

**GROWTH AND SEXUAL MATURATION OF
ADOLESCENTS AMONGST JUKUN AND KUTEB
ETHNIC GROUPS OF TARABA STATE**

BY

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DECLARATION

I, DANGOJI, DAVID PHILIP declare that this dissertation titled “**Growth and Sexual Maturation of Adolescents amongst Jukun and Kuteb Ethnic groups of Taraba State**” was carried out by me in the Department of Human Anatomy ,Faculty of Medicine, Ahmadu Bello University, Zaria . The information used for my literature review was fully acknowledged in the text and references. This dissertation has not been presented in any scientific gathering, neither has it been presented for another degree or diploma at any University.

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SIGNATURE

DATE

APPROVAL PAGE

This project dissertation titled **Growth and Sexual Maturation of Adolescents amongst Jukun and Kuteb Ethnic groups of Taraba State** meets the regulations governing the award of degree of Masters of Science in Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This work is dedicated to Almighty God and my beloved parents Elder and Hon. (Mrs.) J.P. Dangoji.

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LIST OF ABBREVIATIONS

BMI:	Body Mass Index
BS:	BreastSize/Stage
CDC:	Centre for Disease Control and Prevention
DHEA:	Dehydroepiandrosterone
GH:	Growth Hormone
GS:	Genital Size/Stage
GS_BS:	Genital/Breast Stage
IGF- I	Insulin-like Growth Factor 1 (Somatomedin)
PH:	Pubic Hair
PHS:	Pubic Hair Stage
PHV:	Peak Height Velocity
SMR:	Sexual Maturity Rating
UNICEF:	United Nations Children's Fund
WHO:	World Health Organization

ABSTRACT

The present cross sectional study investigated the growth and sexual maturation of adolescents of Jukun and Kuteb ethnic groups of Taraba State. The aim of the study was to assess growth and sexual maturation of the Jukun and Kuteb adolescents. The mean menarcheal age of the respondents was estimated, while also assessing their nutritional status. Results of the growth parameters and anthropometric measurements of the adolescents showed no statistical significant difference based on ethnicity, but there was statistical significant difference based on sex in most of the variables. The plotted growth curves of BMI, height and weight of the population with international references showed that the boys had lower values than the reference population, while the girls from both ethnic groups had values similar, and in some cases such as BMI higher than the reference population. The nutritional assessment of the population also showed that the prevalence of stunting, thinness and overweight among boys and girls was 22.4%, 11.7 % and 1.1 % in boys, and 2.9%, 1.1 % and 3.9 % in girls respectively. Results of the study showed late maturation among the adolescents, especially among males. The mean age at onset of sexual maturation in pubic hair was 11.77 ± 0.87 for Jukun boys and 11.88 ± 1.42 for Kuteb boys. For females, it was 11.25 ± 0.90 for Jukun girls and 11.50 ± 1.14 for Kuteb girls. Age at onset of breast development for females was 11.17 ± 1.04 (Jukun) and 11.12 ± 1.11 (Kuteb) respectively. For males, age at entry of genital development was 11.65 ± 0.86 (Jukun) and 11.65 ± 1.43 (Kuteb). Age at completion of sexual development in PH and BS for females was 17.68 ± 1.43 and 17.63 ± 1.43 (Jukun); 17.80 ± 1.59 and 17.44 ± 1.68 (Kuteb) respectively. For males it was 18.09 ± 1.40 and 18.23 ± 1.31 (Jukun), 18.21 ± 1.25 and 18.13 ± 1.38 (Kuteb). Comparison of the sexual maturity rating with height and weight of this study population showed that girls were shorter than the boys in both PHS and GS_BS stages except during PHS 1. Boys tend to be weightier than girls in stage 5 of PHS and GS_BS only, the girls had

higher values in the other stages. The girls of this study also had BMI and % body fat values significantly higher than the boys at each stage of the PHS and GS_BS. The Hand and Foot anthropometry showed that boys from the two ethnic groups showed statistically significant higher values than their female counterparts. Linear regression models for estimating sexual maturity rating from anthropometric variables of adolescents from each ethnic group were generated. The present study showed that the age at onset of maturation for pubic hair and genital/breast stage was early and compared favorably with other studies, but there was late maturation into adult size in both the boys and girls.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Growth and physical maturation are dynamic processes encompassing a broad spectrum of cellular and somatic changes. Traditionally, the assessment of growth has placed its focus on stature, but changes in body proportions and body composition are essential elements of the growth process. Growth standards have been developed for each of these parameters and aid in the identification of children with normal growth, variations of normal growth and development, and the broad spectrum of abnormal growth states (Rogol *et al.*, 2002). Tanner *et al.*, (1995) has proposed that children be measured accurately to identify individuals or groups of individuals within a community who require special care, to identify illnesses that influence growth, or to determine an ill child's response to therapy.

The beginning of biological growth and development during adolescence is signified by the onset of puberty, which is often defined as the physical transformation of a child into an adult (Kaplowitz *et al.*, 2001). A myriad of biological changes occur during puberty including sexual maturation, increases in height and weight, completion of skeletal growth accompanied by a marked increase in skeletal mass, and changes in body composition (Marshall, 1978; Sisk and Foster, 2004). The succession of these events during puberty is consistent among adolescents (Hazen *et al.*, 2008, Mei *et al.*, 2008), however, there may be a great deal of deviation in the age of onset, duration, and tempo of these events between and within individuals (Rogol *et al.*, 2000; Gasser *et al.*, 2000). For this reason, adolescents of the same chronological age can vary greatly in physical appearance. This has direct relevance for the nutrition requirements of adolescents (Stang and Story, 2005).

Puberty occurs through a long process and begins with a surge in hormone production, which in turn causes a number of physical changes (Cooney, 2010). It is the stage of life in which a child develops secondary sex characteristics (for example, a deeper voice and larger adam's apple in boys, and development of breasts and more curved and prominent hips in girls) as his or her hormonal balance shifts strongly towards an adult state. This is triggered by the pituitary gland, which secretes a surge of hormonal agents into the blood stream, initiating a chain reaction. The male and female gonads are subsequently activated, which puts them into a state of rapid growth and development; the triggered gonads now commence the mass production of the necessary chemicals. The testes primarily release testosterone, and the ovaries predominantly dispense estrogen. The production of these hormones increases gradually until sexual maturation is met. Some boys may develop gynecomastia due to an imbalance of sex hormones, tissue responsiveness or obesity (Nydic *et al.*, 1961; Slap, 2001).

One of the hallmarks of puberty is the adolescent growth spurt. As puberty approaches, growth velocity slows to a nadir (“preadolescent dip”) before its sudden acceleration during midpuberty. The timing of the pubertal growth spurt in girls is typically at Tanner breast stage 3 and does not reach the magnitude of that in boys (Bogin, 2001; Archibald *et al.*, 2003). Girls average a peak height velocity of 9 cm/y at age 12 and a total gain in height of 25 cm during the pubertal growth period (Kelch and Beitins, 1994). Boys, on average, attain a peak height velocity of 10.3 cm/y 2 years later than girls, during Tanner genital stage 4, and gain 28 cm in height (Kelch and Beitins, 1994). The longer duration of prepubertal growth in boys, combined with a greater peak height velocity, results in an average adult height difference of 13 cm

between men and women. After a period of decelerating height velocity, growth virtually ceases because of epiphyseal fusion, typically at a skeletal age of 15 years in girls and 17 years in boys (Tanner, 1989; Bogin, 1999).

Puberty is also a time of significant weight gain; 50% of adult body weight is gained during adolescence. In boys, peak weight velocity occurs at about the same time as peak height velocity and averages 9 kg/y. In girls, peak weight gain lags behind peak height velocity by ≈ 6 mo and reaches 8.3 kg/y at ≈ 12.5 y of age (Tanner, 1989). The rate of weight gain decelerates in a manner similar to height velocity during the later stages of pubertal development.

Body fat (most of which lies just beneath the skin) increases in the last few weeks of prenatal life and continues to do so after birth, reaching a peak at about 9 months of age. This early rise in "baby fat" helps the infant keep a constant body temperature. Starting in the second year and continuing into middle childhood, most toddlers slim down (Fomon and Nelson, 2002). At birth, girls have slightly more body fat than boys, a difference that persists into the early school years and then magnifies. Around age 8, girls start to add more fat on their arms, legs, and trunk; they continue to do so throughout puberty, while the arm and leg fat of adolescent boys decreases (Siervogel *et al.*, 2000). The changes in the distribution of body fat (central compared with peripheral, subcutaneous compared with visceral, and upper compared with lower body) results in the typical android and gynoid patterns of fat distribution of the older adolescent and adult (Johnston, 1992).

Muscle accumulates slowly throughout infancy and childhood, with a dramatic rise at adolescence. Both sexes gain muscle at puberty, but this increase is 150 % greater in boys, who develop larger skeletal muscles, hearts, and lung capacity (Rogol *et al.*,

2002). Also, the number of red blood cells—and therefore the ability to carry oxygen from the lungs to the muscles—increases in boys but not in girls. Altogether, boys gain far more muscle strength than girls, contributing to their superior athletic performance during the teenage years (Ramos *et al.*, 1998).

Growth in a number of dimensions shows a significant familial resemblance. Adult stature, tempo of growth, timing and rate of sexual development, skeletal maturation, and dental development are all significantly influenced by genetic factors (Sinclair, 1978), with estimates of genetic transmissibility ranging from 41 % to 71 % (Tanner, 1989). Twin studies have shown that the average difference in height between monozygotic twins is only 2.8 cm, compared with 12 cm for dizygotic twins of the same sex. Adult stature is best correlated with mid-parental height calculations, but the polygenic model of inheritance results in greater variation in size of children born to parents of disparate heights compared with those born to parents both of average height (Smith, 1977, Sheehy *et al.* 2000; Estourgie-van Burk *et al.*, 2006). The overall contribution of heredity to adult size and shape varies with environmental circumstances, and the two continuously interact throughout the entire period of growth (Oyhenart *et al.*, 2008). Children with similar genotypes, who would reach the same adult height under optimal conditions, may be differently affected by adverse circumstances. Thus, the interaction between genetic makeup and the environment is complex and non-additive (Tanner, 1994; Euling, 2008).

The secular trend in height and adolescent development is further evidence for the significant influence of environmental factors on an individual's genetic potential for linear growth. Since the turn of the century, children in average economic conditions have increased in height approximately 1 to 2 cm per decade (Euling *et al.*,

2008). The secular gain appears early in life, increases over childhood and early adolescence, and then declines as mature body size is reached. This pattern suggests that the larger size of today's children is mostly due to a fast rate of physical development. Consistent with this view, age of first menstruation declined steadily from 1900 to 1970, by about 3 to 4 months per decade. Although evidence on boys is sparse, they, too, show signs of having reached puberty earlier in recent decades. The gain in adult stature, however, has been less, indicating that, in part the trend toward greater size during childhood is the result of earlier maturation and adult height achievement (Tanner, 1994). Improved health and nutrition are largely responsible. As developing nations make socioeconomic progress, they also show secular gains (Ji and Chen, 2009). Secular trends are smaller for low-income children, who have poorer diets and are more likely to suffer from growth-stunting illnesses. In regions with widespread poverty, famine, and disease, either no secular change or a secular decrease in body size has occurred (Barnes-Josiah and Augustin, 1995; Cole *et al.*, 2000). In most industrialized nations, the secular gain in height has slowed, and the trend toward earlier first menstruation (menarche) has stopped or undergone a slight reversal. But in the United States and a few European countries, soaring rates of overweight and obesity are responsible for a modest, continuing trend toward earlier menarche (Parent *et al.*, 2003; Kaplowitz, 2008).

