wrist breadth (cm)	HT = 89.13 + (8.057 * WRB)	0.60	0.36	8.59	7.46	<0.001
Thigh length (cm)	HT = 80.91 + (1.492 * ThL)	0.64	0.42	8.22	8.34	<0.001
Leg length (cm)	HT = 70.50 + (2.130 * LL)	0.69	0.48	7.79	9.41	<0.001
Foot length (cm)	HT = 62.69 + (3.709 * FL)	0.62	0.38	8.48	7.73	<0.001
Foot breadth (cm)	HT = 93.91 + (4.608 * FB)	0.50	0.25	9.34	5.64	<0.001
Ankle breadth (cm)	HT = 90.36 + (4.821 * AKB)	0.48	0.23	9.43	5.43	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.82: Linear regression equations for estimation of height from anthropometric parameters of adolescent males in CSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 80.07 + (5.273 * Age)	0.70	0.49	8.98	6.76	<0.001
Weight (kg)	HT = 112.37 + (0.961 * WT)	0.84	0.70	6.83	10.67	<0.001
Body mass index (kg/m^2)	HT = 132.34 + (1.348 * BMI)	0.27	0.07	12.08	1.94	0.058
Sitting height (cm)	HT = 19.93 + (1.822 * SHt)	0.76	0.58	8.13	8.13	<0.001
Bigonial width (cm)	HT = 157.00 + (0.053 * BGW)	0.00	0.00	12.54	0.03	0.980
Length of mandibular arch (cm)	HT = 67.20 + (4.901 * LOMA)	0.57	0.33	10.30	4.81	<0.001
Neck length (cm)	HT = 130.59 + (2.039 * NL)	0.23	0.05	12.21	1.63	0.110
Biaxillary length (cm)	HT = 85.63 + (2.182 * BALt)	0.58	0.34	10.23	4.91	<0.001
Demispan length (cm)	HT = 29.75 + (1.509 * DSLt)	0.89	0.79	5.72	13.52	<0.001
Hand length (cm)	HT = 50.22 + (5.668 * HL)	0.75	0.57	8.27	7.89	<0.001
Hand breadth (cm)	HT = 75.32 + (7.561 * HB)	0.60	0.36	10.05	5.17	<0.001
Wrist breadth (cm)	HT = 67.71 + (10.598 * WRB)	0.70	0.48	9.02	6.70	<0.001
Thigh length (cm)	HT = 58.73 + (2.020 * ThL)	0.76	0.58	8.14	8.12	<0.001
Leg length (cm)	HT = 56.44 + (2.499 * LL)	0.71	0.51	8.80	7.04	<0.001
Foot length (cm)	HT = 34.70 + (4.770 * FL)	0.73	0.54	8.55	7.44	<0.001
Foot breadth (cm)	HT = 74.16 + (5.976 * FB)	0.53	0.28	10.62	4.36	<0.001
Ankle breadth (cm)	HT = 75.08 + (5.902 * AKB)	0.50	0.25	10.84	4.04	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.83: Linear regression equations for estimation of height from anthropometric parameters of adolescent females in CSZ (n =50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 122.23 + (2.213 * Age)	0.49	0.24	7.35	3.90	<0.001
Weight (kg)	HT = 127.70 + (0.549 * WT)	0.60	0.36	6.75	5.20	<0.001
Body mass index (kg/m^2)	HT = 149.53 + (0.212 * BMI)	0.08	0.01	8.41	0.56	0.576
Sitting height (cm)	HT = 17.71 + (1.814 * SHt)	0.78	0.60	5.31	8.55	<0.001
Bigonial width (cm)	HT = 137.94 + (1.449 * BGW)	0.16	0.03	8.32	1.12	0.270
Length of mandibular arch (cm)	HT = 140.25 + (0.721 * LOMA)	0.15	0.02	8.35	1.02	0.313
Neck length (cm)	HT = 126.54 + (2.172 * NL)	0.42	0.18	7.65	3.22	0.002
Biaxillary length (cm)	HT = 134.36 + (0.577 * BALt)	0.24	0.06	8.19	1.72	0.093
Demispan length (cm)	HT = 46.82 + (1.315 * DSLt)	0.85	0.72	4.50	11.00	<0.001
Hand length (cm)	HT = 48.76 + (5.819 * HL)	0.68	0.47	6.16	6.49	<0.001
Hand breadth (cm)	HT = 99.76 + (5.255 * HB)	0.49	0.24	7.34	3.93	<0.001
Wrist breadth (cm)	HT = 115.49 + (4.762 * WRB)	0.42	0.17	7.68	3.16	0.003
Thigh length (cm)	HT = 84.54 + (1.349 * ThL)	0.69	0.48	6.08	6.66	<0.001
Leg length (cm)	HT = 89.06 + (1.639 * LL)	0.66	0.43	6.37	6.01	<0.001
Foot length (cm)	HT = 103.57 + (2.059 * FL)	0.33	0.11	7.97	2.40	0.020
Foot breadth (cm)	HT = 109.15 + (3.473 * FB)	0.38	0.14	7.82	2.81	0.007
Ankle breadth (cm)	HT = 107.91 + (3.496 * AKB)	0.38	0.14	7.82	2.80	0.007

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.84: Linear regression equations for estimation of height from anthropometric parameters of adolescents in NSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 101.54 + (3.776 * Age)	0.63	0.39	8.03	7.95	<0.001
Weight (kg)	HT = 120.77 + (0.722 * WT)	0.66	0.44	7.71	8.75	<0.001
Body mass index (kg/m^2)	HT = 154.28 + (0.0428 * BMI)	0.01	0.00	10.29	0.12	0.901
Sitting height (cm)	HT = 47.68 + (1.437 * SHt)	0.82	0.67	5.89	14.19	<0.001
Bigonial width (cm)	HT = 116.22 + (3.509 * BGW)	0.32	0.10	9.75	3.36	0.001
Length of mandibular arch (cm)	HT = 98.24 + (2.972 * LOMA)	0.39	0.15	9.50	4.13	<0.001
Neck length (cm)	HT = 122.48 + (2.788 * NL)	0.41	0.17	9.40	4.43	<0.001
Biaxillary length (cm)	HT = 100.84 + (1.687 * BALt)	0.57	0.33	8.45	6.88	<0.001
Demispan length (cm)	HT = 23.88 + (1.569 * DSLt)	0.88	0.78	4.82	18.70	<0.001
Hand length (cm)	HT = 34.78 + (6.455 * HL)	0.80	0.64	6.15	13.27	<0.001
Hand breadth (cm)	HT = 79.32 + (7.172 * HB)	0.70	0.47	7.49	9.34	<0.001
Wrist breadth (cm)	HT = 110.68 + (5.235 * WRB)	0.49	0.24	9.00	5.49	<0.001
Thigh length (cm)	HT = 75.25 + (1.586 * ThL)	0.70	0.49	7.37	9.65	<0.001
Leg length (cm)	HT = 94.51 + (1.543 * LL)	0.64	0.41	7.92	8.22	<0.001
Foot length (cm)	HT = 61.46 + (3.798 * FL)	0.62	0.39	8.05	7.89	<0.001
Foot breadth (cm)	HT = 82.61 + (5.410 * FB)	0.52	0.27	8.78	6.07	<0.001
Ankle breadth (cm)	HT = 74.60 + (5.987 * AKB)	0.55	0.31	8.57	6.58	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.85: Linear regression equations for estimation of height from anthropometric parameters of adolescent males in NSZ (n =50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 73.41 + (5.756 * Age)	0.78	0.60	8.06	8.54	<0.001
Weight (kg)	HT = 109.57 + (0.971 * WT)	0.77	0.60	8.10	8.47	<0.001
Body mass index (kg/m^2)	HT = 152.99 + (0.0700 * BMI)	0.02	0.00	12.78	0.11	0.914
Sitting height (cm)	HT = 33.26 + (1.650 * SHt)	0.91	0.82	5.41	14.82	<0.001
Bigonial width (cm)	HT = 73.47 + (7.265 * BGW)	0.54	0.29	10.76	4.45	<0.001
Length of mandibular arch (cm)	HT = 28.84 + (6.633 * LOMA)	0.56	0.31	10.60	4.67	<0.001
Neck length (cm)	HT = 101.61 + (4.336 * NL)	0.51	0.26	10.10	4.11	<0.001
Biaxillary length (cm)	HT = 82.49 + (2.273 * BALt)	0.69	0.48	9.20	6.69	<0.001
Demispan length (cm)	HT = 16.43 + (1.656 * DSLt)	0.95	0.90	4.10	20.49	<0.001
Hand length (cm)	HT = 22.34 + (7.076 * HL)	0.88	0.78	5.99	13.06	<0.001
Hand breadth (cm)	HT = 49.23 + (9.750 * HB)	0.81	0.66	7.44	9.68	<0.001
Wrist breadth (cm)	HT = 87.40 + (7.856 * WRB)	0.59	0.35	10.31	5.08	<0.001
Thigh length (cm)	HT = 37.83 + (2.398 * ThL)	0.82	0.67	7.36	9.84	<0.001
Leg length (cm)	HT = 91.83 + (1.609 * LL)	0.68	0.46	9.37	6.43	<0.001
Foot length (cm)	HT = 36.47 + (4.743 * FL)	0.77	0.58	8.30	8.11	<0.001
Foot breadth (cm)	HT = 51.29 + (7.549 * FB)	0.65	0.42	9.72	5.92	<0.001
Ankle breadth (cm)	HT = 42.10 + (8.192 * AKB)	0.68	0.47	9.34	6.47	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.86: Linear regression equations for estimation of height from anthropometric parameters of adolescent females in NSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 130.99 + (1.741 * Age)	0.42	0.17	6.52	3.17	0.003
Weight (kg)	HT = 137.22 + (0.381 * WT)	0.46	0.21	6.39	3.55	<0.001
Body mass index (kg/m^2)	HT = 157.03 - (0.055 * BMI)	0.02	0.00	7.17	-0.17	0.867
Sitting height (cm)	HT = 78.03 + (1.023 * SHt)	0.59	0.35	5.78	5.08	<0.001
Bigonial width (cm)	HT = 157.58 - (0.150 * BGW)	0.02	0.00	7.17	-0.14	0.891
Length of mandibular arch (cm)	HT = 133.67 + (1.149 * LOMA)	0.25	0.06	6.95	1.76	0.085
Neck length (cm)	HT = 133.67 + (1.977 * NL)	0.39	0.15	6.62	2.89	0.006
Biaxillary length (cm)	HT = 133.08 + (0.697 * BALt)	0.29	0.08	6.87	2.09	0.042
Demispan length (cm)	HT = 51.36 + (1.245 * DSLt)	0.67	0.45	5.34	6.22	<0.001
Hand length (cm)	HT = 72.64 + (4.470 * HL)	0.55	0.31	5.98	4.59	<0.001
Hand breadth (cm)	HT = 108.19 + (4.607 * HB)	0.56	0.31	5.96	4.64	<0.001
Wrist breadth (cm)	HT = 133.29 + (2.675 * WRB)	0.36	0.13	6.70	2.66	0.011
Thigh length (cm)	HT = 98.80 + (1.096 * ThL)	0.62	0.38	5.64	5.44	<0.001
Leg length (cm)	HT = 105.47 + (1.269 * LL)	0.48	0.23	6.28	3.82	<0.001
Foot length (cm)	HT = 116.39 + (1.616 * FL)	0.28	0.08	6.89	2.02	0.049
Foot breadth (cm)	HT = 113.83 + (3.198 * FB)	0.37	0.14	6.67	2.74	0.009
Ankle breadth (cm)	HT = 106.51 + (3.743 * AKB)	0.40	0.16	6.58	3.01	0.004