1.2 STATEMENT OF THE PROBLEM

The secular trend in growth patterns has been extensively studied. While this exists for some, there is paucity of data on *Jukun* and *Kuteb* ethnic groups. Hence there is a need to generate growth reference values for all ethnic groups and this study location in particular. Furthermore, there are very few if nonexistent sexual maturation studies that have been carried out or published in Nigeria.

1.3 JUSTIFICATION

It is universally accepted that anthropometry is the most useful tool for assessing the growth, nutrition status, and risks of poor health and survival of infants and adolescents. This work is designed to assess growth and sexual maturation of adolescents and also link it with some anthropometric measurements. This will generate a baseline data for growth and sexual maturation and also to identify whether a secular trend in sexual maturation occurs among the study population.

1.4 AIMS AND OBJECTIVES OF THE STUDY

1.4.1 Aims of the Study

The aim of this study is to assess physical growth and sexual maturation of *Jukun* and *Kuteb* adolescents.

1.4.2 Objectives of the Study

The study has been designed with the following objectives:

- i. estimate the mean height, weight and Body Mass Index (BMI) of the population and compare it with international values
- ii. estimate the mean age at menarche of adolescent girls from the *Jukun* and *Kuteb* ethnic groups
- iii. compare the onset of puberty and sexual maturation among the *Jukun* and *Kuteb* ethnic groups
- iv. assess the nutritional status of adolescents among *Jukun* and *Kuteb* ethnic groups
- v. generate growth reference values for adolescents among *Jukun* and *Kuteb* ethnic groups

- vi. Generate linear regression equation for sexual maturation of adolescents of *Jukun* and *Kuteb* using anthropometric variables.

1.5 SIGNIFICANCE

The study will establish baseline data of growth pattern and sexual maturation amongst the *Jukun* and *Kuteb* ethnic groups.

This research work can also be used in planning, evaluation and advocacy that will lead to the implementation of interventions to improve child health and survival.

1.6 STUDY HYPOTHESIS

There will be no difference in growth and sexual maturation between the *Jukuns* and the *Kutebs* adolescents.

1.7 STUDY LOCATION

Takum Local Government is located in Southern part of Taraba State, its headquarters are in the town of Takum, at latitude $7^{\circ} 16' 00''$ N and $9^{\circ} 59' 00''$ E. It has a total land mass of 6400 square kilometer and a population of 135,349 at the 2006 census. Takum chiefdom shares boundaries with Benue State to the west, Donga Local government lies to the Northeast, while to the southeast lies Kurmi Local Government. The Federal Republic of Cameroun lies to the south of Takum local Government area.

1.7.1 Topography of the Study Area

The area consist mainly of gently undulating land with a few dotted mountainous feature with high land area of about 3000 – 9000mm above sea level the land area below 300 meters above see level, suitable for man habitation and indeed farming is carried out extensively in this area.

1.7.2 Climate

Takum local government enjoys two distinctive climate condition in a year which are dry season and rainy (weet) season the farming starts from mid march to October some time, extend to November. The dry season characterized by the north-east trade with which are the tropical continental and resulting to cold weather, with most sever? Being December January and February are dry and some time dusty. The rainy season is dominated by south west tropical maritime wind and the rainfall over the area range from 1,500mm, with humidity rate relatively high. Climate is an important factor that determines the form of any architecture. In Nigeria the Jukun and Kuteb live in northern Savannah type of climate. The rainfall intensity is very high between the months of July and August. As a result though the environment is generally dry, crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water-logging (Udo, 1970). Dry season is the period of harmattan: a transition period between the wet and the hot seasons. It is a period when there is little or no rainfall (Ati, 2002). Daytime temperatures fluctuate between 16 and 32°C in November with clear sky of sunshine hours of between 8.9 and 9.5. December to January in Takum is

characterized by the suspension of fine dust particles in the air, due to Harmattan winds which cause surface turbulence. Visibility is poor, disrupting air navigation while sun's rays barely reach ground surface. This action reduces night temperatures to 14°C, with sunshine hours between 8.7 and 9.5. Daytime temperature may drop to 31°C, giving a variation of 17°C, the highest in the year. This extreme diurnal temperature range is another characteristic of the Savanna type of climate (Areola *et al.*, 2005).

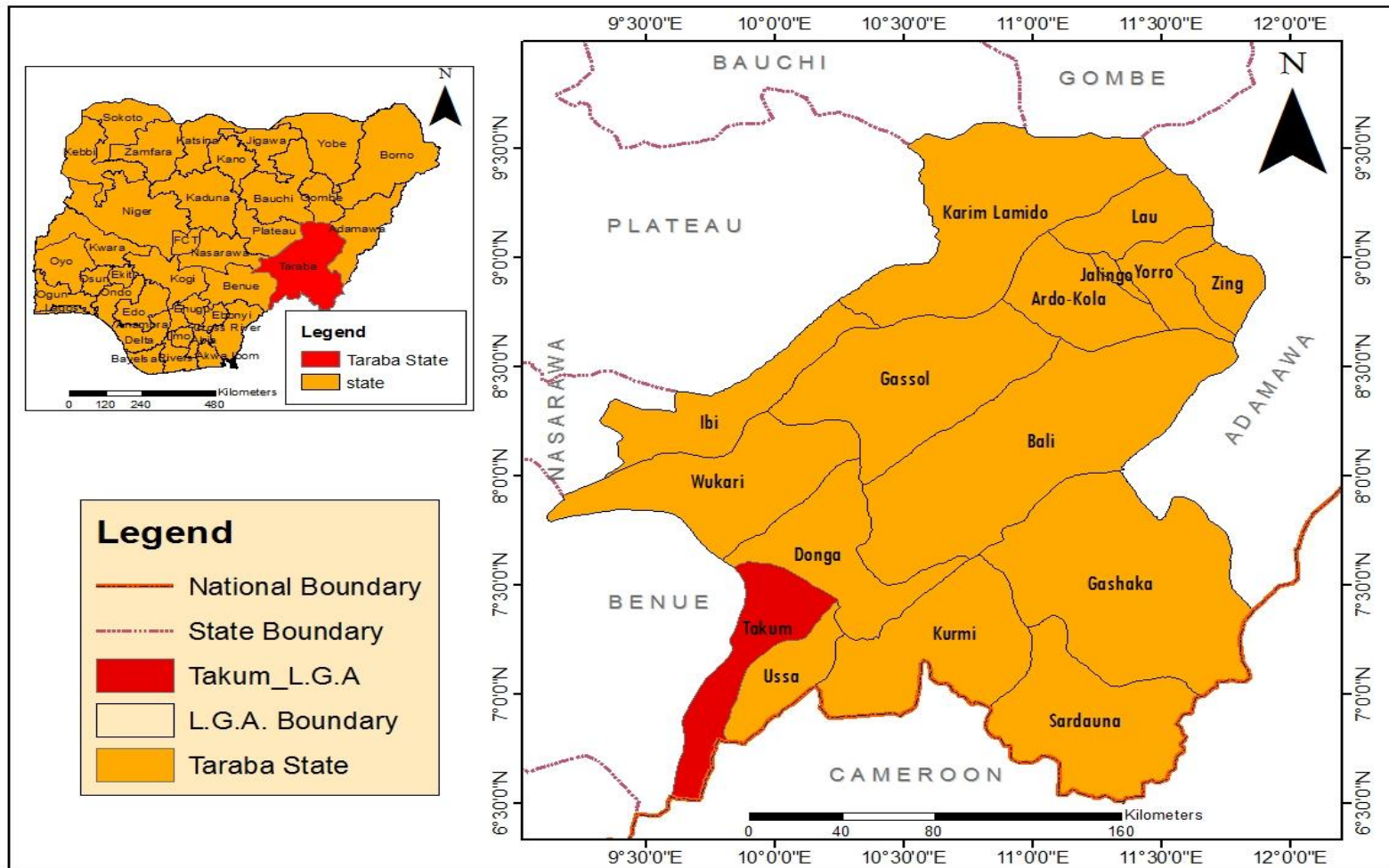


Fig. 1.1: Map of Nigeria, showing Takum LGA. Source:Geographic and information systems (GIS)

1.8 DEFINITION OF TERMS

- i. **Adolescence:** Period of the life span between the time puberty begins and the time adult status is approached, when young people are preparing to take on the roles and responsibilities of adulthood in their culture.
- ii. **Adrenarche:** Maturation of the adrenal gland that results in secretion of androgens from the adrenal cortex. Regulated by the Hypothalamic-pituitary-adrenal axis (HPA) but activated by unknown factors, adrenarche occurs independently of gonadal maturation and breast development.
- iii. **Androgens:** Sex hormones that have especially high levels in males from puberty onward and are mostly responsible for male primary and secondary sex characteristics.
- iv. **Estradiol** The estrogen most important in pubertal development among girls.
- v. **Estrogens:** Sex hormones that have especially high levels in females from puberty onward and are mostly responsible for female primary and secondary sex characteristics.
- vi. **Gonadarche:** Maturation of the gonads (ovaries in girls) that results in a dramatic increase in sex hormone production (estradiol in girls). Gonadarche is the result of the activation of the Hypothalamus-pituitary-gonadal axis and indicates that puberty has commenced. Gonadarche is less visible in girls than boys.
- vii. **HPA axis:** Hypothalamus-pituitary-adrenal axis. A second signaling pathway involved in puberty. The HPA axis permits the production of steroidal

hormones from the adrenal glands (which sit atop the kidneys). These hormones include androgens.

- viii. **HPG axis:** Hypothalamus-pituitary-gonadal axis. This signaling pathway regulates the production of sex hormones by sending chemical messages from the hypothalamus in the brain to the pituitary gland and then, in girls, to the ovary. Its activation marks the onset of puberty.
- ix. **Infant puberty** (also known as “mini puberty”): The period of early development (from late prenatal life through 3 to 9 months) when the HPG axis is active and prior to its repression during the juvenile period. Sex hormones are produced during infant puberty. Unlike adolescent puberty, infant puberty is not tightly regulated.
- x. **Insulin resistance:** Occurs when increasing amounts of insulin are needed to transport blood glucose into body tissues. The result is hyperinsulinism, often a precursor of type 2 diabetes.
- xi. **Isolated premature thelarche:** Breast development without activation of the HPG axis and in the absence of gonadarche in girls younger than 7. Isolated premature thelarche may or may not raise the risk for true precocious puberty. The self-limiting or progressive nature of this condition is a matter of ongoing debate (Salardi, 1998).
- xii. **Menarche:** Onset of menstruation and a consequence of estradiol stimulation. It is a late stage event in the pubertal process. Along with thelarche, menarche is a consequence of HPG activation.