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.87: Linear regression equations for estimation of height from anthropometric parameters of young adults in SSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 165.85 - (0.065 * Age)	0.02	0.00	8.91	-0.22	0.831
Weight (kg)	HT = 135.38 + (0.468 * WT)	0.49	0.24	7.79	5.52	<0.001
Body mass index (kg/m^2)	HT = 179.96 - (0.675 * BMI)	0.25	0.06	8.63	-2.55	0.012
Sitting height (cm)	HT = 91.31 + (0.910 * SHt)	0.49	0.24	7.79	5.51	<0.001
Bigonial width (cm)	HT = 116.54 + (4.072 * BGW)	0.46	0.21	7.94	5.05	<0.001
Length of mandibular arch (cm)	HT = 126.80 + (1.792 * LOMA)	0.29	0.08	8.54	2.98	0.004
Neck length (cm)	HT = 124.15 + (3.388 * NL)	0.61	0.37	7.06	7.65	<0.001
Biaxillary length (cm)	HT = 154.05 + (0.297 * BALt)	0.09	0.01	8.88	0.92	0.358
Demispan length (cm)	HT = 53.38 + (1.249 * DSLt)	0.84	0.71	4.82	15.41	<0.001
Hand length (cm)	HT = 91.70 + (3.734 * HL)	0.70	0.50	6.33	9.81	<0.001
Hand breadth (cm)	HT = 122.06 + (3.878 * HB)	0.60	0.36	7.11	7.49	<0.001
Wrist breadth (cm)	HT = 128.24 + (4.076 * WRB)	0.47	0.22	7.86	5.30	<0.001
Thigh length (cm)	HT = 105.98 + (1.073 * ThL)	0.46	0.21	7.93	5.10	<0.001
Leg length (cm)	HT = 99.03 + (1.568 * LL)	0.68	0.46	6.54	9.19	<0.001
Foot length (cm)	HT = 97.56 + (2.619 * FL)	0.59	0.35	7.22	7.18	<0.001
Foot breadth (cm)	HT = 104.10 + (4.340 * FB)	0.51	0.26	7.68	5.85	<0.001
Ankle breadth (cm)	HT = 100.25 + (4.688 * AKB)	0.54	0.29	7.53	6.27	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.88: Linear regression equations for estimation of height from anthropometric parameters of young adult males in SSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 168.74 + (0.078 * Age)	0.03	0.00	6.94	0.22	0.824
Weight (kg)	HT = 130.64 + (0.615 * WT)	0.67	0.45	5.17	6.23	<0.001
Body mass index (kg/m^2)	HT = 169.12 + (0.061 * BMI)	0.02	0.00	6.95	0.12	0.904
Sitting height (cm)	HT = 130.28 + (0.494 * SHt)	0.41	0.17	6.34	3.12	0.003
Bigonial width (cm)	HT = 156.73 + (1.123 * BGW)	0.14	0.02	6.88	0.99	0.328
Length of mandibular arch (cm)	HT = 131.73 + (1.836 * LOMA)	0.41	0.16	6.35	3.07	0.004
Neck length (cm)	HT = 135.70 + (2.683 * NL)	0.39	0.16	6.39	2.97	0.005
Biaxillary length (cm)	HT = 171.03 - (0.016 * BALt)	0.01	0.00	6.95	-0.04	0.965
Demispan length (cm)	HT = 64.59 + (1.143 * DSLt)	0.80	0.64	4.19	9.15	<0.001
Hand length (cm)	HT = 133.80 + (1.791 * HL)	0.39	0.15	6.41	2.89	0.006
Hand breadth (cm)	HT = 155.62 + (1.252 * HB)	0.21	0.04	6.79	1.48	0.146
Wrist breadth (cm)	HT = 160.04 + (1.106 * WRB)	0.16	0.03	6.86	1.12	0.268
Thigh length (cm)	HT = 122.06 + (0.883 * ThL)	0.54	0.29	5.85	4.44	<0.001
Leg length (cm)	HT = 132.44 + (0.876 * LL)	0.52	0.27	5.94	4.20	<0.001
Foot length (cm)	HT = 135.12 + (1.336 * FL)	0.38	0.14	6.44	2.81	0.007
Foot breadth (cm)	HT = 152.82 + (1.243 * FB)	0.18	0.03	6.84	1.23	0.224
Ankle breadth (cm)	HT = 149.12 + (1.505 * AKB)	0.21	0.04	6.80	1.47	0.148

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.89: Linear regression equations for estimation of height from anthropometric parameters of young adult females in SSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 173.72 - (0.717 * Age)	0.36	0.13	5.74	-2.65	0.011
Weight (kg)	HT = 150.71 + (0.129 * WT)	0.21	0.05	6.01	1.52	0.135
Body mass index (kg/m^2)	HT = 166.61 - (0.347 * BMI)	0.23	0.05	5.98	-1.66	0.103
Sitting height (cm)	HT = 62.31 + (1.210 * SHt)	0.66	0.43	4.62	6.07	<0.001
Bigonial width (cm)	HT = 139.27 + (1.694 * BGW)	0.24	0.06	5.69	1.74	0.089
Length of mandibular arch (cm)	HT = 135.97 + (1.072 * LOMA)	0.24	0.06	5.97	1.69	0.098
Neck length (cm)	HT = 148.89 + (0.877 * NL)	0.20	0.04	6.03	1.38	0.175
Biaxillary length (cm)	HT = 145.55 + (0.369 * BALt)	0.17	0.03	6.06	1.19	0.239
Demispan length (cm)	HT = 85.47 + (0.856 * DSLt)	0.64	0.41	4.72	5.79	<0.001
Hand length (cm)	HT = 95.77 + (3.388 * HL)	0.67	0.45	4.57	6.23	<0.001
Hand breadth (cm)	HT = 135.73 + (2.269 * HB)	0.32	0.10	5.83	2.30	0.026
Wrist breadth (cm)	HT = 147.04 + (1.363 * WRB)	0.16	0.03	6.07	1.12	0.268
Thigh length (cm)	HT = 103.21 + (1.019 * ThL)	0.56	0.31	5.11	4.65	<0.001
Leg length (cm)	HT = 97.41 + (1.525 * LL)	0.68	0.46	4.54	6.33	<0.001
Foot length (cm)	HT = 114.93 + (1.767 * FL)	0.45	0.21	5.48	3.53	<0.001
Foot breadth (cm)	HT = 120.65 + (2.860 * FB)	0.40	0.16	5.63	3.02	0.004
Ankle breadth (cm)	HT = 116.14 + (3.205 * AKB)	0.42	0.18	5.57	3.22	0.002

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.90: Linear regression equations for estimation of height from anthropometric parameters of young adults in CSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 169.27 - (0.106 * Age)	0.04	0.00	9.45	-0.40	0.690
Weight (kg)	HT = 131.93 + (0.548 * WT)	0.57	0.33	7.77	6.89	<0.001
Body mass index (kg/m^2)	HT =179.87 - (0.573 * BMI)	0.18	0.03	9.31	-1.81	0.074
Sitting height (cm)	HT = 47.26 + (1.464 * SHt)	0.62	0.38	7.45	7.74	<0.001
Bigonial width (cm)	HT = 141.24 + (2.131 * BGW)	0.28	0.08	9.08	2.90	0.005
Length of mandibular arch (cm)	HT = 111.67 + (2.742 * LOMA)	0.47	0.22	8.34	5.32	<0.001
Neck length (cm)	HT = 143.99 + (1.748 * NL)	0.35	0.12	8.86	3.69	<0.001
Biaxillary length (cm)	HT = 144.09 + (0.603 * BALt)	0.25	0.07	9.15	2.60	0.011
Demispan length (cm)	HT = 54.42 + (1.267 * DSLt)	0.79	0.63	5.77	12.85	<0.001
Hand length (cm)	HT = 79.56 + (4.497 * HL)	0.70	0.49	6.73	9.78	<0.001
Hand breadth (cm)	HT = 109.23 + (5.028 * HB)	0.60	0.25	7.61	7.32	<0.001
Wrist breadth (cm)	HT = 115.76 + (5.824 * WRB)	0.48	0.23	8.29	5.46	<0.001
Thigh length (cm)	HT = 111.66 + (1.034 * ThL)	0.41	0.17	8.61	4.50	<0.001
Leg length (cm)	HT = 115.99 + (1.218 * LL)	0.47	0.22	8.35	5.29	<0.001
Foot length (cm)	HT = 102.95 + (2.455 * FL)	0.59	0.35	7.63	7.27	<0.001
Foot breadth (cm)	HT = 100.87 + (4.699 * FB)	0.56	0.32	7.81	6.76	<0.001
Ankle breadth (cm)	HT = 103.30 + (4.525 * AKB)	0.51	0.26	8.12	5.92	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.91: Linear regression equations for estimation of height from anthropometric parameters of young adult males in CSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 180.10 - (0.316 * Age)	0.14	0.02	8.07	-0.95	0.348
Weight (kg)	HT = 142.27 + (0.453 * WT)	0.51	0.26	7.01	4.10	<0.001
Body mass index (kg/m^2)	HT = 183.37 - (0.479 * BMI)	0.16	0.03	8.04	-1.11	0.275
Sitting height (cm)	HT = 56.62 + (1.398 * SHt)	0.61	0.37	6.44	5.36	<0.001
Bigonial width (cm)	HT = 162.66 + (0.803 * BGW)	0.14	0.02	8.06	1.01	0.318
Length of mandibular arch (cm)	HT = 128.68 + (2.120 * LOMA)	0.38	0.14	7.55	2.81	0.007
Neck length (cm)	HT = 166.82 + (0.420 * NL)	0.01	0.01	8.11	0.62	0.541
Biaxillary length (cm)	HT = 131.49 + (1.087 * BALt)	0.43	0.19	7.34	3.34	0.002
Demispan length (cm)	HT = 83.43 + (0.966 * DSLt)	0.66	0.44	6.12	6.09	<0.001
Hand length (cm)	HT = 98.13 + (3.703 * HL)	0.51	0.38	6.43	5.39	<0.001
Hand breadth (cm)	HT = 131.78 + (3.368 * HB)	0.40	0.16	7.48	2.98	0.005
Wrist breadth (cm)	HT = 136.97 + (3.899 * WRB)	0.29	0.09	7.78	2.13	0.039
Thigh length (cm)	HT = 110.91 + (1.152 * ThL)	0.49	0.24	7.11	3.86	<0.001
Leg length (cm)	HT = 146.56 + (0.611 * LL)	0.29	0.08	7.80	2.08	0.043
Foot length (cm)	HT = 140.16 + (1.192 * FL)	0.33	0.11	7.68	2.44	0.018
Foot breadth (cm)	HT = 129.75 + (2.919 * FB)	0.36	0.13	7.59	2.69	0.010
Ankle breadth (cm)	HT = 132.76 + (2.736 * AKB)	0.31	0.10	7.75	2.24	0.030

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.92: Linear regression equations for estimation of height from anthropometric parameters of young adult females in CSZ(n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 165.01 - (0.175 * Age)	0.10	0.01	6.74	-0.67	0.504
Weight (kg)	HT = 141.33 + (0.326 * WT)	0.46	0.21	6.03	3.56	<0.001
Body mass index (kg/m^2)	HT = 166.18 - (0.225 * BMI)	0.17	0.01	6.74	-0.75	0.458
Sitting height (cm)	HT = 92.88 + (0.848 * SHt)	0.50	0.25	5.86	4.01	<0.001
Bigonial width (cm)	HT = 157.49 + (0.300 * BGW)	0.04	0.00	6.77	0.26	0.796
Length of mandibular arch (cm)	HT = 138.27 + (1.165 * LOMA)	0.28	0.08	6.51	1.98	0.053
Neck length (cm)	HT = 150.59 + (0.842 * NL)	0.23	0.05	6.60	1.60	0.117
Biaxillary length (cm)	HT = 150.44 + (0.281 * BALt)	0.19	0.04	6.65	1.37	0.178
Demispan length (cm)	HT = 53.35 + (1.265 * DSLt)	0.68	0.46	4.97	6.43	<0.001
Hand length (cm)	HT = 106.00 + (2.943 * HL)	0.54	0.29	5.69	4.47	<0.001
Hand breadth (cm)	HT = 135.98 + (2.319 * HB)	0.29	0.08	6.49	2.08	0.043
Wrist breadth (cm)	HT = 143.03 + (2.140 * WRB)	0.24	0.05	6.58	1.72	0.093
Thigh length (cm)	HT = 118.93 + (0.792 * ThL)	0.49	0.24	5.92	3.85	<0.001
Leg length (cm)	HT = 111.89 + (1.203 * LL)	0.59	0.34	5.50	4.10	<0.001
Foot length (cm)	HT = 107.25 + (2.167 * FL)	0.49	0.24	5.90	3.91	<0.001
Foot breadth (cm)	HT = 133.30 + (2.068 * FB)	0.26	0.07	6.53	1.88	0.066
Ankle breadth (cm)	HT = 133.01 + (2.071 * AKB)	0.29	0.09	6.47	2.13	0.038

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.93: Linear regression equations for estimation of height from anthropometric parameters of young adults in NSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 161.19 + (0.113 * Age)	0.05	0.00	8.47	0.46	0.646
Weight (kg)	HT = 130.30 + (0.533 * WT)	0.56	0.32	7.02	6.72	<0.001
Body mass index (kg/m^2)	HT = 177.80 - (0.598 * BMI)	0.21	0.04	8.30	-2.09	0.039
Sitting height (cm)	HT = 48.21 + (1.430 * SHt)	0.68	0.46	6.24	9.10	<0.001
Bigonial width (cm)	HT = 112.65 + (4.286 * BGW)	0.49	0.24	7.41	5.51	<0.001
Length of mandibular arch (cm)	HT = 119.05 + (2.204 * LOMA)	0.40	0.16	7.79	4.26	<0.001
Neck length (cm)	HT = 136.70 + (2.232 * NL)	0.47	0.22	7.51	5.20	<0.001
Biaxillary length (cm)	HT = 135.97 + (0.784 * BALt)	0.31	0.09	8.08	3.18	0.002
Demispan length (cm)	HT = 50.54 + (1.267 * DSLt)	0.86	0.74	4.33	16.68	<0.001
Hand length (cm)	HT = 72.89 + (4.596 * HL)	0.79	0.62	5.22	12.66	<0.001
Hand breadth (cm)	HT = 104.61 + (5.115 * HB)	0.71	0.50	6.00	9.88	<0.001
Wrist breadth (cm)	HT = 124.04 + (4.344 * WRB)	0.47	0.23	7.46	5.36	<0.001
Thigh length (cm)	HT = 96.17 + (1.269 * ThL)	0.55	0.30	7.10	6.47	<0.001
Leg length (cm)	HT = 96.17 + (1.612 * LL)	0.68	0.47	6.19	9.27	<0.001
Foot length (cm)	HT = 78.02 + (3.381 * FL)	0.66	0.43	6.39	8.64	<0.001
Foot breadth (cm)	HT = 104.02 + (4.310 * FB)	0.58	0.34	6.89	7.12	<0.001
Ankle breadth (cm)	HT = 97.80 + (4.734 * AKB)	0.63	0.40	6.57	8.07	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.94: Linear regression equations for estimation of height from anthropometric parameters of young adult males in NSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 165.27 + (0.177 * Age)	0.09	0.01	6.97	0.60	0.550
Weight (kg)	HT = 130.47 + (0.596 * WT)	0.69	0.48	5.00	6.68	<0.001
Body mass index (kg/m^2)	HT = 165.43 + (0.172 * BMI)	0.05	0.00	6.98	0.34	0.733
Sitting height (cm)	HT = 79.56 + (1.087 * SHt)	0.59	0.35	5.63	5.11	<0.001
Bigonial width (cm)	HT = 146.19 + (1.883 * BGW)	0.25	0.06	6.78	1.77	0.083
Length of mandibular arch (cm)	HT = 139.91 + (1.407 * LOMA)	0.27	0.07	6.73	1.96	0.056
Neck length (cm)	HT = 144.04 + (1.943 * NL)	0.46	0.21	6.23	3.55	<0.001
Biaxillary length (cm)	HT = 153.72 + (0.428 * BALt)	0.21	0.05	6.84	1.50	0.140
Demispan length (cm)	HT = 61.54 + (1.158 * DSLt)	0.80	0.65	4.16	9.38	<0.001
Hand length (cm)	HT = 77.85 + (4.445 * HL)	0.71	0.50	4.96	6.88	<0.001
Hand breadth (cm)	HT = 120.70 + (3.916 * HB)	0.47	0.22	6.16	3.72	<0.001
Wrist breadth (cm)	HT = 151.84 + (1.819 * WRB)	0.22	0.05	6.82	1.55	0.128
Thigh length (cm)	HT = 99.28 + (1.305 * ThL)	0.66	0.44	5.25	6.10	<0.001
Leg length (cm)	HT = 116.61 + (1.207 * LL)	0.60	0.36	5.58	5.25	<0.001
Foot length (cm)	HT = 134.26 + (1.334 * FL)	0.30	0.09	6.68	2.15	0.037
Foot breadth (cm)	HT = 133.36 + (2.472 * FB)	0.35	0.12	6.56	2.57	0.014
Ankle breadth (cm)	HT = 122.23 + (3.231 * AKB)	0.47	0.22	6.16	3.71	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.95: Linear regression equations for estimation of height from anthropometric parameters of young adult females in NSZ (n=50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 158.39 - (0.007 * Age)	0.00	0.00	5.82	-0.03	0.978
Weight (kg)	HT = 144.75 + (0.224 * WT)	0.35	0.12	5.44	2.60	0.012
Body mass index (kg/m^2)	HT = 164.34 - (0.253 * BMI)	0.15	0.02	5.75	-1.08	0.286
Sitting height (cm)	HT = 86.21 + (0.911 * SHt)	0.54	0.29	4.90	4.43	<0.001
Bigonial width (cm)	HT = 123.65 + (2.990 * BGW)	0.45	0.20	5.19	3.50	0.001
Length of mandibular arch (cm)	HT = 151.83 + (0.326 * LOMA)	0.08	0.01	5.80	0.56	0.575
Neck length (cm)	HT = 164.58 - (0.563 * NL)	0.14	0.02	5.76	-0.98	0.334
Biaxillary length (cm)	HT = 154.35 + (0.113 * BALt)	0.06	0.00	5.81	0.39	0.699
Demispan length (cm)	HT = 72.50 + (1.000 * DSLt)	0.68	0.47	4.24	6.50	<0.001
Hand length (cm)	HT = 103.02 + (2.912 * HL)	0.66	0.43	4.39	6.03	<0.001
Hand breadth (cm)	HT = 126.80 + (2.933 * HB)	0.39	0.15	5.37	2.90	0.006
Wrist breadth (cm)	HT = 144.46 + (1.587 * WRB)	0.21	0.05	5.68	1.50	0.140
Thigh length (cm)	HT = 108.19 + (0.946 * ThL)	0.62	0.38	4.57	5.45	<0.001
Leg length (cm)	HT = 118.93 + (0.978 * LL)	0.47	0.22	5.13	3.71	<0.001
Foot length (cm)	HT = 70.28 + (3.600 * FL)	0.71	0.50	4.10	6.97	<0.001
Foot breadth (cm)	HT = 135.95 + (1.691 * FB)	0.25	0.06	5.63	1.79	0.080
Ankle breadth (cm)	HT = 128.40 + (2.243 * AKB)	0.33	0.11	5.50	2.40	0.020

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.96: Linear regression equations for estimation of height from anthropometric parameters of adults in SSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 147.19 + (0.488 * Age)	0.19	0.04	10.99	1.94	0.055
Weight (kg)	HT = 142.06 + (0.334 * WT)	0.31	0.10	10.63	3.26	0.002
Body mass index (kg/m^2)	HT = 197.60 - (1.321 * BMI)	0.56	0.31	9.29	-6.66	<0.001
Sitting height (cm)	HT = 65.46 + (1.214 * SHt)	0.42	0.18	10.17	4.57	<0.001
Bigonial width (cm)	HT = 117.72 + (3.845 * BGW)	0.40	0.16	10.28	4.27	<0.001
Length of mandibular arch (cm)	HT = 119.78 + (2.105 * LOMA)	0.31	0.95	10.65	3.21	0.002
Neck length (cm)	HT = 131.84 + (2.777 * NL)	0.38	0.14	10.36	4.05	<0.001
Biaxillary length (cm)	HT = 146.89 + (0.481 * BALt)	0.11	0.01	11.13	1.12	0.267
Demispan length (cm)	HT = 79.97 + (0.945 * DSLt)	0.52	0.27	9.59	5.96	<0.001
Hand length (cm)	HT = 123.68 + (2.102 * HL)	0.27	0.07	10.79	2.75	0.007
Hand breadth (cm)	HT = 123.30 + (3.701 * HB)	0.43	0.19	10.08	4.78	<0.001
Wrist breadth (cm)	HT = 125.70 + (4.315 * WRB)	0.38	0.15	10.34	4.11	<0.001
Thigh length (cm)	HT = 105.22 + (1.079 * ThL)	0.38	0.14	10.37	4.02	<0.001
Leg length (cm)	HT = 94.98 + (1.632 * LL)	0.49	0.24	9.77	5.55	<0.001
Foot length (cm)	HT = 108.79 + (2.188 * FL)	0.36	0.13	10.46	3.78	<0.001
Foot breadth (cm)	HT = 124.18 + (2.966 * FB)	0.27	0.07	10.78	2.78	0.006
Ankle breadth (cm)	HT = 123.96 + (2.985 * AKB)	0.27	0.07	10.79	2.74	0.007

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.97: Linear regression equations for estimation of height from anthropometric parameters of adult males in SSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 144.59 + (0.726 * Age)	0.25	0.06	12.08	1.75	0.087
Weight (kg)	HT = 135.20 + (0.511 * WT)	0.39	0.15	11.48	2.92	0.005
Body mass index (kg/m^2)	HT = 216.02 - (1.908 * BMI)	0.71	0.51	8.72	-7.07	<0.001
Sitting height (cm)	HT = 103.88 + (0.798 * SHt)	0.26	0.07	12.03	1.87	0.068
Bigonial width (cm)	HT = 146.23 + (1.883 * BGW)	0.14	0.02	12.34	0.97	0.337
Length of mandibular arch (cm)	HT = 139.69 + (1.397 * LOMA)	0.15	0.02	12.31	1.08	0.286
Neck length (cm)	HT = 156.73 + (1.077 * NL)	0.09	0.01	12.41	0.60	0.550
Biaxillary length (cm)	HT = 147.15 + (0.636 * BALt)	0.13	0.02	12.36	0.90	0.371
Demispan length (cm)	HT = 123.43 + (0.500 * DSLt)	0.17	0.03	12.28	1.18	0.245
Hand length (cm)	HT = 172.36 - (0.104 * HL)	0.01	0.00	12.46	-0.08	0.937
Hand breadth (cm)	HT = 151.13 + (1.596 * HB)	0.13	0.02	12.35	0.93	0.356
Wrist breadth (cm)	HT = 142.77 + (2.915 * WRB)	0.24	0.06	12.11	1.67	0.101
Thigh length (cm)	HT = 125.31 + (0.804 * ThL)	0.23	0.05	12.13	1.63	0.109
Leg length (cm)	HT = 145.55 + (0.555 * LL)	0.13	0.02	12.36	0.88	0.386
Foot length (cm)	HT = 140.92 + (1.125 * FL)	0.20	0.04	12.21	1.43	0.161
Foot breadth (cm)	HT = 126.30 + (3.178 * FB)	0.28	0.08	11.97	1.10	0.051
Ankle breadth (cm)	HT = 127.04 + (3.129 * AKB)	0.28	0.08	11.98	1.98	0.054

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.98: Linear regression equations for estimation of height from anthropometric parameters of adult females in SSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 146.92 + (0.332 * Age)	0.28	0.08	5.33	2.03	0.048
Weight (kg)	HT = 152.84 + (0.089 * WT)	0.18	0.00	5.46	1.29	0.202
Body mass index (kg/m^2)	HT = 165.60 - (0.264 * BMI)	0.22	0.05	5.42	-1.56	0.125
Sitting height (cm)	HT = 120.80 + (0.474 * SHt)	0.25	0.06	5.38	1.76	0.085
Bigonial width (cm)	HT = 143.17 + (1.344 * BGW)	0.25	0.06	5.37	1.81	0.076
Length of mandibular arch (cm)	HT = 151.16 + (0.366 * LOMA)	0.11	0.01	5.52	0.76	0.453
Neck length (cm)	HT = 148.32 + (0.949 * NL)	0.26	0.07	5.36	1.88	0.066
Biaxillary length (cm)	HT = 135.59 + (0.629 * BALt)	0.31	0.10	5.28	2.24	0.030
Demispan length (cm)	HT = 110.33 + (0.568 * DSLt)	0.47	0.22	4.91	3.66	<0.001
Hand length (cm)	HT = 131.46 + (1.443 * HL)	0.34	0.11	5.23	2.48	0.017
Hand breadth (cm)	HT = 148.86 + (0.959 * HB)	0.16	0.03	5.48	1.13	0.265
Wrist breadth (cm)	HT = 153.56 + (0.602 * WRB)	0.08	0.01	5.53	0.58	0.565
Thigh length (cm)	HT = 120.99 + (0.699 * ThL)	0.51	0.26	4.78	4.12	<0.001
Leg length (cm)	HT = 104.45 + (1.337 * LL)	0.62	0.39	4.34	5.53	<0.001
Foot length (cm)	HT = 117.59 + (1.656 * FL)	0.30	0.01	5.30	2.16	0.036
Foot breadth (cm)	HT = 166.15 - (0.558 * FB)	0.09	0.01	5.53	-0.63	0.530
Ankle breadth (cm)	HT = 168.13 - (0.707 * AKB)	0.11	0.01	5.52	-0.76	0.451

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; SSZ = Southern Senatorial Zone

Table 4.99: Linear regression equations for estimation of height from anthropometric parameters of adults in CSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 166.47 - (0.015 * Age)	0.01	0.00	8.21	-0.08	0.938
Weight (kg)	HT = 161.00 + (0.068 * WT)	0.11	0.01	8.16	1.10	0.275
Body mass index (kg/m^2)	HT = 181.21 - (0.576 * BMI)	0.39	0.15	7.56	-4.19	<0.001
Sitting height (cm)	HT = 71.63 + (1.143 * SHt)	0.66	0.41	6.33	8.18	<0.001
Bigonial width (cm)	HT = 157.97 + (0.637 * BGW)	0.09	0.01	8.18	0.88	0.383
Length of mandibular arch (cm)	HT = 4.02 - (0.052 * LOMA)	0.06	0.00	1.41	-0.61	0.546
Neck length (cm)	HT = 141.50 + (1.988 * NL)	0.43	0.18	7.42	4.69	<0.001
Biaxillary length (cm)	HT = 150.56 + (0.398 * BALt)	0.19	0.36	8.96	1.92	0.058
Demispan length (cm)	HT = 50.81 + (1.287 * DSLt)	0.82	0.67	4.73	14.03	<0.001
Hand length (cm)	HT = 100.74 + (3.349 * HL)	0.61	0.38	6.48	7.70	<0.001
Hand breadth (cm)	HT = 123.57 + (3.672 * HB)	0.53	0.28	6.97	6.17	<0.001
Wrist breadth (cm)	HT = 134.93 + (3.435 * WRB)	0.36	0.13	7.66	3.80	<0.001
Thigh length (cm)	HT = 126.42 + (0.741 * ThL)	0.33	0.11	7.76	3.42	<0.001
Leg length (cm)	HT = 127.50 + (0.931 * LL)	0.35	0.13	7.68	3.75	<0.001
Foot length (cm)	HT = 74.57 + (3.557 * FL)	0.69	0.48	5.91	9.54	<0.001
Foot breadth (cm)	HT = 130.23 + (2.514 * FB)	0.43	0.18	7.43	4.66	<0.001
Ankle breadth (cm)	HT = 118.12 + (3.368 * AKB)	0.50	0.25	7.11	5.71	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.100: Linear regression equations for estimation of height from anthropometric parameters of adult males in CSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 169.25 + (0.052 * Age)	0.03	0.00	6.46	0.24	0.814
Weight (kg)	HT = 154.14 + (0.234 * WT)	0.41	0.17	5.90	3.12	0.003
Body mass index (kg/m^2)	HT = 174.31 - (0.129 * BMI)	0.07	0.01	6.45	-0.49	0.625
Sitting height (cm)	HT = 78.91 + (1.088 * SHt)	0.62	0.38	5.10	5.40	<0.001
Bigonial width (cm)	HT = 180.18 - (0.709 * BGW)	0.15	0.02	6.40	-1.02	0.312
Length of mandibular arch (cm)	HT = 162.24 + (0.419 * LOMA)	0.11	0.01	6.43	0.77	0.448
Neck length (cm)	HT = 154.98 + (1.222 * NL)	0.27	0.07	6.23	1.94	0.058
Biaxillary length (cm)	HT = 152.79 + (0.468 * BALt)	0.25	0.06	6.26	1.79	0.079
Demispan length (cm)	HT = 65.77 + (1.131 * DSLt)	0.68	0.46	4.76	6.37	<0.001
Hand length (cm)	HT = 122.07 + (2.418 * HL)	0.43	0.19	5.84	3.31	0.002
Hand breadth (cm)	HT = 140.04 + (2.535 * HB)	0.36	0.13	6.04	2.64	0.011
Wrist breadth (cm)	HT = 132.39 + (4.156 * WRB)	0.44	0.20	5.80	3.43	0.001
Thigh length (cm)	HT = 141.07 + (0.559 * ThL)	0.34	0.12	6.08	2.51	0.016
Leg length (cm)	HT = 146.43 + (0.591 * LL)	0.35	0.12	6.07	2.57	0.014
Foot length (cm)	HT = 96.14 + (2.816 * FL)	0.57	0.32	5.33	4.77	<0.001
Foot breadth (cm)	HT = 166.44 + (0.313 * FB)	0.06	0.00	6.46	0.40	0.692
Ankle breadth (cm)	HT = 135.54 + (2.407 * AKB)	0.36	0.13	6.04	2.66	0.011