- xiii. **Precocious puberty:** Signs of sexual maturation that appear at an age that is more than two standard deviations below the mean. True precocious puberty refers to premature activation of the (HPG) axis that initiates gonadarche and thelarche. True precocious puberty is five times more common in girls than boys. In the past, true precocious puberty was defined as onset of gonadarche and thelarche before age 8, which was considered the lower limit for normal puberty in girls. In 1999 in the United States, these age limits were revised downward to 7 years old for white girls and 6 years old for black girls (Kaplowitz and Oberfield, 1999).
- xiv. **Premenstrual Syndrome** is defined as the cyclical recurrence of symptoms, physical, psychological, and/or behavioural, that occur after ovulation and disappear within a few days of onset of bleeding. These symptoms affect how women function in daily life, often interfering with work, school or personal relationships.
- xv. **Primary Sex Characteristics:** Production of eggs (ova) and sperm and the development of the sex organs
- xvi. **Pubarche:** Appearance of pubic and underarm hair, adult body odour, increased oiliness of skin and hair and, sometimes, acne.
- xvii. **Puberty:** Changes in physiology, anatomy, and physical functioning that develop a person into a mature adult biologically and prepare the body for sexual reproduction.
- xviii. **Puberty:** The time at which the onset of sexual maturity occurs and the reproductive organs become functional. This is manifested in both sexes by

the appearance of secondary sexual characteristics. These changes are brought about by an increase in sex hormone activity due to the stimulation of the ovaries and testes by pituitary hormones.

- xix. **Secondary Sex Characteristics:** Bodily changes of puberty not directly related to reproduction.
- xx. **Spermarche:** Beginning of development of sperm in boys' testicles at puberty.
- xxi. **Testosterone:** The androgen most important in pubertal development among boys
- xxii. **Thelarche:** Onset of breast development, also called "breast budding." It is a physical consequence of gonadarche and an early visible event in pubertal development.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ADOLESCENT GROWTH AND SEXUAL MATURATION

Adolescence is the period of transition from childhood to adulthood, which comprises the age range from 10 to 19 years, characterized by intense bio-psychosocial transformations (WHO, 2005). Adolescence begins with the first notable changes of puberty, and in the course of puberty the body is transformed in many ways and reaches the capacity for sexual reproduction (Behrman and Vaughan, 2002; Alsaker and Flammer, 2006). Puberty refers to the biological transition period between childhood and adulthood, ranging from individual to individual regarding the age of its onset and speed of changes, during which the secondary sexual characteristics begin to develop and the capability of sexual reproduction is achieved (Adami, 2007). Although adolescence is a culturally-constructed period of life, the biological changes of puberty are a central part of development during adolescence in all cultures. Many changes take place, and they are often dramatic (Hockenberry *et al.*, 2007). Sexual maturity is a biological process and can be defined as the progression towards the mature state, when specialization and cell differentiation occur (Malina and Bouchard, 1991; Rogol *et al.*, 2002). After growing at a more or less steady rate through childhood, at some time early in the second decade of life children begin a remarkable metamorphosis that includes a growth spurt, the appearance of pubic hair and underarm hair, changes in body shape, breast development and menstruation in girls, the appearance of facial hair in boys, and much more. The changes can be exciting and joyful, but adolescents experience them with other emotions as well—fear, surprise, annoyance, and anxiety (Becker, 2001; Shirtcliff *et al.*, 2009).

Growth is a dominant biological activity during the first two decades or so of human life including, of course nine months of prenatal life. While growing the individual also matures. Growth is an increase in the size of the body as a whole or the size attained by specific parts of the body. It is a fundamental characteristic of all living organisms. The term development is frequently used along with growth and even considered synonymous by some people. But growth and development are not identical. The child is characterized by two fundamental facts – the growth and the development. Growth means the increase in the size of the various parts and organs of the body by multiplication of cells and intercellular components during the period commencing from fertilization to physical maturity. Changes in size are outcomes of three underlying cellular processes: hyperplasia (increase in cell number); hypertrophy (increase in cell size) and accretion (increase in intercellular substance) (Sloboda *et al.*, 2007).

Development is the gaining of skills in all aspects of the child's life. The term development is frequently used along with growth and even considered synonymous by some people. But growth and development are not the identical. Therefore it requires a careful examination and proper understanding. Development refers to the increase of functional capacity in perfect form resulting from production of specialized tissues from unspecialized ones. (Vaida, 2013). An individual may grow in size but some organs though fully grown in size may fail to develop to perform the specific functions. Interactions of several processes with each other occur during growth and development. Growth may mean increase in physical size of the whole or any of its part which may be measured. On the other hand, development indicates an increase in skill and complexity of function. In any case the processes of development

and growth are not the same but are interrelated and interdependent. Maturation is more difficult to define than growth. It is often described as the process of becoming mature, or progress toward the mature state. Maturity, however, varies with the biological system considered. Sexual maturity is fully functional reproductive capability. Maturation refers to the tempo and timing of progress toward the mature biological state (Malina 2010).

2.2 COURSE OF PHYSICAL GROWTH

2.2.1 Changes in Body Size

The most obvious signs of physical growth are changes in overall body size. During infancy, these changes are rapid—faster than at any other time after birth. By the end of the first year, a typical infant's height is 50 percent greater than at birth; by 2 years, it is 75 percent greater. Similarly, birth weight typically doubles by age 5 months, triples by 1 year, and quadruples by age 2. If children kept growing at this rate, by age 10 they would be 10 feet tall and weigh over 200 pounds! Fortunately, growth slows in early and middle childhood, when children add about 2 to 3 inches in height and 5 pounds in weight each year. Then, puberty brings a sharp acceleration. On average, adolescents gain 10 to 11 inches in height and about 50 to 75 pounds in weight (Berk, 2012).

Two types of growth curves are used to track overall changes in body size. The first, shown in Figure 2.1a, is a distance curve, which plots the average size of a sample of children at each age, indicating typical yearly progress toward maturity. The figure shows gains in height; weight gain follows a similar trend. Notice how during infancy and childhood the two sexes are similar, with the typical girl just slightly

shorter (and lighter) than the typical boy. Around age 10 to 11, the typical North American and European girl becomes taller (and heavier) for a time because her pubertal growth spurt takes place two years earlier than the boy's (Bogin, 2001; Archibald *et al.*, 2003). At age 14, however, she is surpassed by the typical boy, whose growth spurt has now started, whereas hers is almost finished. Growth in height is complete for most North American and European girls by age 16, for boys by age 17.5.

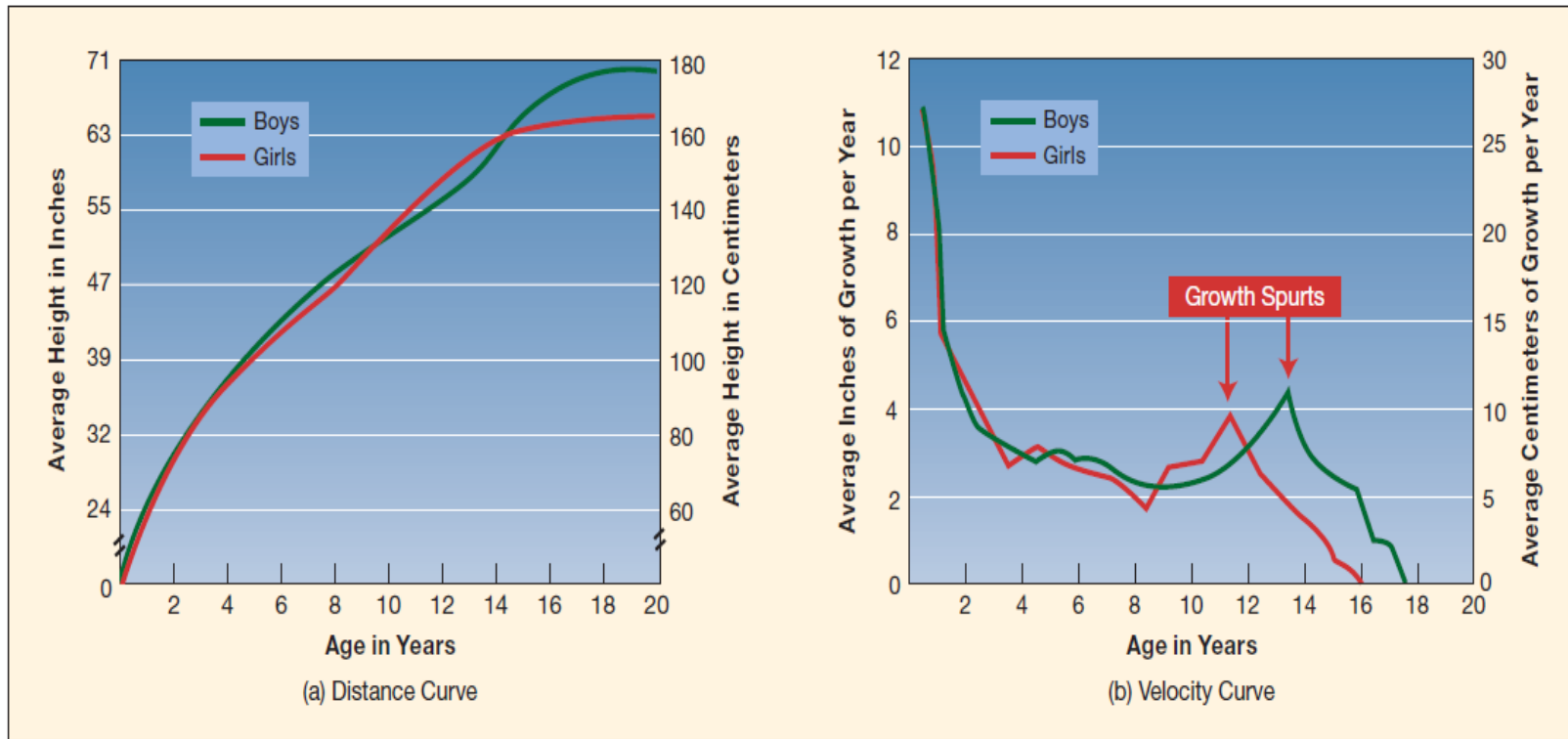


Fig. 2.1: Distance and velocity curve for height. The scores are based on cross sectional height measurements taken on thousands of U.S children. (U.S. Department of Health and Human Services, 2000.)

Figure 2.1b shows a second type of growth curve, the velocity curve, which plots the average amount of growth at each yearly interval, revealing the exact timing of growth spurts. Note the rapid but decelerating growth in infancy; a slower, constant rate during early and middle childhood; and a sharp increase in early adolescence, followed by a swift decrease as the body approaches its adult size (Berk, 2012).

2.2.2 Changes in Body Proportion

As the child's overall size increases, parts of the body grow at different rates. Two growth patterns describe these changes. The first is the cephalocaudal trend—from the Latin for “head to tail.” During the prenatal period, the head develops first from the primitive embryonic disk, followed by the lower part of the body. After birth, the head and chest continue to have a growth advantage, but the trunk and legs gradually pick up speed. In the second pattern, the proximodistal trend, growth proceeds, literally, from “near to far”—from the center of the body outward. In the prenatal period, the head, chest, and trunk grow first, then the arms and legs, finally the hands and feet. During infancy and childhood, the arms and legs continue to grow somewhat ahead of the hands and feet (Berk, 2012).

During puberty, growth proceeds in the reverse direction. The hands, legs, and feet accelerate first, followed by the torso, which accounts for most of the adolescent height gain (Sheehy *et al.*, 2000). This pattern helps explain why young adolescents often appear awkward and out of proportion—long-legged, with giant feet and hands.

In infancy and childhood, girls and boys have similar body proportions. During adolescence, however, large differences appear, caused by the action of sex hormones on the skeleton. Boys' shoulders broaden relative to the hips, whereas girls' hips broaden relative to the shoulders and waist. Of course, boys also end up considerably

larger than girls, and their legs are longer in relation to the rest of the body. The major reason is that boys have two extra years of preadolescent growth, when the legs are growing the fastest (Berk, 2012).

2.2.3 Changes in Body Fat Makeup

Body fat (most of which lies just beneath the skin) increases in the last few weeks of prenatal life and continues to do so after birth, reaching a peak at about 9 months of age. This early rise in “baby fat” helps the infant keep a constant body temperature. Starting in the second year and continuing into middle childhood, most toddlers slim down (Fomon and Nelson, 2002). At birth, girls have slightly more body fat than boys, a difference that persists into the early school years and then magnifies. Around age 8, girls start to add more fat on their arms, legs, and trunk; they continue to do so throughout puberty, while the arm and leg fat of adolescent boys decreases (Siervogel *et al.*, 2000).

Muscle accumulates slowly throughout infancy and childhood, with a dramatic rise at adolescence. Both sexes gain muscle at puberty, but this increase is 150 percent greater in boys, who develop larger skeletal muscles, hearts, and lung capacity (Rogolet *et al.*, 2002). Also, the number of red blood cells—and therefore the ability to carry oxygen from the lungs to the muscles—increases in boys but not in girls. Altogether, boys gain far more muscle strength than girls, contributing to their superior athletic performance during the teenage years (Ramos *et al.*, 1998).

2.2.4 Skeletal Growth

Because children of the same age differ in *rate* of physical growth, researchers have devised methods for measuring progress toward physical maturity that are useful for studying the causes and consequences of these individual differences. The best estimate

of a child's physical maturity is skeletal age—a measure of development of the bones of the body. The embryonic skeleton is first formed out of soft, pliable tissue called cartilage. In the sixth week of pregnancy, cartilage cells begin to harden into bone, a gradual process that continues throughout childhood and adolescence (Moore and Persaud, 2008).

Just before birth, special growth centers, called epiphyses, appear at the two extreme ends of each of the long bones of the body (see Figure 2.2). Cartilage cells continue to be produced at the growth plates of these epiphyses, which increase in number throughout childhood and then, as growth continues, get thinner and disappear. After that, no further growth in bone length is possible. Skeletal age can be estimated by X-raying the bones to determine the number of epiphyses and the extent to which they are fused (Berk, 2012).

African-American children tend to be slightly ahead of Caucasian-American children in skeletal age. Girls are considerably ahead of boys—a gap of about four to six weeks at birth, which widens over infancy and childhood (Tanner *et al.*, 2001). Girls are advanced in development of other organs as well. This greater physical maturity may contribute to girls' greater resistance to harmful environmental influences. Girls experience fewer developmental problems than boys and have lower infant and childhood mortality rates (Berk, 2007).

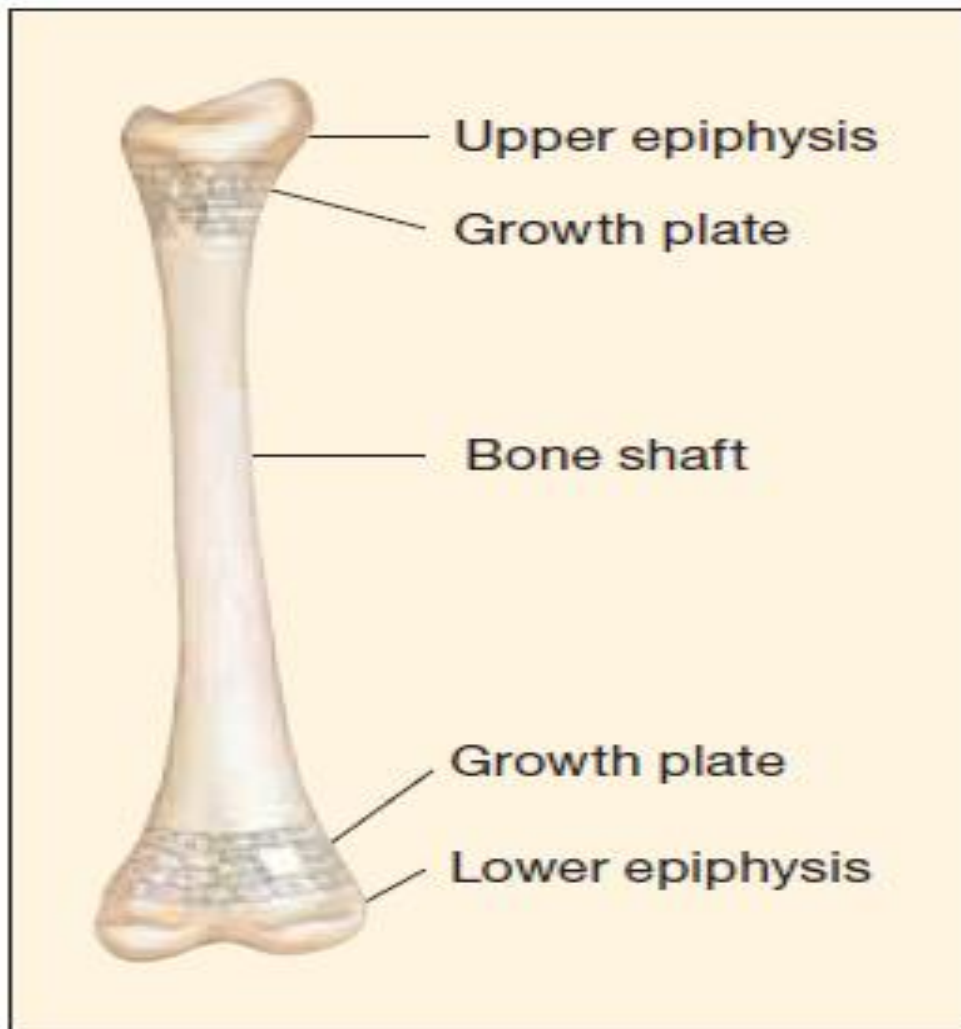


Fig 2.2. Diagram of a long bone showing upper and lower epiphyses (Berk, 2012)

2.3 INDICATORS OF BIOLOGICAL MATURATION

Maturation is a process that marks progress toward the adult (mature) state. Maturation is a process, whereas maturity is a state. All tissues, organs, and organ systems of the body mature, but they do so at different times and rates. As a result, assessment of biological maturity status varies with the bodily system considered. Of necessity, therefore, the concept of maturation is operational. The more commonly used systems for the assessment of maturation are the skeletal, reproductive (sexual), and somatic systems; hence, the terms skeletal, sexual, and somatic maturation are standard in the growth literature. Dental maturation (eruption and calcification) is occasionally used, but it tends to proceed independently of the other three systems. Biochemical and hormonal maturation, as steering mechanisms for the other systems, must also be considered (Beunen and Malina, 1996; Beunen, 2001).

Maturation of different systems tends to proceed independently of chronological (calendar) age, so that chronological age is not a good indicator of biological maturity. Nevertheless, the growth and maturity status of an individual or sample of individuals is routinely placed in the context of chronological age (Beunen *et al.*, 2006).

In constructing objective, reliable, and valid indicators of biological maturity status, it is of importance that the indicators reflect the maturation of a biological system, occur in all individuals as they progress toward the adult state, and reach the same endpoint, i.e., the mature or adult state. The indicators should also, to some extent, be independent of growth (size attained), i.e., they should not quantify the growth status of a tissue, an organ, or a biological system. Finally, a relevant indicator should be applicable throughout the entire maturation process, but the reality of variation among systems

precludes this criterion (Tanner, 1962; Acheson, 1966; Roche, 1986; Malina *et al.*, 2004).

2.3.1. Sexual Maturity

Sexual maturity is a biological process and can be defined as the progression towards the mature state, when specialization and cell differentiation occur (Malina and Bouchard, 1991; Rogol *et al.*, 2002). After growing at a more or less steady rate through childhood, at some time early in the second decade of life children begin a remarkable metamorphosis that includes a growth spurt, the appearance of pubic hair and underarm hair, changes in body shape, breast development and menstruation in girls, the appearance of facial hair in boys, and much more. The changes can be exciting and joyful, but adolescents experience them with other emotions as well—fear, surprise, annoyance, and anxiety (Becker, 2001; Shirtcliff *et al.*, 2009).

The assessment of sexual maturation is based on secondary sex characteristics: breast development and age at menarche in girls, genital (penis and testes) development in boys, and pubic hair in both sexes. Development of the breasts, genitals, and pubic hair is most often rated on five-point scales described by Tanner (Tanner, 1962; Hall *et al.*, 2007). The stages should not be identified as “Tanner stages” but as stages of sexual maturation with identification of the specific characteristic(s) (breast, pubic hair, or genitals) assessed. The stages of each characteristic are neither equivalent nor interchangeable. Stage 1 of each characteristic indicates the prepubertal state (absence of development) and stage 2 the initial, overt development of each characteristic that marks the transition into puberty. Stages 3 and 4 mark progress in maturation, and stage five indicates the adult (mature) state (Beunen, 2001).

Ratings of stages of secondary sex characteristics are ordinarily made by individual observation at clinical examination. Sometimes, as in the Harpenden Growth Study (Marshall and Tanner, 1969; Marshall and Tanner, 1970), the examination was made from standardized, nude photographs. In nonmedical settings, self-assessments by youths are increasingly used. Self-assessments should be done privately in a quiet room using good-quality photographs of the stages and simplified descriptions. There is obviously a need for quality control (intra- and interobserver reliability), and in the case of self-assessment concordance with experienced assessors should be verified. Overall reproducibility by experienced assessors is generally good, with about 80% of agreement in assigning the stages, although some studies report a percentage of agreement as low as 40% (Malina *et al.*, 2004).

Age at menarche, the first menstruation, is perhaps the most widely monitored secondary sex characteristic in females. It can be obtained in three different ways: prospectively (longitudinal design), by interrogating the same girls at regular intervals of 3 to 6 months; retrospectively, by interrogating postmenarcheal girls or women and asking them to recall when they experienced their first menstruation; and status quo, by interrogating large samples of girls approximately 9 to 16 years of age about their menarcheal status (i.e., pre- or postmenarcheal, see below). The first two methods provide ages at menarche for individuals, whereas the status quo method provides an estimated age at menarche for a sample and does not apply to individuals (Schlossberger *et al.*, 1992).