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.101: Linear regression equations for estimation of height from anthropometric parameters of adult females in CSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 157.44 + (0.090 * Age)	0.06	0.00	6.25	0.42	0.680
Weight (kg)	HT = 162.06 - (0.019 * WT)	0.05	0.00	6.25	-0.32	0.751
Body mass index (kg/m^2)	HT = 170.66 - (0.352 * BMI)	0.37	0.14	5.81	-2.77	0.008
Sitting height (cm)	HT = 118.28 + (0.529 * SHt)	0.37	0.14	5.82	2.74	0.009
Bigonial width (cm)	HT = 165.67 - (0.408 * BGW)	0.05	0.00	6.25	-0.28	0.709
Length of mandibular arch (cm)	HT = 155.56 + (0.256 * LOMA)	0.06	0.00	6.24	12.79	0.673
Neck length (cm)	HT = 159.84 + (0.076 * NL)	0.02	0.00	6.26	0.14	0.893
Biaxillary length (cm)	HT = 159.52 + (0.031 * BALt)	0.02	0.01	6.25	0.15	0.882
Demispan length (cm)	HT = 60.32 + (1.170 * DSLt)	0.66	0.44	4.69	6.12	<0.001
Hand length (cm)	HT = 127.88 + (1.761 * HL)	0.39	0.15	5.77	2.89	0.006
Hand breadth (cm)	HT = 155.30 + (0.500 * HB)	0.08	0.01	6.24	0.53	0.597
Wrist breadth (cm)	HT = 161.61 - (0.105 * WRB)	0.02	0.00	6.26	-0.11	0.916
Thigh length (cm)	HT = 129.14 + (0.597 * ThL)	0.31	0.10	5.94	2.29	0.026
Leg length (cm)	HT = 124.55 + (0.887 * LL)	0.31	0.10	5.94	2.29	0.026
Foot length (cm)	HT = 108.23 + (2.123 * FL)	0.43	0.19	5.64	3.34	0.002
Foot breadth (cm)	HT = 148.67 + (0.896 * FB)	0.16	0.03	6.17	1.15	0.255
Ankle breadth (cm)	HT = 145.25 + (1.136 * AKB)	0.21	0.05	6.11	1.51	0.138

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; CSZ = Central Senatorial Zone

Table 4.102: Linear regression equations for estimation of height from anthropometric parameters of adults in NSZ (n = 100)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 174.20 - (0.295 * Age)	0.14	0.02	9.03	-1.36	0.178
Weight (kg)	HT = 146.53 + (0.244 * WT)	0.36	0.13	8.50	3.83	<0.001
Body mass index (kg/m^2)	HT = 174.01 - (0.398 * BMI)	0.21	0.05	8.91	-2.16	0.033
Sitting height (cm)	HT = 48.32 + (1.424 * SHt)	0.74	0.54	6.17	10.76	<0.001
Bigonial width (cm)	HT = 112.97 + (4.185 * BGW)	0.44	0.19	8.19	4.84	<0.001
Length of mandibular arch (cm)	HT = 123.21 + (1.907 * LOMA)	0.38	0.15	8.43	4.07	<0.001
Neck length (cm)	HT = 136.84 + (2.333 * NL)	0.46	0.21	8.09	5.13	<0.001
Biaxillary length (cm)	HT = 145.84 + (0.475 * BALt)	0.16	0.03	8.10	1.63	0.106
Demispan length (cm)	HT = 51.44 + (1.257 * DSLt)	0.78	0.62	5.66	12.52	<0.001
Hand length (cm)	HT = 78.91 + (4.346 * HL)	0.72	0.51	6.37	10.12	<0.001
Hand breadth (cm)	HT = 108.79 + (4.819 * HB)	0.60	0.36	7.28	7.47	<0.001
Wrist breadth (cm)	HT = 121.84 + (4.518 * WRB)	0.38	0.14	8.45	4.01	<0.001
Thigh length (cm)	HT = 85.53 + (1.457 * ThL)	0.59	0.34	7.38	7.17	<0.001
Leg length (cm)	HT = 86.86 + (1.807 * LL)	0.67	0.45	6.74	9.02	<0.001
Foot length (cm)	HT = 71.11 + (3.639 * FL)	0.69	0.48	6.60	9.44	<0.001
Foot breadth (cm)	HT = 101.80 + (4.343 * FB)	0.56	0.31	7.58	6.61	<0.001
Ankle breadth (cm)	HT = 101.47 + (4.394 * AKB)	0.54	0.29	7.67	6.35	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.103: Linear regression equations for estimation of height from anthropometric parameters of adult males in NSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 179.58 - (0.295 * Age)	0.16	0.03	7.90	-1.10	0.277
Weight (kg)	HT = 140.44 + (0.415 * WT)	0.60	0.36	6.42	5.14	<0.001
Body mass index (kg/m^2)	HT = 166.87 + (0.092 * BMI)	0.04	0.00	7.99	0.25	0.802
Sitting height (cm)	HT = 55.73 + (1.369 * SHt)	0.73	0.53	5.50	7.32	<0.001
Bigonial width (cm)	HT = 119.39 + (3.969 * BGW)	0.41	0.16	7.31	3.07	0.004
Length of mandibular arch (cm)	HT = 126.73 + (1.975 * LOMA)	0.35	0.12	7.49	2.59	0.013
Neck length (cm)	HT = 159.66 + (0.750 * NLt)	0.15	0.02	7.91	1.05	0.299
Biaxillary length (cm)	HT = 146.31 + (0.607 * BALt)	0.20	0.04	7.85	1.39	0.170
Demispan length (cm)	HT = 80.32 + (0.962 * DSLt)	0.61	0.37	6.33	5.36	<0.001
Hand length (cm)	HT = 94.22 + (3.699 * HL)	0.59	0.35	6.44	5.09	<0.001
Hand breadth (cm)	HT = 134.38 + (2.853 * HB)	0.30	0.09	7.64	2.14	0.038
Wrist breadth (cm)	HT = 144.73 + (2.574 * WRB)	0.25	0.06	7.75	1.77	0.083
Thigh length (cm)	HT = 83.27 + (1.587 * ThL)	0.74	0.54	5.42	7.52	<0.001
Leg length (cm)	HT = 103.96 + (1.490 * LL)	0.58	0.34	6.52	4.91	<0.001
Foot length (cm)	HT = 97.96 + (2.716 * FL)	0.52	0.27	6.85	4.18	<0.001
Foot breadth (cm)	HT = 128.62 + (2.756 * FB)	0.38	0.15	7.39	2.86	0.006
Ankle breadth (cm)	HT = 120.25 + (3.368 * AKB)	0.47	0.22	7.08	3.64	<0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

Table 4.104: Linear regression equations for estimation of height from anthropometric parameters of adult females in NSZ (n = 50)

Parameters	**Predictive Equations**	**r**	**R^2**	**SEE**	**t**	***P***
Age (years)	HT = 157.48 + (0.0164 * Age)	0.01	0.00	6.53	0.07	0.942
Weight (kg)	HT = 143.94 + (0.199 * WT)	0.47	0.22	5.76	3.70	<0.001
Body mass index (kg/m^2)	HT = 154.21 + (0.137 * BMI)	0.11	0.01	6.49	0.79	0.434
Sitting height (cm)	HT = 85.41 + (0.919 * SHt)	0.63	0.39	5.09	5.59	<0.001
Bigonial width (cm)	HT = 153.59 + (0.385 * BGW)	0.05	0.00	6.53	0.37	0.711
Length of mandibular arch (cm)	HT = 131.60 + (1.267 * LOMA)	0.42	0.17	5.94	3.17	0.003
Neck length (cm)	HT = 152.08 + (0.579 * NL)	0.11	0.01	6.50	0.76	0.448
Biaxillary length (cm)	HT = 147.77 + (0.277 * BALt)	0.15	0.02	6.46	1.08	0.288
Demispan length (cm)	HT = 61.24 + (1.125 * DSLt)	0.77	0.59	4.17	8.36	<0.001
Hand length (cm)	HT = 102.47 + (2.970 * HL)	0.60	0.37	5.21	5.25	<0.001
Hand breadth (cm)	HT = 129.91 + (2.663 * HB)	0.33	0.11	6.16	2.45	0.018
Wrist breadth (cm)	HT = 134.56 + (2.607 * WRB)	0.28	0.08	6.28	1.99	0.052
Thigh length (cm)	HT = 107.41 + (0.955 * ThL)	0.53	0.28	5.53	4.36	<0.001
Leg length (cm)	HT = 104.24 + (1.306 * LL)	0.65	0.43	4.94	5.10	<0.001
Foot length (cm)	HT = 89.61 + (2.779 * FL)	0.68	0.46	4.80	8.38	<0.001
Foot breadth (cm)	HT = 115.46 + (3.095 * FB)	0.50	0.25	5.66	4.01	<0.001
Ankle breadth (cm)	HT = 119.71 + (2.787 * AKB)	0.44	0.19	5.87	3.40	0.001

HT = Height; WT = Weight; BMI = Body Mass Index; SHt = Sitting Height; BGW = Bigonial Width; LOMA = Length of Mandibular Arch; NL = Neck Length; BALt = Biaxillary Length; DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WRB = Wrist Breadth; ThL = Thigh Length; LL = Leg Length; FL = Foot Length; FB = Foot Breadth; AKB = Ankle Breadth; NSZ = Northern Senatorial Zone

4.6 Multiple Regression Models for some Anthropometric Variables

Table 4.105 - 4.116 shows the simple and multiple regression with the parameters that had the highest correlation coefficients. It is clear from the equations that combining the two parameters tends to give better predictions and lower standard error of estimates than using one parameter, so also combining three or more parameters gives better predictions with lower standard error of estimates. That is to say in most cases, the more the parameters used the better the prediction and the lower the standard error of estimates. The reason for this is that better correlation coefficient was observed with the double and triple parameter equations respectively. Parameters with higher correlation coefficient were chosen in order to have a better precision of the equations.

Table 4.105: Simple and multiple linear regressions for predictions of height from anthropometric parameters of children in SSZ

Parameters	Predictive Equations	R	R^2	SEE	t	p
Boys + Girls (n =100)						
DSLt	HT = 24.99 + (1.541 * DSLt)	0.86	0.74	6.57	12.58	<0.001
WT	HT = 88.83 + (1.517 * WT)	0.79	0.62	6.61	9.27	<0.001
LL	HT = 69.76 + (1.842 * LL)	0.74	0.55	7.10	11.03	<0.001
DSLt + WT	HT = 37.06 + (1.154 * DSLt) + (0.524 * WT)	0.88	0.77	5.12	5.33	<0.001
DSLt + WT + LL	HT = 39.63 + (0.910 * DSLt) + (0.525 * WT) + (0.429 * LL)	0.88	0.78	5.01	5.74	<0.001
Boys (n = 50)						
DSLt	HT = 27.83 + (1.500 * DSLt)	0.82	0.67	6.39	9.76	<0.001
WT	HT = 84.99 + (1.605 * WT)	0.80	0.64	6.61	9.27	<0.001
FL	HT = 56.22 + (3.479 * FL)	0.73	0.53	7.61	7.29	<0.001
DSLt + WT	HT = 47.50 + (0.892 * DSLt) + (0.778 * WT)	0.84	0.71	6.05	3.82	<0.001
DSLt + WT + FL	HT = 46.65 + (0.827 * DSLt) + (0.739 * WT) + (0.303 * FL)	0.84	0.71	6.10	3.67	<0.001
Girls (n = 50)						
DSLt	HT = 21.51 + (1.590 * DSLt)	0.91	0.83	4.25	15.05	<0.001
SHt	HT = 40.02 + (1.407 * SHt)	0.83	0.69	5.65	10.37	<0.001
ThL	HT = 56.32 + (1.737 * ThL)	0.80	0.65	6.05	9.37	<0.001
DSLt + SHt	HT = 14.57 + (1.136 * DSLt) + (0.589 * SHt.)	0.94	0.88	3.58	2.28	<0.001
DSLt + SHt + ThL	HT = 15.51 + (0.956 * DSLt) + (0.542 * SHt) + (0.34 * ThL)	0.94	0.89	3.49	2.49	<0.001