Other secondary sex characteristics include axillary hair in both sexes and facial hair and voice change in boys. As a rule, these are late-developing indicators during puberty and are not widely used in studies of biological maturation. A more direct estimate of

genital maturity in boys is provided by testicular volume. The method is used primarily in the clinical setting and requires a series of ellipsoid models of known volume, which have the shape of the testes (Prader orchidometer). The models range in volume from 1 to 25 ml; a volume above 4 ml marks the beginning of puberty (Prader, 1966; Zachmann *et al.*, 1974).

Secondary sex characteristics are reasonably easy to determine, reflect an important biological system, and are closely related to underlying hormonal axes. On the other hand, secondary sex characteristics have limitations, in that the stages are somewhat arbitrary and discrete, they are limited to puberty, and the method of assessment is invasive in nonclinical settings (not necessarily true for self-assessment). Moreover, the use of secondary sex characteristics may have associated sanctions among some cultural groups (Rapkin *et al.*, 2006).

2.3.2 Somatic or Morphological Maturity

Body size by itself is not a valid indicator of biological maturity, since the adult state is not the same for all individuals. As such, it is not appropriate for use as an indicator of biological maturation. Concepts such as height age, i.e., the corresponding chronological age at which, in a population, a specific stature is on average attained, are not useful maturity estimates. If longitudinal height data that span late childhood through adolescence are available, the characteristics of the adolescent growth spurt can provide two indicators of somatic maturity: age at the onset of the growth spurt in height (first inflection point of the adolescent growth curve, takeoff) and age at maximum velocity (second inflection point of the adolescent growth curve, Peak Height Velocity (PHV)). PHV is a measure of the maximum rate of growth in stature during a growth spurt. The age of maximum velocity of growth is called the age at PHV (Go

sselin-Després, 2007).

If adult height is available (as in longitudinal studies), the percentage of adult height attained at a given age or the age at which a certain percentage of adult height is attained can be used as a maturity indicator. To accurately estimate the parameters of the growth curve, careful measurements that span adolescence and that are taken at regular intervals, at least two times per year (preferably three or four times a year), are needed. Curve-fitting techniques based on structural and nonstructural models have facilitated estimation of the parameters (Marubini, 1978; Gasser *et al.*, 1984; Hauspie and Chrzastek-Spruch, 1999).

The assessment of somatic maturity based on the parameters of the growth curve (age at onset and age at maximum velocity) is limited to the adolescent period, and only one or two biological events are considered. As noted, their derivation requires longitudinal measurements of individual children over a relatively large age span, but they do provide an accurate estimate for a major event in the pubertal period. Percentage of adult height is calculated from present height and adult height. Adult height is measured if children are followed until adult stature is attained or can be estimated. Prediction formulas are available for European and American samples but have not been validated on other populations (Bayley and Pinneau, 1952; Roche *et al.*, 1975; Roche *et al.*, 1975b; Roche *et al.*, 1975c; Tanner *et al.*, 1975; Tanner *et al.*, 1983; Tanner *et al.*, 2001). Attempts have also been made to predict adult stature without skeletal age (Khamis and Roche, 1995; Beunen *et al.*, 1997).

Use of the percentage of adult height as an indicator of somatic maturity is an indirect technique that requires the estimation of skeletal maturation, at least for the most accurate systems. It can, however, be applied throughout most of the maturation period,

beginning in childhood, and reflects the progress toward maturity of an important biological characteristic (Berk, 2007).

2.3.3 Interrelationships Among Maturity Indicators

The issue of interrelationships among the various indicators of biological maturation is complex, because only skeletal maturity and percentage of adult stature span the entire maturation period from birth to adulthood. Indicators such as age at peak height velocity (PHV), stages of sexual maturation, and age at menarche in girls are limited to puberty. A cluster analysis of 21 maturity indicators (skeletal, sexual, somatic, and dental) assessed in a sample of 111 Polish boys followed longitudinally from 8 to 18 years identified a general maturity factor during adolescence. This general factor included age at peak velocity for several linear dimensions, attainment of stages of sexual maturity, skeletal ages of 14 and 15 years, ages at attaining 90%, 95%, and 99% of adult stature, and age at onset of the growth spurt in height. Correlations among these indicators were high; none was below 0.70 and many were above 0.80. This suggests central regulation of the timing of the growth spurt and sexual maturation by the nervous system and corresponding hormonal correlates. The second and third factors were related to indicators associated with prepubertal maturity (skeletal age of 11 and 12 years, 80% of adult height) and the ages by which 14, 20, and 26 teeth had erupted (Bielicki *et al.*, 1984). Similar results were obtained in Polish girls (Bielicki, 1975) and in American boys and girls (Nicolson and Hanley, 1953), although indicators of dental maturity were not included in these analyses. The clustering of prepubertal maturational events that are somewhat independent of the clustering of pubertal events suggests that different hormonal and related growth factors are the driving forces that underlie these events. In general, it is the hypothalamic–pituitary–GH/IGF-I and the hypothalamic-pituitary-

gonadal axes, but especially their interactions, that drive adolescent growth and maturation, given adequate thyroid status (Bogin, 2009).

Indicators of skeletal, somatic, and sexual maturity are thus related during adolescence. When children are grouped according to an event of sexual maturation, the mean chronological age and the skeletal age at reaching that event are generally quite similar, but the standard deviation in skeletal age at reaching the event is markedly reduced. There is more variation in chronological age than in skeletal age at the time of menarche and at the time of PHV (Malina *et al.*, 2004).

2.4 PROCESSES OF SEXUAL, REPRODUCTIVE AND COGNITIVE MATURATION

2.4.1 Hormonal Changes and Growth Spurts

Stimulated in late childhood by a “cascade of endocrine changes” (Patton and Viner 2007), the processes of bodily growth and sexual and reproductive maturation associated with puberty are accompanied by a series of emotional, cognitive and behavioural transformations that mark the period of early adolescence (Kagan 1998; Campbell 2003; Breinbauer and Mattaleno 2005). Research on individual and group variations in the timing, sequencing, correlates and consequences of these maturational processes, and on how young adolescents experience them, can offer important insights into the foundations of sexual and reproductive health during these formative years. The onset of puberty in girls begins about two years before menarche, with the gradual build-up of estrogens and progesterone released from the adrenal cortex (Bullough and Bullough, 1994; Kagan 1998; Patton and Viner 2007). There is also a slight rise in dehydroepiandrosterone (DHEA) from the adrenal cortex, which is responsible for the early growth spurt. At menarche and beyond, the ovaries take over the primary

production of the female hormones, which are slightly libido-depressing. In contrast, boys are subjected to surges of libido-enhancing testosterone from the adrenal cortex and the testes: during puberty, testosterone levels typically multiply 10 to 20 times for boys while doubling for girls. Mediated by the adrenal steroids such as DHEA and cortisol, variations in testosterone appear to have direct effects on male sexual arousal as well as on sexual and other risk-taking behaviours if their expression is not suppressed by externally imposed or internalized social controls (Patton and Viner 2007).

In healthy populations, the growth spurts of girls begin at about 10–13 years and end at 16 years or later; among boys they begin at 12–15 years and end at about 18 years or later. Peak bone mass is achieved by the early 20s (Patton and Viner, 2007). The relationship between height and weight (body mass index) is correlated with the timing of first menstruation in girls, with overweight and obese girls experiencing menarche earlier, and underweight or “stunted” girls maturing later. In contrast, overweight boys are more likely to experience delayed maturation. Because height and weight gains (and, for girls, breast development) are visible signs of puberty, and because marked deviations from the norm are likely to attract (often unwelcome) attention from others – especially for early-maturing girls and late-maturing boys – they can affect adolescents’ self-image in powerful ways. In a nine-country study of adolescent health in the Caribbean, for example, almost one in every five boys and girls ages 10–12 years and 13–15 years said they worried that their bodies were “developing too fast”, while 3% at 10–12 years and 12% at 13–15 years worried that their bodies were not developing fast enough (differences between boys and girls were not statistically significant) (Halcón *et al.*, 2003). The question remains as to how significant departures from developmental norms in early adolescence affect boys’ and girls’ sexual

attitudes, behaviours and experiences (e.g.their vulnerability to harassment from others) as compared with those whose growth falls within the normal range for the group.

2.4.2 Menarche, Semenarche and the Stages of Sexual Maturation

The standard five-stage visual Tanner scale of sexual maturation classifies girls according to breast shape (B1–B5) and distribution of pubic hair (P1–P5), with stage 1 representing pre-pubertal appearance and stage 5 the achievement of adult size and form (Tanner 1962; Hall *et al.*, 2007). The Tanner scale for boys tracks changes in testicular and penile (genital) size and shape (G1–G5) and pubic hair (P1–P5). These scales can be self-administered by adolescents who compare their bodies with drawings illustrating each stage, which makes them a useful research tool for documenting variations in the timing of these physical changes and their correlation with other maturational events and conditions.

Among girls, the first signs of puberty may emerge as early as 8 or 9 years (stage 2 of breast budding) and terminate at 15 or 16 years (stage 5), with menarche typically occurring around stages 3 or 4 – that is, in the middle of the pubertal sequence. In a sample of Hong Kong schoolgirls, for example, breast budding occurred at a median age of 9.8 years, followed by the first appearance of light pubic hair (P2) at 11.6 years and menarche at 12.4 years (Huen *et al.*, 1997). The downward trend in age at menarche to an average of 12–13 years in most developing countries has been well established: surveys show that urban, educated, middle-class girls in many countries are now starting their periods on average at 12.5 years or earlier – the same age as (or even younger than) their European and North American counterparts (Morabia and Constanza 1998; Thomas *et al.*, 2001; Parent *et al.*, 2003; Breinbauer and Maddaleno 2005; Lloyd 2005; Patton and Viner 2007).

Because standard deviations within samples are typically 1.0–1.5 years around the mean of positively skewed distributions, the normal timing of first menses among healthy girls extends from about 11 years to 14–15 years. Means of 14 or 15 years are not unusual among rural girls or urban girls in low-income urban households, however. (Median values are typically lower than means by half a year or so.) Studies that graph the cumulative percentages of girls who have experienced menarche by single years of age are helpful in identifying variations around the mean or median in maturational patterns across and within populations and, potentially, their association with subsequent behaviours (Awusabo-Asare *et al.*, 2006; Guiella and Woog 2006; Munthali *et al.*, 2006; Neema *et al.*, 2006). In addition, the collection of evidence of protein or vitamin deficiencies or iron-deficiency anaemia would help to establish the relationship between nutrition and individual and group variations in the timing of menarche in diverse populations (Berk 2012).