DSLt = Demispan Length; WT = Weight; LL = Leg Length; FL = Foot Length; SHt = Sitting Height; ThL = Thigh Length; SSZ = Southern Senatorial Zone

Table 4.106: Simple and multiple linear regressions for predictions of height from anthropometric parameters of children in CSZ

Parameters	Predictive Equations	R	R^2	SEE	t	p
Boys + Girls (n =100)						
HL	HT = 24.63 + (6.815 * HL)	0.86	0.73	5.58	16.43	<0.001
WT	HT = 87.47 + (1.550 * WT)	0.85	0.73	5.63	16.21	<0.001
DSLt	HT = 33.88 + (1.402 * DSLt)	0.83	0.70	5.97	14.95	<0.001
HL + WT	HT = 47.08 + (3.854 * HL) + (0.853 * WT)	0.90	0.82	4.66	7.42	<0.001
HL + WT + DSLT	HT = 37.23 + (2.632 * HL) + (0.675 * WT) + (0.491 * DSLt)	0.92	0.84	4.31	5.88	<0.001
Boys (n = 50)						
HL	HT = 13.92 + (7.507 * HL)	0.87	0.76	5.12	12.35	<0.001
WT	HT = 82.75 + (1.730 * WT)	0.87	0.76	5.12	12.34	<0.001
FL	HT = 38.18 + (4.234 * FL)	0.86	0.75	5.28	11.85	<0.001
HL + WT	HT = 38.97 + (4.191 * HL) + (0.964 * WT)	0.92	0.85	4.12	4.37	<0.001
HL + WT + FL	HT = 31.24 + (3.286 * HL) + (0.669 * WT) + (1.374 * FL)	0.93	0.87	3.87	3.53	<0.001
Girls (n = 50)						
DSLt	HT = 12.35 + (1.735 * DSLt)	0.93	0.87	4.09	17.95	<0.001
HL	HT = 31.68 + (6.365 * HL)	0.85	0.72	6.01	11.09	<0.001
WT	HT = 90.43 + (1.438 * WT)	0.84	0.71	6.09	10.90	<0.001
DSLt + HL	HT = 10.29 + (1.400 * DSLt) + (1.606 * HL)	0.94	0.88	3.91	1.62	<0.001
DSLt + HL + WT	HT = 22.97 + (1.203 * DSLt) + (0.996 * HL) + (0.367 * WT)	0.95	0.90	3.71	2.93	<0.001

HL = Hand Length; WT = Weight; DSLt = Demispan Length; FL = Foot Length; CSZ = Central Senatorial Zone

Table 4.107: Simple and multiple linear regressions for predictions of height from anthropometric parameters of children in NSZ

Parameters	Predictive Equations	R	R^2	SEE	t	p
Boys + Girls (n =100)						
DSLt	HT = 24.40 + (1.516 * DSLt)	0.91	0.82	4.98	21.07	<0.001
WT	HT = 90.14 + (1.344 * WT)	0.85	0.73	6.11	16.21	<0.001
FL	HT = 34.57 + (4.431 * FL)	0.84	0.71	6.35	15.36	<0.001
DSLt + WT	HT = 39.90 + (1.110 * DSLt) + (0.442 * WT)	0.92	0.84	4.73	6.24	<0.001
DSLt + WT + FL	HT = 37.76 + (0.959 * DSLt) + (0.411 * WT) + (0.633 * FL)	0.92	0.84	4.71	5.74	<0.001
Boys (n = 50)						
DSLt	HT = 23.34 + (1.524 * DSLt)	0.87	0.76	6.04	12.22	<0.001
SHt	HT = -0.95 + (2.026 * SHt)	0.84	0.71	6.62	10.80	<0.001
WT	HT = 88.23 + (1.416 * WT)	0.84	0.70	6.72	10.56	<0.001
DSLt + SHt	HT = -3.06 + (0.955 * DSLt.) + (1.033 * SHt.)	0.91	0.84	5.02	-0.34	<0.001
DSLt + SHt + WT	HT = 4.47 + (0.859 * DSLt) + (0.948 * SHt) + (0.161 * WT)	0.92	0.84	5.05	0.32	<0.001
Girls (n = 50)						
DSLt	HT = 24.10 + (1.528 * DSLt)	0.95	0.89	3.69	20.10	<0.001
LL	HT = 39.99 + (2.687 * LL)	0.90	0.80	5.02	14.00	<0.001
HL	HT = 37.03 + (5.808 * HL)	0.88	0.77	5.49	12.51	<0.001
DSLt + LL	HT = 24.57 + (1.214 * DSLt) + (0.642 * LL)	0.95	0.90	3.59	5.04	<0.001
DSLt + LL + HL	HT = 24.06 + (1.075 * DSLt) + (0.604 * LL) + (0.722 * HL)	0.95	0.90	3.58	4.92	<0.001

DSLt = Demispan Length; WT = Weight; FL = Foot Length; SHt = Sitting Height; LL = Leg Length; HL = Hand Length; NSZ = Northern Senatorial Zone

Table 4.108: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adolescents in SSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 48.24 + (1.282 * DSLt)	0.72	0.52	6.66	10.21	<0.001
WT	HT = 120.34 + (0.708 * WT)	0.68	0.46	7.05	9.08	<0.001
LL	HT = 74.70 + (1.984 * LL)	0.64	0.41	7.33	8.31	<0.001
DSLt + WT	HT = 64.91 + (0.864 * DSLt) + (0.384 * WT)	0.77	0.60	6.12	6.40	<0.001
DSLt + WT + LL	HT = 59.66 + (0.590 * DSLt) + (0.362 * WT) + (0.728 * LL)	0.79	0.62	5.94	5.94	<0.001
Males (n = 50)						
WT	HT = 109.82 + (0.994 * WT)	0.76	0.57	7.53	7.97	<0.001
DSLt	HT = 46.23 + (1.317 * DSLt)	0.72	0.52	7.98	7.17	<0.001
FL	HT = 63.76 + (3.578 * FL)	0.64	0.40	8.86	5.71	<0.001
WT + DSLt	HT = 73.18 + (0.649 * WT) + (0.639 * DSLt)	0.79	0.62	7.13	4.83	<0.001
WT + DSLt + FL	HT = 43.75 + (0.479 * WT) + (0.562 * DSLt) + (1.738 * FL)	0.83	0.69	6.52	2.63	<0.001
Females (n = 50)						
DSLt	HT = 46.56 + (1.293 * DSLt)	0.73	0.53	5.05	7.37	<0.001
SHt	HT = 73.60 + (1.059 * SHt)	0.68	0.46	5.43	6.39	<0.001
LL	HT = 75.61 + (1.972 * LL)	0.68	0.46	5.43	6.38	<0.001
DSLt + SHt	HT = 28.52 + (0.921 * DSLt) + (0.650 * SHt)	0.81	0.66	4.35	2.17	<0.001
DSLt + SHt + LL	HT = 19.70 + (0.520 * DSLt) + (0.649 * SHt) + (1.070 * LL)	0.86	0.74	3.81	1.68	<0.001

DSLt = Demispan Length; WT = Weight; LL = Leg Length; FL = Foot Length; SHt = Sitting Height; SSZ = Southern Senatorial Zone

Table 4.109: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adolescents in CSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n = 100)						
DSLt	HT = 37.77 + (1.421 * DSLt)	0.88	0.77	5.15	18.13	<0.001
SHt	HT = 17.26 + (1.839 * SHt)	0.76	0.58	6.95	11.69	<0.001
HL	HT = 52.78 + (5.564 * HL)	0.74	0.55	7.24	10.86	<0.001
DSLt + SHt	HT = 14.32 + (1.101 * DSLt.) + (0.664 * SHt)	0.90	0.81	4.75	1.77	<0.001
DSLt + SHt + HL	HT = 13.70 + (1.067 * DSLt) + (0.660 * SHt) + (0.200 * HL)	0.90	0.81	4.77	1.64	<0.001
Males (n = 50)						
DSLt	HT = 29.75 + (1.509 * DSLt)	0.89	0.79	5.15	18.13	<0.001
WT	HT = 112.37 + (0.961 * WT)	0.84	0.70	6.95	11.69	<0.001
SHt	HT = 19.93 + (1.822 * SHt)	0.76	0.58	7.24	10.86	<0.001
DSLt + WT	HT = 45.75 + (1.184 * DSLt) + (0.246 * WT)	0.90	0.80	5.65	3.20	<0.001
DSLt + WT + SHt	HT = 38.92 + (1.098 * DSLt) + (0.224 * WT) + (0.201 * SHt)	0.90	0.80	5.68	2.27	<0.001
Females (n = 50)						
DSLt	HT = 46.82 + (1.315 * DSLt)	0.85	0.72	4.50	11.00	<0.001
SHt	HT = 17.71 + (1.814 * SHt)	0.78	0.60	5.31	8.55	<0.001
ThL	HT = 84.54 + (1.349 * ThL)	0.69	0.48	6.08	6.66	<0.001
DSLt + SHt	HT = 0.56 + (0.931 * DSLt) + (1.033 * SHt)	0.92	0.85	3.29	0.06	<0.001
DSLt + SHt + ThL	HT = 1.11 + (0.844 * DSLt.) + (1.002 * SHt) + (0.174 * ThL)	0.92	0.86	3.29	0.11	<0.001

DSLt = Demispan Length; SHt = Sitting Height; HL = Hand Length; WT = Weight; ThL = Thigh Length; CSZ = Central Senatorial Zone

Table 4.110: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adolescents in NSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 23.88 + (1.569 * DSLt)	0.88	0.78	4.82	18.70	<0.001
SHt	HT = 47.68 + (1.437 * SHt)	0.82	0.67	5.89	14.19	<0.001
HL	HT = 34.78 + (6.455 * HL)	0.80	0.64	6.15	13.27	<0.001
DSLt + SHt	HT = 20.17 + (1.125 * DSLt) + (0.546 * SHt)	0.90	0.82	4.44	3.08	<0.001
DSLt + SHt + HL	HT = 12.67 + (0.873 * DSLt) + (0.455 * SHt) + (1.900 * HL)	0.92	0.84	4.20	1.93	<0.001
Males (n = 50)						
DSLt	HT = 16.43 + (1.656 * DSLt)	0.95	0.90	4.10	20.49	<0.001
SHt	HT = 33.26 + (1.650 * SHt)	0.91	0.82	5.41	14.82	<0.001
HL	HT = 22.34 + (7.076 * HL)	0.88	0.78	5.99	13.06	<0.001
DSLt + SHt	HT = 13.94 + (1.140 * DSLt) + (0.619 * SHt)	0.96	0.93	3.52	2.39	<0.001
DSLT + SHt + HL	HT = 9.82 + (0.931 * DSLt) + (0.531 * SHt) + (1.500 * HL)	0.97	0.93	3.35	1.69	<0.001
Females (n = 50)						
DSLt	HT = 51.36 + (1.245 * DSLt)	0.67	0.45	5.34	6.22	<0.001
ThL	HT = 98.80 + (1.096 * ThL)	0.62	0.38	5.64	5.44	<0.001
SHt	HT = 78.03 + (1.023 * SHt)	0.59	0.35	5.78	5.08	<0.001
DSLt + ThL	HT = 54.38 + (0.861 * DSLt.) + (0.561 * ThL)	0.71	0.50	5.11	3.37	<0.001
DSLt + ThL + SHt	HT = 44.20 + (0.403 * DSLt) + (0.652 * ThL) + (0.577 *SHt)	0.75	0.57	4.82	2.81	<0.001

DSLt = Demispan Length; SHt = Sitting Height; HL = Hand Length; ThL = Thigh Length; NSZ = Northern Senatorial Zone

Table 4.111: Simple and multiple linear regressions for predictions of height from anthropometric parameters of young adults in SSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 53.38 + (1.249 * DSLt)	0.84	0.71	4.82	15.41	<0.001
HL	HT = 91.70 + (3.734 * HL)	0.70	0.50	6.33	9.81	<0.001
LL	HT = 99.03 + (1.568 * LL)	0.68	0.46	6.54	9.19	<0.001
DSLt + HL	HT = 49.73 + (0.997 * DSLt) + (1.336 * HL)	0.86	0.74	4.55	7.22	<0.001
DSLt + HL + LL	HT = 48.52 + (0.883 * DSLt) + (1.030 * HL) + (0.415 * LL)	0.87	0.76	4.42	7.24	<0.001
Males (n = 50)						
DSLt	HT = 64.59 + (1.143 * DSLt)	0.80	0.64	4.19	9.15	<0.001
WT	HT = 130.64 + (0.615 * WT)	0.67	0.45	5.17	6.23	<0.001
ThL	HT = 122.06 + (0.883 * ThL)	0.54	0.29	5.85	4.44	<0.001
DSLt + WT	HT = 71.25 + (0.894 * DSLt) + (0.254 * WT)	0.83	0.68	3.96	6.34	<0.001
DSLt + WT + ThL	HT = 70.52 + (0.862 * DSLt) + (0.245 * WT) + (0.078 * ThL)	0.83	0.68	3.10	6.16	<0.001
Females (n = 50)						
LL	HT = 97.41 + (1.525 * LL)	0.68	0.46	4.54	6.33	<0.001
HL	HT = 95.77 + (3.388 * HL)	0.67	0.45	4.57	6.23	<0.001
SHt	HT = 62.31 + (1.210 * SHt)	0.66	0.43	4.62	6.07	<0.001
LL + HL	HT = 76.66 + (1.018 * LL) + (2.219 * HL)	0.77	0.60	3.95	7.80	<0.001
LL + HL + SHt	HT = 54.91 + (0.873 * LL) + (1.470 * HL) + (0.521 * SHt)	0.80	0.64	3.76	4.22	<0.001

DSLt = Demispan Length; HL = Hand Length; LL = Leg Length; WT = Weight; ThL = Thigh Length; SHt = Sitting Height; SSZ = Southern Senatorial Zone

Table 4.112: Simple and multiple linear regressions for predictions of height from anthropometric parameters of young adults in CSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 54.42 + (1.267 * DSLt)	0.79	0.63	5.77	12.85	<0.001
HL	HT = 79.56 + (4.497 * HL)	0.70	0.49	6.73	9.78	<0.001
SHt	HT = 47.26 + (1.464 * SHt)	0.62	0.38	7.45	7.74	<0.001
DSLt + HL	HT = 51.36 + (0.994 * DSLt.) + (1.406 * HL)	0.80	0.65	5.65	5.92	<0.001
DSLt + HL + SHt	HT = 20.20 + (0.926 * DSLt) + (0.651 * HL) + (0.635 * SHt)	0.83	0.70	5.28	1.77	<0.001
Males (n = 50)						
DSLt	HT = 83.43 + (0.966 * DSLt)	0.66	0.44	6.12	6.09	<0.001
SHt	HT = 56.62 + (1.398 * SHt)	0.61	0.37	6.44	5.36	<0.001
HL	HT = 98.13 + (3.703 * HL)	0.51	0.38	6.43	5.39	<0.001
DSLt + SHt	HT = 38.10 + (0.690 * DSLt) + (0.854 * SHt)	0.74	0.54	5.58	1.97	<0.001
DSLt + SHt + HL	HT = 36.80 + (0.478 * DSLt) + (0.807 * SHt) + (1.230 * HL)	0.75	0.56	5.54	1.92	<0.001
Females (n = 50)						
DSLt	HT = 53.35 + (1.265 * DSLt)	0.68	0.46	4.97	6.43	<0.001
LL	HT = 111.89 + (1.203 * LL)	0.59	0.34	5.50	4.10	<0.001
HL	HT = 106.00 + (2.943 * HL)	0.54	0.29	5.69	4.47	<0.001
DSLt + LL	HT = 58.82 + (0.980 * DSLt) + (0.462 * LL)	0.70	0.49	4.89	3.49	<0.001
DSLt + LL + HL	HT = 56.80 + (0.839 * DSLt) + (0.378 * LL) + (0.931 * HL)	0.71	0.51	4.86	3.38	<0.001

DSLt = Demispan Length; HL = Hand Length; SHt = Sitting Height; LL = Leg Length; CSZ = Central Senatorial Zone

Table 4.113: Simple and multiple linear regressions for predictions of height from anthropometric parameters of young adults in NSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 50.54 + (1.267 * DSLt)	0.86	0.74	4.33	16.68	<0.001
HL	HT = 72.89 + (4.596 * HL)	0.79	0.62	5.22	12.66	<0.001
HB	HT = 104.61 + (5.115 * HB)	0.71	0.50	6.00	9.88	<0.001
DSLt + HL	HT = 49.34 + (0.985 * DSLt) + (1.333 * HL)	0.87	0.76	4.22	7.42	<0.001
DSLt + HL + HB	HT = 51.07 + (0.909 * DSLt) + (1.130 * HL) + (0.789 * HB)	0.87	0.76	4.20	7.59	<0.001
Males (n = 50)						
DSLt	HT = 61.54 + (1.158 * DSLt)	0.80	0.65	4.16	9.38	<0.001
HL	HT = 77.85 + (4.445 * HL)	0.71	0.50	4.96	6.88	<0.001
WT	HT = 130.47 + (0.596 * WT)	0.69	0.48	5.00	6.68	<0.001
DSLt + HL	HT = 59.14 + (1.008 * DSLt) + (0.794 * HL)	0.81	0.65	4.17	4.96	<0.001
DSLt + HL + WT	HT = 68.84 + (0.761 * DSLt) + (0.678 * HL) + (0.241 * WT)	0.83	0.70	3.94	5.80	<0.001
Females (n = 50)						
FL	HT = 70.28 + (3.600 * FL)	0.71	0.50	4.10	6.97	<0.001
DSLt	HT = 72.50 + (1.000 * DSLt)	0.68	0.47	4.24	6.50	<0.001
HL	HT = 103.02 + (2.912 * HL)	0.66	0.43	4.39	6.03	<0.001
FL + DSLt	HT = 51.70 + (2.342 * FL) + (0.575 * DSLt)	0.77	0.60	3.73	4.04	<0.001
FL + DSLt + HL	HT = 55.23 + (2.005 * FL) + (0.457 * DSLt) + (0.782 * HL)	0.78	0.61	3.71	4.24	<0.001

DSLt = Demispan Length; HL = Hand Length; HB = Hand Breadth; WT = Weight; FL = Foot Length; NSZ = Northern Senatorial Zone

Table 4.114: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adults in SSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n =100)						
DSLt	HT = 79.97 + (0.945 * DSLt)	0.52	0.27	9.59	5.96	<0.001
LL	HT = 94.98 + (1.632 * LL)	0.49	0.24	9.77	5.55	<0.001
HB	HT = 123.30 + (3.701 * HB)	0.43	0.19	10.08	4.78	<0.001
DSLt + LL	HT = 73.55 + (0.623 * DSLt) + (0.827 * LL)	0.55	0.30	9.44	5.13	<0.001
DSLt + LL + HB	HT = 76.13 + (0.478 * DSLt) + (0.779 * LL) + (1.118 * HB)	0.55	0.31	9.43	5.25	<0.001
Males (n = 50)						
BMI	HT = 216.02 - (1.908 * BMI)	0.71	0.51	8.72	-7.07	<0.001
WT	HT = 135.20 + (0.511 * WT)	0.39	0.15	11.48	2.92	<0.005
FB	HT = 126.30 + (3.178 * FB)	0.28	0.08	11.97	1.10	0.051
BMI + WT	HT = 168.42 - (2.472 * BMI) + (0.890 * WT)	0.96	0.93	3.46	42.63	<0.001
BMI + WT + FB	HT = 153.03 - (2.470 * BMI) + (0.817 * WT) + (1.469 * FB)	0.97	0.94	3.17	25.16	<0.001
Females (n = 50)						
LL	HT = 104.45 + (1.337 * LL)	0.62	0.39	4.34	5.53	<0.001
ThL	HT = 120.99 + (0.699 * ThL)	0.51	0.26	4.78	4.12	<0.001
DSLt	HT = 110.33 + (0.568 * DSLt)	0.47	0.22	4.91	3.66	<0.001
LL + ThL	HT = 96.15 + (1.052 * LL) + (0.368 * ThL)	0.67	0.44	4.19	9.39	<0.001
LL + ThL + DSLt	HT = 90.38 + (0.930 * LL) + (0.340 * ThL) + (0.144 * DSLt)	0.67	0.45	4.20	7.41	<0.001

DSLt = Demispan Length; LL = Leg Length; HB = Hand Breadth; BMI = Body Mass Index; WT = Weight; Foot Breadth; ThL = Thigh Length; SSZ = Southern Senatorial Zone

Table 4.115: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adults in CSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n = 100)						
DSLt	HT = 50.81 + (1.287 * DSLt)	0.82	0.67	4.73	14.03	<0.001
FL	HT = 74.57 + (3.557 * FL)	0.69	0.48	5.91	9.54	<0.001
SHt	HT = 71.63 + (1.143 * SHt)	0.66	0.41	6.33	8.18	<0.001
DSLt + FL	HT = 44.72 + (1.045 * DSLt) + (1.078 * FL)	0.83	0.69	4.61	5.36	<0.001
DSLt + FL + SHt	HT = 38.49 + (0.959 * DSLt) + (0.842 * FL) + (0.242 * SHt)	0.84	0.70	4.56	4.27	<0.001
Males (n = 50)						
DSLt	HT = 65.77 + (1.131 * DSLt)	0.68	0.46	4.76	6.37	<0.001
SHt	HT = 78.91 + (1.088 * SHt)	0.62	0.38	5.10	5.40	<0.001
FL	HT = 96.14 + (2.816 * FL)	0.57	0.32	5.33	4.77	<0.001
DSLt + SHt	HT = 39.13 + (0.824 * DSLt) + (0.653 * SHt)	0.75	0.56	4.34	2.29	<0.001
DSLt + SHt + FL	HT = 32.29 + (0.683 * DSLt) + (0.559 * SHt) + (1.046 * FL)	0.77	0.59	4.23	1.89	<0.001
Females (n = 50)						
DSLt	HT = 60.32 + (1.170 * DSLt)	0.66	0.44	4.69	6.12	<0.001
FL	HT = 108.23 + (2.123 * FL)	0.43	0.19	5.64	3.34	0.002
HL	HT = 127.88 + (1.761 * HL)	0.39	0.15	5.77	2.89	0.006
DSLt + FL	HT = 56.47 + (1.071 * DSLt) + (0.499 * FL)	0.67	0.45	4.71	3.28	<0.001
DSLt + FL + HL	HT = 56.08 + (1.108 * DSLt) + (0.517 * FL) - (0.171 * HL)	0.67	0.45	4.76	3.22	<0.001

DSLt = Demispan Length; FL = Foot Length; SHt = Sitting Height; HL = Hand Length; CSZ = Central Senatorial Zone

Table 4.116: Simple and multiple linear regressions for predictions of height from anthropometric parameters of adults in NSZ

Parameters	Predictive Equatios	R	R^2	SEE	t	p
Male + Female (n = 100)						
DSLt	HT = 51.44 + (1.257 * DSLt)	0.78	0.62	5.66	12.52	<0.001
SHt	HT = 48.32 + (1.424 * SHt)	0.74	0.54	6.17	10.76	<0.001
HL	HT = 78.91 + (4.346 * HL)	0.72	0.51	6.37	10.12	<0.001
DSLt + SHt	HT = 19.57 + (0.866 * DSLt) + (0.825 * SHt)	0.86	0.74	4.70	2.22	<0.001
DSLt + SHt + HL	HT = 20.12 + (0.708 * DSLt) + (0.721 * SHt) + (1.127 * HL)	0.87	0.75	4.58	2.34	<0.001
Males (n = 50)						
ThL	HT = 83.27 + (1.587 * ThL)	0.74	0.54	5.42	7.52	<0.001
SHt	HT = 55.73 + (1.369 * SHt)	0.73	0.53	5.50	7.32	<0.001
DSLt	HT = 80.32 + (0.962 * DSLt)	0.61	0.37	6.33	5.36	<0.001
ThL + SHt	HT = 34.42 + (1.087 * ThL) + (0.917 * SHt)	0.85	0.72	4.25	2.75	<0.001
ThL + SHt + DSLt	HT = 28.53 + (0.953 * ThL) + (0.867 * SHt) + (0.187 * DSLt)	0.86	0.73	4.23	2.12	<0.001
Females (n = 50)						
DSLt	HT = 61.24 + (1.125 * DSLt)	0.77	0.59	4.17	8.36	<0.001
FL	HT = 89.61 + (2.779 * FL)	0.68	0.46	4.80	8.38	<0.001
LL	HT = 104.24 + (1.306 * LL)	0.65	0.43	4.94	5.10	<0.001
DSLt + FL	HT = 57.39 + (0.841 * DSLt) + (1.150 * FL)	0.80	0.63	3.10	5.10	<0.001
DSLt + FL + LL	HT = 58.10 + (0.750 * DSLt) + (1.030 * FL) + (0.222 * LL)	0.80	0.64	4.01	5.15	<0.001

DSLt = Demispan Length; SHt = Sitting Height; HL = Hand Length; ThL = Thigh Length; FL = Foot Length; LL = Leg Length; NSZ = Northern Senatorial Zone

CHAPTER FIVE

5.0 DISCUSSION

Stature prediction from body proportions and fragmented body parts of an individual plays a significant role in forensic examinations and anthropological research. It provides insight into a population, defines the ethnic variability of the population and provide significant evidence in the medico-legal investigation for the establishment of identity. The descriptive statistics of the entire population of Cross River State in this study showed that males presented with statistically significant higher mean values of stature than females, and can therefore be inferred that males are generally taller than females. This agrees with previous studies on stature estimation in Nigeria (Danborno and Elukpo, 2008; Danborno *et al.,* 2008; Ebite *et al.,* 2009; Numan *et al.,* 2013; Ibegbu *et al.,* 2014; Oria *et al.,* 2016). Males also showed higher mean values of measured anthropometric variables compared to females $P < 0.05$, except for body mass index which was significantly higher among the females than males. The difference in anthropometric variables between males and females could be explained as part of genetic expression of males being larger than females. However, this is in line with (Kanchan and Rastogi, 2009) who reported that there are ethnic differences in anatomical dimensions and its relation to sex. In this study, females showed higher mean values of BMI compared to males owing to the part of genetic expression of females having more adipose tissues than males. This may be associated to their sedentary life styles, less labour structure, eating habit and less physical activities observed in the females than males. Also, this agrees with the work done by Danborno *et al*. (2008) which shows no statistically significant difference (with respect to the Hausas), though the mean values in females are slightly greater than those in males, the reason being that sexual dimorphism in human body size and composition is well established, and apparent in diverse populations.