The first signs of pubertal change in boys occur at the beginning of the growth spurt in height and weight, when the testes and scrotum begin to change visibly (G2), followed 1–2 years later by lengthening and broadening of the penis. Male adolescents typically reach adult sexual development at about 16–17 years, although some late-maturing boys do not complete the process before the age of 20 years (Ezeome *et al.*, 1997). In Gwembe, Zambia, urban Tonga boys averaged 11.2 years at the onset of testicular growth (G2) and 15.3 years at completion (G5), while rural boys, whose compromised nutritional status was reflected in shorter height and smaller muscle mass, averaged 12.4 years and 17.1 years, respectively (Campbell *et al.*, 2005).

Boys' first experience of conscious ejaculation or nocturnal emission (semenarche) has received little attention in the literature, even though it is a significant psychological (if

not social) event. In Mali, boys experienced semenarche at 16.8 years on average, compared with 15.2 years for menarche in girls (Gueye *et al.*, 2001); in the Americas, typical averages of 13.4 years and 12.4 years are cited for these events (Breinbauer and Maddaleno 2005). Contrasts across countries can be pronounced: 37% of 12–14-year-old boys in Malawi had experienced signs of puberty such as pubic hair growth, deepening of the voice or nocturnal emissions (“wet dreams”), compared with 32% in Uganda, 30% in Ghana and only 17% in Burkina Faso (Bankole *et al.*, 2007). Boys may engage in penetrative sex quite early in this sequence, however, long before their genitals have reached adult size. In rural Transkei, South Africa, for example, middle-school boys (of whom 90% were sexually active) reported first ejaculation at a mean age of 15.1 years but first intercourse at 13.4 years (Buga *et al.*, 1996).

For both sexes, early pubertal maturation appears to be associated with earlier relationship formation and sexual initiation, as observed in peer-oriented dating cultures where at least some sexual expression is permitted, although most sexual activity may be delayed to later adolescence. Among Hong Kong adolescents, for example, a positive association between the timing of menarche/semnarche and dating, “fondling” and coitus by the age of 18 years (coitus before 15 years was not documented) was statistically significant for both sexes after controlling for family characteristics, peer relations and social context (Lam *et al.*, 2002). In kinship-oriented intergenerational marriage cultures, parents and elders may select early-maturing girls for early marriage, both to “protect” their virginity and the honour of the family and because they are viewed as desirable prospective brides. The relationships between boys’ and girls’ chronological ages, developmental stages, and their own or others’ sexual and marital decision-making processes need to be more clearly specified in diverse settings (Berk, 2007).

2.4.3 Reproductive Maturation

Girls' sexual and reproductive maturation continues long past menarche. The full development of the pelvis, breasts and uterus and the maturation and protective lubrication of the cervix and vagina occur mostly after menstruation begins, as a lagged effect of the build-up of estrogen over time. Precocious intercourse can cause abrasions that heighten girls' risks of acquiring STIs/HIV from an infected partner (Duncan *et al.*, 1990; Glynn *et al.*, 2001), quite apart from the pain and emotional trauma it may cause, especially if it is forced. Female fecundity is suppressed in the first few years following menarche, as a result of irregular, long and frequently anovulatory menstrual cycles and an elevated chance of spontaneous abortion if conception does occur (Kagan, 1998). The reproductive maturation of boys also continues after semenarche, a stage at which testicular and penile growth is by no means complete. Sperm counts may not reach their full adult levels for several years following the onset of ejaculation (Kagan, 1998; Campbell, 2003).

Girls who get pregnant at the age of 14 years or younger, and, to a lesser extent, at 15–17 years and 18–19 years, are at considerably heightened risk of complications such as pregnancy-induced hypertension, obstructed and prolonged labour, vaginal tearing, obstetric fistula, and postpartum haemorrhage, in addition to premature delivery, low infant birth weight, perinatal mortality and health problems in the newborn (Senderowitz, 1996; Phipps and Sowers, 2002; WHO, 2004a; Lloyd 2005; Temin and Levine, 2009). The relative risks of early pregnancy to both mothers and newborns are exacerbated for girls who are nutritionally deprived: a pregnancy can compromise the

mother's status even further and disrupt the normal growth patterns, while babies born to such mothers are even more likely to be underweight and to die (Temin and Levine, 2009). The absolute and relative risks of pregnancy at each age and developmental stage could be documented at different levels of antenatal and delivery coverage, for better estimates of the extent to which the disadvantages of precocious pregnancy can be ameliorated by nutritional supplements and by accessible high quality obstetric care (Temin and Levine, 2009).

2.4.4 Brain Growth and Maturation

Adolescence is characterized by uneven progressions in the development of brain structures and mental processes that are associated with emotions, interpersonal relationships (empathy, social bonding), aggression, impulsive behaviours and the capacity for critical and logical thought (Campbell, 2003; Patton and Viner, 2007). The growth and functioning of the brain respond not only to hormonal factors but also to other genetic influences, nutritional states and educational, emotional and life experiences (Patton and Viner, 2007).

At 10–12 years, most boys and girls are in the “concrete operational” stage of their thinking and have the capacity to use specific types of information, such as arithmetic manipulations or rules for games. The prefrontal lobe, which deals with tasks such as impulse control, complex organization and abstract reasoning, is not yet fully formed (Breinbauer and Maddaleno, 2005; Johnson *et al.*, 2009). At about 12–14 years for well-nourished girls and 13–15 years for boys the neurological pathways for advanced conceptual thought and rational calculation are being established in interaction with environmental stimuli. “Sensation-seeking” drives intensify, peaking at about 15–16 years. Not until the ages of 14–16 years for girls and 15–17 years for boys is there is “a

major opening to abstract thinking and full meta-cognitive functions”, however (Breinbauer and Maddaleno, 2005). By the age of 18 years in most healthy individuals (but later among those who are nutritionally deprived or severely stressed), brain structures and cognitive processes are becoming better articulated, hormonal systems are generally in balance, and risk-taking and sensation-seeking drives decline. The development of regions of the brain linked to mature judgment and impulse control continues for more than a decade after puberty, however, well into early adulthood (Breinbauer and Maddaleno, 2005; Patton and Viner, 2007; Johnson, *et al.*, 2009).

Research on brain maturation and cognitive development would benefit from longitudinal studies of male and female adolescents in diverse settings as they pass through puberty, with a special emphasis on the relationship between brain growth and maturation at specific chronological ages and pubertal stages and their associated behavioural manifestations. Studies assessing group differences in the curves of cognitive development across dissimilar socioeconomic, ethnic and geographic populations (assuming that standard measurement scales similar to the Tanner stages could be constructed) would also be helpful, as would independent assessments of both “cold cognition” (capacities exhibited in relatively calm problem-solving situations) and “hot cognition” (capacities exhibited in the “heat of the moment” under high stress, which could apply to sexual risk-taking) (Johnson, *et al.*, 2009). Factors associated with cognitive development, such as nutrition, a history of abuse or neglect during childhood, and formal schooling, could be identified, as well as associations between cognitive immaturity and the expression of impulsive and sensation-seeking behaviours that place some adolescent boys and girls at considerable risk to themselves and to others. The greater the disparity between the

emergence of sexual interests and drives, on the one hand, and the elaboration of cognitive functions such as impulse control and critical thinking, on the other, the greater the risks are likely to be (SRH, 2011).

2.5 FACTORS AFFECTING GROWTH

Physical growth, like other aspects of development, results from a complex interplay between genetic and environmental factors. Although heredity remains important, environmental factors continue to affect genetic expression. Good nutrition, relative freedom from disease, and emotional well-being are essential to children's healthy development, while environmental pollutants can be a threat (Berk 2012).

2.5.1 Heredity

Because identical twins are much more alike in body size than fraternal twins, we know that heredity contributes considerably to physical growth (Estourgie-van Burk *et al.*, 2006). When diet and health are adequate, height and rate of physical growth (as measured by skeletal age and timing of first menstruation) are largely determined by heredity. In fact, as long as negative environmental influences, such as poor nutrition or illness, are not severe, children and adolescents typically show catch-up growth—a return to a genetically influenced growth path once conditions improve. Still, the brain, the heart, the digestive system, and many other internal organs may be permanently compromised (Hales and Ozanne, 2003).

Genes influence growth by controlling the body's production of and sensitivity to hormones. Mutations can disrupt this process, leading to deviations in physical size. Occasionally, a mutation becomes widespread in a population. Consider the Efe of the

Republic of Congo, whose typical adult height is less than 5 feet. For genetic reasons, the impact of growth hormone (GH) is reduced in Efe children (Bailey, 1991). By age 5, the average Efe child is shorter than over 97 % of North American age mates. The Efe's small size probably evolved because it reduces their caloric requirements in the face of food scarcity in the rain forests of Central Africa and enables them to move easily through the dense forest underbrush (Perry and Dominy, 2009).

2.5.2. Nutrition

Nutrition is important at any time of development, but it is especially crucial during the first two years because the baby's brain and body are growing so rapidly. Pound for pound, an infant's energy needs are twice those of an adult. 25 % of babies' total caloric intake is devoted to growth, and infants need extra calories to keep their rapidly developing organs functioning properly (Meyer, 2009).

2.5.2.1 Breastfeeding versus Bottle-Feeding

Babies need not only enough food but also the right kind of food. In early infancy, breast milk is ideally suited to their needs, and bottled formulas try to imitate it. Breastfed babies in poverty-stricken regions are much less likely to be malnourished and 6 to 14 times more likely to survive the first year of life. The World Health Organization (WHO) recommends breastfeeding until age 2 years, with solid foods added at 6 months. These practices, if widely followed, would save the lives of more than a million infants annually (WHO 2011).

Yet many mothers in the developing world do not know about the benefits of breastfeeding. In Africa, the Middle East, and Latin America, most babies get some breastfeeding, but fewer than 40 percent are exclusively breastfed for the first 6 months, and one-fourth are fully weaned from the breast by 1 year. In place of breast milk,

mothers give their babies commercial formula or low-grade nutrients, such as rice water or highly diluted cow or goat milk. Contamination of these foods as a result of poor sanitation is common and often leads to illness and infant death. The United Nations has encouraged all hospitals and maternity units in developing countries to promote breastfeeding as long as mothers do not have viral or bacterial infections (such as HIV or tuberculosis) that can be transmitted to the baby. Today, most developing countries have banned the practice of giving free or subsidized formula to new mothers (Berk, 2012).

Partly as a result of the natural childbirth movement, breastfeeding has become more common in industrialized nations, especially among well-educated women. Today, 75 percent of American mothers breastfeed, but more than half stop by 6 months (U.S. Centers for Disease Control and Prevention, 2011). And despite the health benefits of breast milk, only 50 percent of preterm infants are breastfed at hospital discharge. Breastfeeding a preterm baby presents special challenges, including maintaining a sufficient milk supply with artificial pumping until the baby is mature enough to suck at the breast and providing the infant with enough sucking experience to learn to feed successfully (Callen and Pinelli, 2005).

Because breast milk is so easily digestible, a breastfed infant becomes hungry every 1 to 2 hours, compared to every 3 or 4 hours for a bottle-fed baby. This makes breastfeeding inconvenient for many employed women. Not surprisingly, mothers who return to work sooner wean their babies from the breast earlier (Kimbro, 2006). But mothers who cannot be with their babies all the time can still combine breast- and bottle-feeding.