However, this present study is inconsistent with the work of Goswami (2013), who reported that, the mean BMI of the Juang males was higher than the females. This study also confirms the existence of sexual dimorphism in body proportions in the studied population of Cross River State. These sex differences in body proportions are often related to hormonal, genetic, and environmental factors (Vodanovic *et al.,* 2006; Hasegawa *et al.,* 2009). The average values of the measured parameters of the mandible (bigonia width and length of mandibular arch) vary in the three different senatorial zones of the state (SSZ, CSZ and NSZ) population. This makes it possible to determine the variations between the average values of the existing measurements with the average value of the measured parameters of the mandible in other states in the Nigerian population. Many studies have shown the significance of stature estimates using bigonia width and length of mandibular arch in forensic practice. In the present study, males had higher values of bigonia width and length of mandibular arch than their female counterparts, and these dimensions were all statistically significant ($P < 0.001$ and $p = 0.018$) respectively. This agrees with the work of Aragao *et al.* (2019) who reported that the mean values for both anthropometric facial variables (bigonia width and length of mandibular arch) were significantly higher ($P < 0.001$) among the men than among the women. Similar results were obtained by Shah *et al.* (2015) and by Patil and Mody (2005) in a lateral cephalometric study on adults in central India. Agnihotri *et al.* (2011) studied height estimates from cephalofacial variables among 150 young adults aged 20 to 28 years and observed that among the men, the horizontal circumference of the head, nose width and morphological length of the face stood out as the main factors responsible for height estimates. On the other hand, among the women, the main predictors were the physiognomic length of the face, horizontal circumference of the head and bizygomatic width. The sexual variations in mandibles may bear genetic, hormonal or environmental influences,

since mandible is the last skull bone to cease growth, it is sensitive to adolescent growth spurt. Due to the effect of oestrogen, epiphyseal maturation and skeletal mineralization, mandibular growth becomes stable in females at the age of around 14, while it continues for two more years in males, making the flexure more obvious. Relatively, weaker muscle forces during mastication, may also contribute to small sized mandibles in females (Lazenby, 2001; Rosas *et al.*, 2002).

In the entire children population of the three senatorial zones of Cross River State, descriptive statistics showed higher, statistically insignificant mean values of stature among the girls when compared with the boys in the Southern and Central Senatorial Zones of the state and can therefore be inferred that girls grow taller than the boys, except in the Northern Senatorial Zone where boys grow taller than the girls. However, boys showed insignificantly higher mean values of measured anthropometric variables than girls in the Central and Northern Senatorial Zones, except in the Southern Senatorial Zone where girls showed insignificantly higher mean values than boys. This agrees with the work of Jambunath *et al.* (2016) who conducted a preliminary study on pre-pubertal age group and reported that the gonial angle was larger in females and bigonial width was not significantly different in males and females. These findings are also in accordance with the studies conducted by Rajalakshmi *et al.* (2007), Grivas *et al.* (2008) but in contrast with the study conducted by Kharoshah *et al*. (2010).

In the adolescent population of the three senatorial zones of Cross River State, descriptive statistics showed higher, statistically insignificant mean values of stature among the adolescent females when compared to males in the Southern and Northern Senatorial Zones of the state and can therefore be inferred that the adolescent females grow taller than the males, except in the

Central Senatorial Zone where the adolescent males grow taller than their female counterparts. This is in line with the work of Stini (1969) who reported that males are more susceptible to fluctuations in nutritional quality, hence growth is reduced to a greater degree than in females, thus resulting in a more equal body size and reduced dimorphism (Stini, 1969). Basically, this means that under conditions of inadequate nutrition, males are achieving a lower percentage of their genetic growth potential than females. Moreso, it is also known that the nature of the division of labour and other cultural activities result in differential mechanical loading and musculoskeletal development which can contribute to variation in the pattern and degree of sexual dimorphism in a population. These findings also agrees with the works of Bidmos (2008a and 2008b) who reported a higher correlation of total skeletal height in females when compared to males (Bidmos, 2008a), however, these findings are in contrast with the study conducted by Bidmos (2008b) whose varying results was reported to be due to differences in sex, age group and population selected (Bidmos 2008b). In the SSZ the adolescent females show significantly higher mean values of body anthropometrics when compared to the males ($P < 0.05$), except for bigonial width, neck length, hand breadth and wrist breadth which were significantly higher in the males when compared to the females ($P < 0.05$). More so, demi span length was insignificantly higher in the females. While, ankle breath and foot breadth were insignificantly higher in the males. In the CSZ, adolescent males show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$), except for BMI and thigh length which were significantly higher in the females when compared to the males ($P < 0.05$). More so, leg length was insignificantly higher in the males while, weight, sitting height and biaxillary length were insignificantly higher in the females when compared to the males. This agrees with the work of Schulte-Hostedde *et al.* (2001) who reported that variation in body mass and body

proportions between sexes may be a reflection of differences in structural size and/or differences in body composition due to relative contribution of fat and lean mass. In the NSZ adolescent females show significantly higher mean values of body anthropometrics when compared to the males ($P < 0.05$), except for neck length, hand breadth, foot breadth and ankle breadth which were significantly higher in the males when compared to the females ($P < 0.05$). More so, WT, BMI, LOMA, BALt, DSLt and LL were insignificantly higher in the females while, FL was insignificantly higher in the males when compared to the females. These findings are in line with the works of Lovich and Gibbons (1992), Fairbairn (1997), Mata *et al.* (2006) and Einoder *et al.* (2008) who reported that body condition can represent energy reserves and, hence, is an indication of an individual's health and nutritional state (Viblanc *et al.,* 2012). Moreso, determining body condition is a valuable tool as it can be used to indicate how individuals are managing natural environmental variation and stressors (Mata *et al.,* 2006). Further more, Fairbairn stated that the degree of dimorphism can vary greatly, geographically within and between closely related species (Fairbairn, 1997), that such differences in the degree of dimorphism may be due to food availability or inter-population growth patterns (Lovich and Gibbons, 1992). Nevertheless, sexual selection may be driving the greater divergence in dimorphism (Einoder *et al.,* 2008). However, studies have also demonstrated that male and female biology react differently to environmental pressures, where in colder climates males create more lean mass and females create more adipose tissue, and environmental pressures seemingly affect males more prominently than females (Ruff, 1987; Ruff, 2002; Wells, 2012).

In the young adult population of the three senatorial zones of Cross River State, descriptive statistics showed higher, statistically significant mean values of stature among the young adult

males when compared to females in the Southern, Central and Northern Senatorial Zones of the state ($P < 0.001$), and can therefore be inferred that the young adult males grow taller than the females across the three senatorial zones of the state. These findings are in contrast with the works done by Ozaslan *et al*. (2003) and Patel *et al.* (2007) who reported a higher correlation coefficient among females when compared to the males. In the SSZ males show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$), except for BMI which was significantly higher in the females when compared to the males ($P < 0.05$). More so, LOMA, BALt and ThL were insignificantly higher in the males. In the CSZ, males show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$). More so, BALt and ThL were insignificantly higher in the males while, BMI was insignificantly higher in the females when compared to the males. In the NSZ, males also show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$), except for BMI which was significantly higher in the females when compared to the males ($p < 0.05$). More so, ThL was insignificantly higher in the males when compared to the females. These findings agree with the work done by Agnihotri *et al*. (2007) on Mauritius of ages 18-30 who reported a higher correlation coefficient among the males than among the females. This also agree with the works of Danborno and Elukpo (2008), Gulsah *et al.* (2008) and Bhavana and Nath (2009) who reported higher correlation coefficients among the males when compared to the females.

In the adults population of the three senatorial zones of Cross River State, descriptive statistics showed higher, statistically significant mean values of stature among the adult males when compared to females in the Southern, Central and Northern Senatorial Zones of the state ($P <$

0.001), and can therefore be inferred that the adult males grow taller than the females across the three senatorial zones of the state. This is in line with the work of Byers (2011) who proposed that differences between adult males and females can be attributed to variations in both gross morphology and functional morphology, with males being on average, 7 - 8% larger in size when compared to the females (Byers, 2011; Wells, 2012). In the SSZ, the adult males show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$), except for BMI which was significantly higher in the females when compared to the males ($P < 0.05$). More so, WT was insignificantly higher in the males while, BALt was insignificantly higher in the females when compared to the males. This is in line with the works conducted by Behl *et al.* (2020) and Batool and Areej (2020) who reported that gonial angles can serve as adjunct and additional forensic parameter which guides for age group assessment and sex determination, and that bigonial width was larger in males and increases with age as when compared with the females (Behl *et al.*, 2020; Batool and Areej, 2020). In the CSZ, males show significantly higher mean values of anthropometrics when compared to the females ($p < 0.05$), except for BMI which was significantly higher in the females when compared to the males ($P < 0.05$). More so, BALt, ThL and LL were insignificantly higher in the males while, WT was insignificantly higher in the females when compared to the males. In the NSZ, males also show significantly higher mean values of body anthropometrics when compared to the females ($P < 0.05$), except for BMI which was significantly higher in the females when compared to the males ($P < 0.05$). More so, LOMA, BALt and ThL were insignificantly higher in the males while, WT was insignificantly higher in the females when compared to the males. This is in line with the work of Fessler *et al*. (2005) who reported that the bone area values at different sites strongly

correlates to muscle strength, body size, height, weight, lean mass, fat mass and body mass index (BMI).

The results from the ANOVA of the study indicates that there are no substantial differences in the range of variation of stature across the senatorial zones, the differences in mean stature between various age groups is only slight. Therefore, the observable differences in mean stature across these various age bands or groups can be interpreted with context. The Central population of the state is the tallest in stature owing to the availability of food and moderate climate. The Southern population of the state is the shortest of the groups, this may be associated with the reoccurrence of cold environmental conditions and altitude. The lower stature groups observed within the Northern population of the state may be due to the mountainous regions of the place which may in turn results to the extremely cold environmental difference between this samples, thus, resulting to their lower stature. These findings also demonstrate that moderate differences in altitude (about 1000m) in a steep and rugged environment does not significantly affect average stature or range in variation. The tallest individuals for both males and females across age groups could be due to multiple factors contributing to their height, hence, the variety in social structure and subsistence strategy may be an adequate basis for the investigation of the effect of altitude on mean and range of stature. Furthermore, the diversity in climates and geographies (i.e., coastal, plains and mountain) also provide a comparative benchmark for investigations of the effects of climates on stature. The moderate to high degree of correlation obtained in this study is in agreement with the usefulness of different body proportions in the estimation of stature in Nigerians of West African descent.

The accuracy of each regression equation derived in this study was assessed using the obtained standard error of estimate (SEE). In the Southern, Central and Northern Cross River State, regression equations for height prediction in males presented with higher SEE compared to those obtained in females, this agrees with the report of Danborno and Elukpo (2008), in their study of Nigeria population which reported that; when hand and foot were correlated, the relationship between hand and foot length was higher in the females than the males, but when hand and foot lengths were compared to height the relationship was stronger in the males than in the females. Multiple regression analysis was conducted with parameters that showed the strongest correlation with height to see if the height of subjects could be predicted from body proportions. This proved to be effective and provided valuable predictive equations that enable the prediction of height for both males and females at various age groups and age bands. Higher predictive ability was observed in males than females in the combined study population of the SSZ because it showed lower standard error of estimates in males than females. This finding agrees with the reports of Danborno and Elukpo (2008) in Nigerian population and from Turkish sample (Ozden *et al*., 2005; Sanli *et al*., 2005) and Indian sample (Krishan and Sharma, 2007; Patel *et al*., 2007). Also, in the CSZ and NSZ, males tend to show higher predictive ability when compared to the females in the combined study population, owing to their lower standard error of estimates (SEE) in the males than the females. This also agree with the work of Danborno and Elukpo (2008) in Nigerian population and from Turkish sample (Ozden *et al*., 2005; Sanli *et al*., 2005) and Indian sample (Krishan and Sharma, 2007; Patel *et al*., 2007). In conclusion, stature estimation could be predicted from body proportions with minimum error in the events of missing bodies and in situations where only mandibles are obtained. Therefore, practitioners of forensic anthropology

in Nigeria and West Africa will find the regression equations presented in this study useful in cases where fragmented body remains were obtained.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Demispan length, sitting height, bigonial width, length of mandibular arch, weight, hand length, thigh length, leg length, foot length, hand breadth and foot breadth, and combination could be applied for stature estimation in Cross River State population. Although demispan length had the highest precision as single prediction parameter, other parameters were also proposed with acceptable error margin. Combination of double and triple parameters might decrease actual deviation in all subjects. However, over-estimation might be of concern in shorter people and vice versa in taller people. Therefore, formula for prediction should be used only in cases when direct measurement of stature is not possible. Obtained formulae are specific to the study populations, therefore application of these by the other populations might cause incorrect results. Thus, necessity in creation of specific equations peculiar to populations should be taken into account by researchers. Also, moderate differences in altitude does not significantly affect average stature or range in variation, the tallest individuals for both males and females across age groups could be due to multiple factors contributing to their height,

hence, the variety in social structure and subsistence strategy may be an adequate basis for the investigation of the effect of altitude on mean and range of stature.

6.2 Recommendations

Based on the findings of the present study, the following recommendations are formulated:

i. The present study was conducted on direct measurement of only length variables. Further research with a larger study design and larger group of samples are required to compare the results of this study in a larger more representative population of the state which is more reliable and accurate.

ii. Differences in stature estimation between the three senatorial zones of Cross River State population has been established in this study, indicating population specificity in stature estimations. Therefore, further studies should be conducted on different ethnic groups among senatorial zones of the state in order to establish a more reference data base for stature estimation in Nigerian populations, because morphological variations related to race and population can be worked out using population-based studies.

iii. The present approach is new especially for the three senatorial zones of Cross River State, as no report of stature estimation using bigonial width and length of mandibular arch has been given for the population, i therefore recommend further studies in the state using the three senatorial zones in order to validate the current study.

iv. Further studies on molecular anthropology should be done to establish the genetic basis of differing stature across the three senatorial zones of the state.