2.5.2.2 Nutrition in Childhood and Adolescence

Around 1 year, infants' diets should include all the basic food groups. As children approach age 2, their appetites become unpredictable. Preschoolers eat well at one meal but barely touch their food at the next. And many become picky eaters. This decline in appetite occurs because growth has slowed. Furthermore, preschoolers' wariness of new foods is adaptive. If they stick to familiar foods, they are less likely to swallow dangerous substances when adults are not around to protect them (Birch and Fisher, 1995). Parents need not worry about variations in amount eaten from meal to meal. Over the course of a day, preschoolers compensate for eating little at one meal by eating more at a later one (Koivisto-Hursti, 1999).

Children tend to imitate the food choices and eating practices of people they admire, both adults and peers. For example, mothers who drink milk or soft drinks tend to have 5-year-old daughters with a similar beverage preference (Fisher *et al.*, 2001). In Mexico, where children see family members delighting in the taste of peppery foods, preschoolers enthusiastically eat chili peppers, whereas most U.S. children reject them (Birch *et al.*, 1980).

Repeated, unpressured exposure to a new food also increases acceptance, serving broccoli or tofu increases children's liking for these healthy foods. In contrast, offering sweet fruit or soft drinks promotes "milk avoidance" (Black *et al.*, 2002).

During puberty, rapid body growth leads to a dramatic rise in food intake. This increase in nutritional requirements comes at a time when eating habits are the poorest. Of all age groups, adolescents are the most likely to skip breakfast (a practice linked to obesity), eat on the run, and consume empty calories rather than nutrient-rich fruits and vegetables (Ritchie *et al.*, 2007; Striegel-Moore *et al.*, 2006). Fast-food restaurants, where teenagers often gather, have begun to offer some healthy menu options, but

adolescents need guidance in choosing these alternatives. Eating fast food and school purchases from snack bars and vending machines is strongly associated with consumption of high-fat foods and soft drinks (Bowman *et al.*, 2004; Kubik *et al.*, 2003).

Frequency of family meals is a powerful predictor of healthy eating—greater intake of fruits, vegetables, grains, and milk products and reduced soft drink and fast-food consumption (Burgess-Champoux *et al.*, 2009; Fiese and Schwartz, 2008). But compared to families with children, those with adolescents eat fewer meals together. Finding ways to arrange family meals, despite busy schedules, can greatly improve teenagers' diets.

2.5.2.3 Malnutrition

In developing countries and war-torn areas where food resources are limited, malnutrition is widespread. Black *et al* (2013) estimate that undernutrition in the aggregate—including fetal growth restriction, stunting, wasting, and deficiencies of vitamin A and zinc along with suboptimum breastfeeding—is a cause of 3.1 million child deaths annually or 45% of all child deaths in 2011. Globally 161 million under-five year olds were estimated to be stunted in 2013, while 51 million under-five year olds were wasted and 17 million were severely wasted. About half of all stunted and wasted children lived in Asia and over one third in Africa (UNICEF *et al.*, 2014).

Learning and behavior are also seriously affected. In one long-term study of marasmic children, an improved diet led to some catch-up growth in height, but not in head size (Stoch *et al.*, 1982). The malnutrition probably interfered with growth of neural fibers and myelination, causing a permanent loss in brain weight. And animal evidence reveals that a deficient diet alters the production of neurotransmitters in the

brain—an effect that can disrupt all aspects of development (Haller, 2005). These children score low on intelligence tests, show poor fine-motor coordination, and have difficulty paying attention (Bryce *et al.*, 2008; Liu *et al.*, 2003). They also display a more intense stress response to fear-arousing situations, perhaps caused by the constant, gnawing pain of hunger (Fernald and Grantham-McGregor, 1998).

2.5.2.4 Obesity

Today, 32 % of U.S. children and adolescents are overweight, more than half of them extremely so: 17 % suffer from obesity, a greater-than-20-percent increase over healthy weight, based on body mass index (*BMI*)—a ratio of weight to height associated with body fat. (A *BMI* above the 85th percentile for the child's age and sex is considered overweight, a *BMI* above the 95th percentile obese.) During the past several decades, a rise in overweight and obesity has occurred in many Western nations, with large increases in Canada, Germany, Israel, Greece, Ireland, New Zealand, the United Kingdom, and the United States (Ogden *et al.*, 2010). Smaller increases have occurred in other industrialized nations, including Australia, Finland, the Netherlands, Norway, and Sweden.

Obesity rates are also increasing rapidly in developing countries as urbanization shifts the population toward sedentary lifestyles and diets high in meats and energy-dense refined foods. In China, for example, where obesity was nearly nonexistent a generation ago, today 20 percent of children are overweight, with 7 percent obese—a nearly fivefold increase over the past twenty-five years, with boys affected more than girls (Ding, 2008). Childhood obesity in China is especially high in cities, where it

has reached 10 percent (Ji and Chen, 2008). In addition to lifestyle changes, a prevailing belief in Chinese culture that excess bodyfat represents prosperity and health—carried over from a halfcenturyago, when famine caused millions of deaths—has contributed to this alarming upsurge. High valuing of sons may induce Chinese parents to offer boys especially generous portions of meat, dairy products, and other energy-dense foods that were once scarce but now are widely available (Berk 2012).

Overweight rises with age, from 21 percent among U.S. preschoolers to 35 percent among school-age children and adolescents (Ogden *et al.*, 2010). In a longitudinal study of more than 1,000 U.S. children, overweight preschoolers were five times more likely than their normal-weight peers to be overweight at age 12 (Nader *et al.*, 2006).

Besides serious emotional and social difficulties, obese children are at risk for lifelong health problems. Symptoms that begin to appear in the early school years—high blood pressure, high cholesterol levels, respiratory abnormalities, and insulin resistance—are powerful predictors of heart disease and other circulatory difficulties, type 2 diabetes, gall bladder disease, sleep and digestive disorders, many forms of cancer, and early death (Krishnamoorthy, Hart, and Jelalian, 2006). Indeed, type 2 diabetes—formerly also known as “adult-onset” diabetes because it was rarely seen in childhood—is rising rapidly among overweight children, sometimes leading to early, severe complications, including stroke, kidney failure, and circulatory problems that heighten the risk of eventual blindness and leg amputation (Hannon *et al.*, 2005).

Not all children are equally at risk for excessive weight gain. Overweight children tend to have overweight parents, and identical twins are more likely to share the disorder than fraternal twins. But heredity accounts for only a tendency to gain weight (Kraland Faith, 2009). The importance of environment is seen in the consistent relationship of low

education and income to overweight and obesity in industrialized nations, especially among ethnic minorities—in the United States, African-American, Hispanic, and Native-American children and adults (CDC, 2009; Ogden *et al.*, 2010). Factors responsible include lack of knowledge about healthy diet; a tendency to buy high-fat, low-cost foods; neighborhoods that lack convenient access to affordable, healthy foods in grocery stores and restaurants; and family stress, which can prompt overeating (Ogden *et al.*, 2010).

Furthermore, children who were undernourished in their early years are at risk for later excessive weight gain. In industrialized nations, many studies confirm that infants whose mothers smoked during pregnancy and who therefore are often born underweight are more likely to suffer from childhood overweight and obesity (Rogers, 2009). Nevertheless, in the developing world (unlike in industrialized countries), obesity risk is greatest for individuals living in economically well-off households, probably because of greater food availability and reduced activity levels (Subramanian *et al.*, 2011).

Parental feeding practices also contribute to childhood obesity. Overweight children are more likely to eat larger quantities of high-calorie sugary and fatty foods, perhaps because these foods are prominent in the diets offered by their parents, who also tend to be overweight. Interviews with more than 3,000 U.S. parents revealed that many served their 4- to 24-month-olds French fries, pizza, candy, sugary fruit drinks, and soda on a daily basis. On average, infants consumed 20 % and toddlers 30 % more calories than they needed (Briefel *et al.*, 2004). Recent research confirms a strengthening relationship between rapid weight gain in infancy and later obesity (Botton *et al.*, 2008; Chomtho *et al.*, 2008).

Some parents anxiously overfeed, interpreting almost all their child's discomforts as a desire for food. Others pressure their children to eat, a practice common among immigrant parents and grandparents who, as children themselves, survived periods of food deprivation. Still other parents are overly controlling, restricting when, what, and how much their children eat and worrying that the child will gain too much weight (Moenset *al.*, 2007). In each case, parents fail to help children learn to regulate their own food intake. Also, parents of overweight children often use high-fat, sugary foods to reinforce other behaviors, leading children to attach great value to treats (Sherry *et al.*, 2004).

Another factor consistently associated with weight gain is insufficient sleep (Nielsen *et al.*, 2011). Reduced sleep may increase time available for eating, leave children too fatigued for physical activity, or disrupt the brain's regulation of hunger and metabolism. Overweight children are less physically active than their normal-weight peers. Inactivity is both cause and consequence of excessive weight gain. Research reveals that the rise in childhood obesity is due in part to the many hours U.S. children spend watching television. In a study that tracked children's TV viewing from ages 4 to 11, the more TV children watched, the more body fat they added. Children who devoted more than 3 hours per day to TV accumulated 40 percent more fat than those devoting less than 13 hours (Proctor *et al.*, 2003). Watching TV reduces time devoted to physical exercise, and TV ads encourage children to eat fattening, unhealthy snacks. Children permitted to have a TV in their bedroom—a practice linked to especially high TV viewing—are at even greater risk for overweight (Adachi-Mejia *et al.*, 2007).

Finally, the broader food environment affects the incidence of obesity. The Pima Indians of Arizona, who two decades ago changed from a traditional diet of plant foods to a

high-fat, typically American diet, have one of the world's highest obesity rates. Compared with descendants of their ancestors living in the remote Sierra Madre region of Mexico, the Arizona Pima have bodyweights 50 percent greater. Half the population has diabetes (eight times the national average), with many in their twenties and thirties already disabled by the disease—blind, in wheelchairs, and on kidney dialysis. The Pima have a genetic susceptibility to overweight, but it emerges only under Western dietary conditions (Gladwell, 1998; Traurig *et al.*, 2009). Other ethnic groups with a hereditary tendency to gain weight are the Pacific Islanders, including native Hawaiians and Samoans (Furusawa *et al.*, 2010).

Unfortunately, physical attractiveness is a powerful predictor of social acceptance. In Western societies, both children and adults rate obese youngsters as unlikable, stereotyping them as lazy, sloppy, dirty, ugly, stupid, and deceitful (Kirkpatrick and Sanders, 1978; Penny and Haddock, 2007; Tiggemann and Anesbury, 2000). In school, obese children and adolescents are often socially isolated. They report more emotional, social, and school difficulties, including peer teasing and consequent low self-esteem, depression, and (among obese teenagers) suicidal thoughts and suicide attempts. Because unhappiness and overeating contribute to each other, the child remains overweight (Puhl and Latner, 2007; Zeller and Modi, 2006). Persistent obesity from childhood into adolescence predicts serious disorders, including defiance, aggression, and severe depression (Schwimmer *et al.*, 2003; Young-Hyman *et al.*, 2006).