6.2 Contributions to Knowledge.

i. This study was the first to report the use of bigonial width and length of mandibular arch in stature estimation in Nigeria.

ii. This study observed that the Central Senatorial Zone subjects showed higher anthropometrics when compared with the Southern and Northern Senatorial Zones. This may be influenced by nutrition, moderate climate, physical activity, labour structure and changes in altitude as you move from Southern, Central and Northern Cross River State. The lower anthropometric variables observed within the Southern and the Northern populations of Cross River State may be associated with the colder climatic conditions, less physical activity, sedentary life styles and labour structure.

iii. This study also observed that girls from the SSZ and CSZ showed higher anthropometrics when compared with the boys, except the NSZ where boys were presented with higher anthropometrics when compared with the girls.

iv. In the adolescent age-group, this study also observed that females from the Southern and Northern senatorial zones of Cross River State showed higher anthropometrics than their male counterparts while, the reverse was the case in the Central senatorial zone. Across senatorial zones, there was no significant difference in body anthropometrics among the adolescent age group in both males and females.

v. Also, males showed higher anthropometrics in the young adult and adult age groups when compared with their female counterparts.

vi. Baseline data was obtained as follows:

   a. Mean height for SSZ = 152.90 ± 17.16 cm; males = 155.35 ± 20.09 cm and females = 150.45 ± 13.21 cm.

b. Mean height for CSZ = 154.44 ± 18.01 cm; males = 157.59 ± 19.95 cm and females = 151.30 ± 15.26 cm.

c. Mean height for NSZ = 151.92 ± 18.68 cm; males = 154.71 ± 20.35 cm and females = 149.12 ± 16.43 cm.

vii. Regression equations using some anthropometric parameters were generated for the study population indicating population specificity in stature as follows:

i. SSZ children: HT = 39.63 + (0.910 * DSLt) + (0.525 * WT) + (0.429 * LL), SEE = 5.01, t = 5.74, $P < 0.001$

ii. CSZ children: HT = 37.23 + (2.632 * HL) + (0.675 * WT) + (0.491 * DSLt), SEE = 4.31, t = 5.88, $P < 0.001$

iii. NSZ children: HT = 37.76 + (0.959 * DSLt) + (0.411 * WT) + (0.633 * FL), SEE = 4.71, t = 5.74, $P < 0.001$

iv. SSZ adolescents: HT = 59.66 + (0.590 * DSLt) + (0.362 * WT) + (0.728 * LL), SEE = 5.94, t = 5.94, $P < 0.001$

v. CSZ adolescent: HT = 13.70 + (1.067 * DSLt) + (0.660 * SHt) + (0.200 * HL), SEE = 4.77, t = 1.64, $P < 0.001$

vi. NSZ adolescent: HT = 12.67 + (0.873 * DSLt) + (0.455 * SHt) + (1.900 * HL), SEE = 4.20, t = 1.93, $P < 0.001$

vii. SSZ young adults: HT = 48.52 + (0.883 * DSLt) + (1.030 * HL) + (0.415 * LL), SEE = 4.42, t = 7.24, $P < 0.001$

viii. CSZ young adults: HT = 20.20 + (0.926 * DSLt) + (0.651 * HL) + (0.635 * SHt), SEE = 5.28, t = 1.77, $P < 0.001$

ix. NSZ young adults: HT = 51.07 + (0.909 * DSLt) + (1.130 * HL) + (0.789 * HB), SEE = 4.20, t = 7.59, $P < 0.001$

x. SSZ adults: HT = 76.13 + (0.478 * DSLt) + (0.779 * LL) + (1.118 * HB), SEE = 9.43, t = 5.25, $P < 0.001$

xi. CSZ adults: HT = 38.49 + (0.959 * DSLt) + (0.842 * FL) + (0.242 * SHt), SEE = 4.56, t = 4.27, $P < 0.001$

xii. NSZ adults: HT = 20.12 + (0.708 * DSLt) + (0.721 * SHt) + (1.127 * HL), SEE = 4.58, t = 2.34, $P < 0.001$

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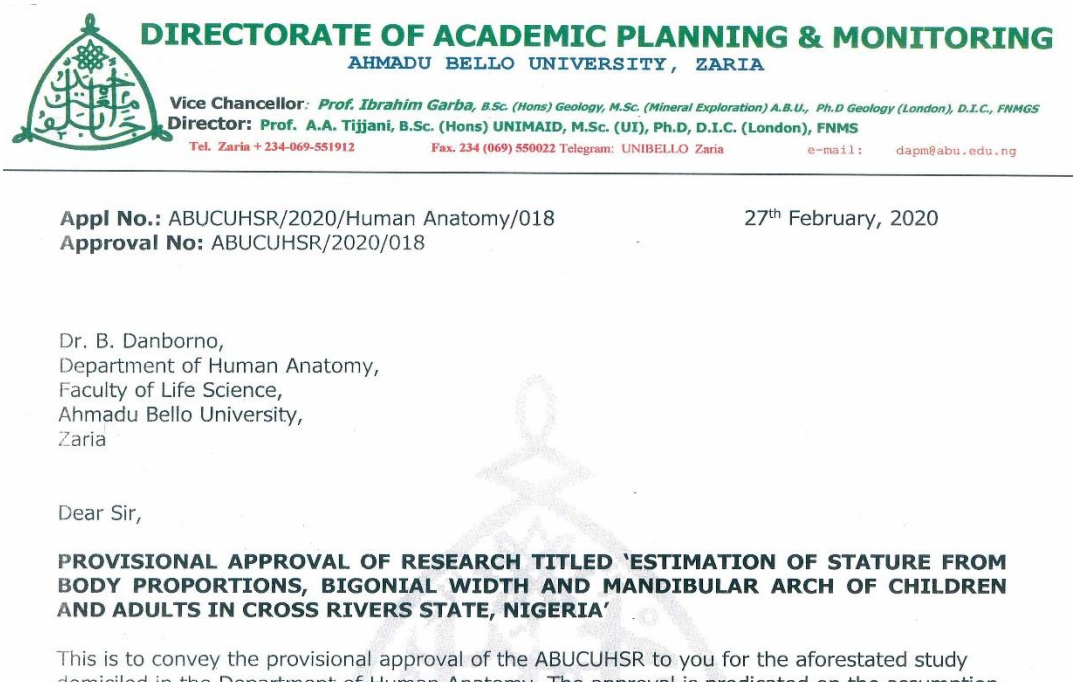
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APPENDIX I



DIRECTORATE OF ACADEMIC PLANNING & MONITORING
AHMADU BELLO UNIVERSITY, ZARIA
Vice Chancellor: *Prof. Ibrahim Garba, B.Sc. (Hons) Geology, M.Sc. (Mineral Exploration) A.B.U., Ph.D Geology (London), D.I.C., FNMGS*
Director: Prof. A.A. Tijjani, B.Sc. (Hons) UNIMAID, M.Sc. (UI), Ph.D, D.I.C. (London), FNMS
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Appl No.: ABUCUHSR/2020/Human Anatomy/018 27th February, 2020
Approval No: ABUCUHSR/2020/018

Dr. B. Danborno,
Department of Human Anatomy,
Faculty of Life Science,
Ahmadu Bello University,
Zaria

Dear Sir,

PROVISIONAL APPROVAL OF RESEARCH TITLED 'ESTIMATION OF STATURE FROM BODY PROPORTIONS, BIGONIAL WIDTH AND MANDIBULAR ARCH OF CHILDREN AND ADULTS IN CROSS RIVERS STATE, NIGERIA'

This is to convey the provisional approval of the ABUCUHSR to you for the aforestated study

APPENDIX II

DEPARTMENT OF ANATOMY
FACULTY OF BASIC MEDICAL SCIENCES
COLLEGE OF MEDICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA

Dear Respondent,

I, Koko Ottoh Arikpo, a PhD student in the Department of Anatomy of the above-named institution, I am carrying out a research on Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria.

Participation is voluntary. It involves collection of certain information about your personal and family characteristics and measurements of some anthropometric parameters: weight, height, demi span length, biaxillary length, bigonial width, length of mandibular arch, hand length, foot

length, thigh length, leg length, neck length, hand breadth, ankle breadth, wrist breadth and sitting height.

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

Thank you for your cooperation.

Yours sincerely,

Koko Ottoh Arikpo

APPENDIX III

CONSENT TO PARTICIPATE IN RESEARCH

Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria.

You are kindly being asked to participate in a research study conducted by Koko Ottoh Arikpo for a Doctorate degree under the supervision of Prof. B. Danborno, Dr. J. A. Timbuak and Dr. M. Tanko from the Department of Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria.

If you have any questions or concerns about the research, please feel free to contact: Koko Ottoh Arikpo, Faculty of Basic Medical Sciences, Tel: 08062679628, Prof. B. Danborno, Faculty of Basic Medical Sciences, Tel: 08143842647, Dr. J. A. Timbuak, Faculty of Basic Medical Sciences, Tel: 08036986537 or Dr. M. Tanko, Faculty of Basic Medical Sciences, Tel: 08029314944.

PURPOSE OF THE STUDY

The present study is primarily aimed to determine the anthropometric variables, estimate stature and determine sexual dimorphism from body proportions of children and adults in the Southern, Central and Northern senatorial zones of Cross River State, Nigeria, and to test the hypothesis that estimations of stature are more accurate if different regression formulae are used for sex and age-specific stature groups. However, it is also expected that the results might implicate certain anthropometric indexes, ethnicity, demography, nutrition, physical activities and socioeconomic factors of the ethnicities in the state.

If you volunteer to participate in this study, I would ask you to do the following things:

To fill in proforma and I shall take some of your anthropometric measurements.

POTENTIAL RISKS AND DISCOMFORT

This study does not pose any form of physical, emotional or psychological risks to you.

POTENTIAL BENEFITS TO PARTICIPANTS

The result of this study, when published will help to provide a reference data base for the association between anthropometric variables considered in this study and stature in Cross River State population, contribute to understanding of the relative status of Cross River State

population in the context of anthropometric variations around the world, in medico-legal cases in establishing identity of an individual in fragmentary and dismembered human remains of Nigerian children and adults of Cross River State, and to create sex and age-group specific regression equations which could help in prediction of stature of children and adults in Cross River State, and the influence of these body parameters on anthropometric indexes, ethnicity, demography, nutrition, physical activities and socioeconomic factors. The conclusions that will be drawn will suggest whether there is a strong correlation between stature and the parameters measured, and will indicate if stature could be predicted using these parameters, age, weight, bigonial width, mandibular arch and BMI among children and adults of Cross River State, Nigeria.

PAYMENT FOR PARTICIPATION

Participation will not attract any financial benefit.

CONFIDENTIALITY

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

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If 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 investigator may withdraw you from this research if circumstances arise that warrant doing so.

RIGHTS OF RESEARCH PARTICIPANTS

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

Prof. B. Danborno,
Department of Anatomy,
Faculty of Basic Medical Sciences,
College of Medical Sciences,
Ahmadu Bello University.
Tel: 08143842647
E-mail: sbdanborno@yahoo.com

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I have read the information provided for the study "Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria" as described herein. I have been given a copy of this form.

_____

Name of Participant

_____

Signature of Participant _____ Date

SIGNATURE OF WITNESS

_____

Name of Witness

_____

Signature of Witness _____

Date

Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria

Name: Koko Ottoh Arikpo

Position: PhD Student

Contact Address: Department of Anatomy, Faculty of Basic Medical Sciences, Ahmadu Bello University, Zaria

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

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Name of Participant Date Signature

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Name of Researcher Date Signature

APPENDIX IV

DEPARTMENT OF ANATOMY
FACULTY OF BASIC MEDICAL SCIENCES
COLLEGE OF MEDICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA

PhD RESEARCH PROFORMA

TOPIC: **Stature Estimation and Sexual Dimorphism from Body Proportions of Children and Adults in Cross River State, Nigeria**

RESEARCHER: Koko Ottoh Arikpo

Research ID: _____

A. BIODATA

1. Age: _____years
2. Date of Birth: _____/ _____/ _____ (DD/MM/YYYY)
3. Sex: Male [ ] Female [ ]
4. Zone: SSZ [ ] CSZ [ ] NSZ [ ]

B. SOCIODEMOGRAPHICS:

1. Father's ethnic group: _____
2. Mother's ethnic group: _____
3. Paternal grandfather's ethnic group: _____
4. Paternal grandmother's ethnic group: _____
5. Maternal grandfather's ethnic group: _____
6. Maternal grandmother's ethnic group: _____

7. Father's level of education (None/Primary/Secondary/Tertiary): _____
8. Mother's level of education (None/Primary/Secondary/Tertiary): _____
9. Father's occupation_____
10. Mother's occupation_____
11. Birth order (First, second, third, later born) _____
12. Number of siblings: _____ Brother(s): _____ Sister(s): _____

C. ANTHROPOMETRY

1. Height: _____ cm
2. Weight: _____ kg
3. BMI: _____kg/m^2
4. Sitting height: _____cm
5. Bigonial width: _____cm
6. Length of mandibular arch: _____cm
7. Neck length: _____cm
8. Biaxillary length: _____cm
9. Demi span length: _____cm
10. Hand length: _____ cm
11. Hand breadth: _____ cm
12. Wrist Breadth: _____cm
13. Thigh length: _____cm
14. Leg length: _____ cm
15. Foot length: _____ cm
16. Foot breadth: _____ cm
17. Ankle breadth: _____cm