The psychological consequences of obesity combine with continuing discrimination to result in reduced life chances. Overweight individuals are less likely than their normal-weight age mates to receive financial aid for college, be rented apartments, find mates, and be offered jobs. And they report frequent mistreatment by family members, peers,

co-workers, and health-care professionals, which contributes further to physical and psychological health problems (Carr and Friedman, 2005; Puhlet *et al.*, 2010).

2.5.3 Infectious Disease

Infectious disease is a major contributor to malnutrition, hindering both physical growth and cognitive development. Illness reduces appetite and limits the body's ability to absorb foods, especially in children with intestinal infections. In developing countries, widespread diarrhea, resulting from unsafe water and contaminated foods, leads to growth stunting and nearly 3 million childhood deaths each year. Studies carried out in the slums and shantytowns of Brazil and Peru reveal that the more persistent diarrhea is in early childhood, the shorter children are in height and the lower they score on mental tests during the school years (Checkley *et al.*, 2003; Niehaus *et al.*, 2002).

Most developmental impairments and deaths due to diarrhea can be prevented with nearly cost-free oral rehydration therapy (*ORT*), in which sick children are given a glucose, salt, and water solution that quickly replaces fluids the body loses. Since 1990, public health workers have taught nearly half the families in the developing world how to administer *ORT*. Also, supplements of zinc (essential for immune system functioning), which cost only 30 cents for a month's supply, substantially reduce the incidence of severe and prolonged diarrhea (Aggarwal *et al.*, 2007).

2.5.3.2 Immunization

Inability to pay for vaccines is only one cause of inadequate immunization. Parents with little education and with stressful daily lives often fail to schedule vaccination appointments, and those without a primary-care physician do not want to endure long waits in crowded U.S. public health clinics (Falagas and Zarkadoulia, 2008). Some parents have been influenced by media reports suggesting a link between a mercury-

based preservative used for decades in vaccines and a rise in the number of children diagnosed with autism. But large-scale studies show no association with autism and no consistent effects on cognitive performance (Dales *et al.*, 2001; Richler *et al.*, 2006; Stehr-Green *et al.*, 2003; Thompson *et al.*, 2007).

In areas where many parents have refused to immunize their children, outbreaks of whooping cough, polio and rubella have occurred, with life-threatening consequences (Tuyen and Bisgard, 2014; Kennedy and Gust, 2008).

2.5.4 Physical Activity

The literature is replete with reports that the effects of athletic training on growth and pubertal development are salutary, deleterious, or nonexistent. Certain sports show advantages for the early maturer, especially for males, and others, especially gymnastics and dance, favor the later-developing female. Thus, there is concern about the potential effects of training on the timing and progression (tempo) of puberty “caused” by participation in training and sports. Critical analysis with the biological indicators of bone age or peak height velocity in longitudinal study designs is required to tease out the effects of such training on pubertal development and adult height (Malina, 1994a).

2.5.4.1 Females

Delay in growth and sexual maturation is well documented among certain groups of elite female athletes, most notably gymnasts, dancers, and long-distance runners. The underlying mechanisms, however, are not entirely clear, in part because of few longitudinal data in girls. Control of growth and age at menarche involve the complex interaction of many factors, including the physical and metabolic demands of intensive athletic training and competition (Malina, 1994b).

Investigations of growth parameters in adolescent female gymnasts consistently find these girls to be shorter and lighter and to have a significantly lower percentage of body fat than do age-matched control girls or athletes participating in less strenuous sports, such as swimming. Girls participating in the latter types of sports are generally taller and mature earlier than normal (Theintz *et al.*, 1993; Malina, 1994b; Theintz, 1994; Constantini and Warren, 1995). Theintz *et al.*, (1993) followed a cohort of adolescent gymnasts and swimmers over an interval of 2–3 years. Training periods averaged 22 h/wk for the gymnasts and 8 h/wk for the swimmers. The gymnasts had significantly lower growth velocities from skeletal age 11–13 years, showing a peak height velocity of only 5.48 ± 0.32 cm/y compared with 8.0 ± 0.50 cm/y for the swimmers. Over time, height SD scores decreased significantly in the gymnasts without a change in the ratio of chronological age to bone age. Consequently, predicted heights of the gymnasts decreased with time, but those of the swimmers did not change (Theintz *et al.*, 1993).

Lindholm *et al.*, (1994) also observed slower growth velocities among a group of adolescent female gymnasts. These girls did not display the distinct growth spurt seen in the control group of inactive girls, and 27% had adult heights that were less than expected based on midparental height. Bernadot and Czerwinski (1991) studied 2 groups of female gymnasts, one aged 7–10 years and the other aged 11–14 years. Weight-for-age and height-for-age decreased from the 48th percentile in the younger group to the 20th percentile in the older gymnasts. Body fat did not differ significantly between the age groups, and at all ages the gymnasts had significantly more muscle mass for their size than did the control group (Bernadot and Czerwinski 1991).

Several investigations have compared age at menarche among female athletes participating in different sports with that of the general population. Claessens *et al.*, (1992) found the median age at menarche to be 15.6 ± 2.1 y among a group of gymnasts and 13.2 ± 1.2 years among the control population. Theintz *et al.*, (1993) observed that among a group of gymnasts and swimmers aged 12.7 ± 1.1 y, only 7.4% of the gymnasts had experienced menarche, in contrast with 50% of the age-matched swimmers. The gymnasts in this study, however, had a significant delay in skeletal age (-1.42 ± 0.99 y), but the swimmers had comparable chronological and skeletal ages. This report emphasized the importance of the interaction between somatic growth and sexual maturation and the interpretation of physiologically versus pathologically delayed puberty. Baxter-Jones *et al.*, (1994) reported the mean ages at menarche of adolescents being intensively trained in gymnastics, swimming, and tennis to be 14.3, 13.3, and 13.2 y, respectively, with population reference value of 13.0 y. Significant delay was again noted only among the group of gymnasts. The data for gymnasts are replicated to a lesser degree in dancers and runners. Sports such as swimming, speed skating, and tennis appear to have minimal effects on growth or age at menarche (Malina, 1994a; Malina, 1994b; Baxter-Jones *et al.*, 1994).

An individual's general state of health is critical to normal growth and development, but this is assumed in adolescents who meet the great physical demands of long-term training. Genetic predisposition also plays an important role; the short stature of gymnasts is often familial (Malina, 1994b) and a positive correlation has been found between menarcheal age in mothers and daughters (Baxter-Jones *et al.*, 1994). Historically, socioeconomic class and family size have been influential; menarche occurs earlier in the higher socioeconomic classes and in families with fewer siblings (Tanner, 1989). Psychologic and emotional stressors associated with

years-long training, frequent competition, maintenance of low bodyweight, altered peer relations, and demands of coaches may also influence growth and pubertal timing (Malina, 1994b).

Alterations in growth and pubertal maturation are not common among young women engaging in recreational exercise or in adolescents who train < 15 h/wk (Bonen, 1992). The incidence of oligomenorrhea or amenorrhea and secondary amenorrhea has been cited as 10–40% among athletes and 2–5% among the general population. The distinction between elite and nonelite athletes is important because it pertains to training time and intensity. Olympic athletes have been shown to have significantly later menarche than high school, college, and club-level athletes (Malina, 1994a). The different demands of various sports also dictate the amount of time spent in strenuous physical activity; gymnasts and dancers far exceed swimmers and tennis players in the available studies. Catch-up growth has been reported in gymnasts when their training is temporarily reduced or stopped (Theintz, 1994).

However, one of the most important variables (perhaps the single most important variable) to take into account is that of selection bias. Body types that are most successful are selected for particular sports. Several studies have reported gymnasts to be smaller than their peers from a young age (Malina, 1994a; Malina, 1994b). Delayed menarche favors the continuation of sports such as gymnastics, which suggests that elite gymnasts are selected in part for this attribute. Continued participation in turn leads to more intense training and blurring of cause and effect (Malina, 1994b).

2.5.4.2 *Males*

In general, boys who participate in sports have normal growth rates and are normal or advanced for their state of skeletal and sexual maturation (Malina, 1994a). The

advanced states of maturation in male athletes may be attributed to the power and performance advantages associated with maturation (Roemmich and Rogol, 1995).

However, for sports that may create an energy drain, the effects on growth and maturation remain inconclusive. Seefeldt *et al* (1988) reported that the height velocity of elite male distance runners was equal to nonrunning control subjects during 1 year of training. Other investigations have reported the linear growth of male distance runners to be either slowed or advanced relative to reference data. Unfortunately, the maturity levels of the runners, the reference data, or both were not given for the 2 former studies, so few conclusions can be made with regard to the influence of distance running on growth velocity (Berk, 2007).

In a cross-sectional study, the growth patterns of 477 high school wrestlers were compared with those of a representative sample of adolescent males (Houshet *al.*, 1993). The wrestler and reference groups were not different at any age for body weight, but the slope value for the gain in body weight was significantly greater for the reference sample. The reference group was significantly taller than the wrestlers after age 16.4 year, but the slope values for gain in height were not statistically different. Slope values were also compared for 13 other anthropometric variables, with few notable group differences. The investigators concluded that wrestling does not slow growth and maturation (Houshet *al.*, 1993).

As expected, many investigators have reported reductions in weight, fat mass, and percentage of body fat during the wrestling season (Roemmich and Sinning, 1996; Hughes *et al.*, 1991). However, the fat-free mass is more conserved; most investigators report nonsignificant reductions (Hughes *et al.*, 1991; Roemmich and Sinning, 1996). Still, the fat-free mass does not increase as one would expect for normal

pubescent males. Because arm and leg strength diminish (Roemmich and Sinning, 1996), one might suggest that statistically insignificant reductions in these variables may be biologically relevant. After the sport season, wrestlers experience accelerated incremental gains in weight, fat mass, and fat-free mass (Tipton and Tchong, 1970; Roemmich and Sinning, 1996). The post-season gains in weight may be above the 99th percentile for age. Accelerated post-season gains in weight, fat mass, and fat-free mass suggest soft-tissue catch-up growth in the wrestlers. During the sport season, changes in anthropometric measures of lean tissue, such as mid-arm girth and lean limb cross-sectional areas (obtained from skinfold corrected girths), also provide evidence that despite heavy bouts of training, wrestlers can fail to accrue lean tissue during the sport season and show an accelerated accrual post-season (Roemmich and Sinning, 1996).

2.5.5 Emotional Well-Being

We may not think of affection as necessary for healthy physical growth, but it is as vital as food. Growth faltering is a term applied to infants whose weight, height, and head circumference are substantially below age-related growth norms and who are withdrawn and apathetic (Berk, 2012). In as many as half such cases, a disturbed parent–infant relationship contributes to the failure to grow normally. These infants often keep their eyes on nearby adults, anxiously watching their every move, and they rarely smile at their caregiver (Berk, 2012).

Family circumstances surrounding growth faltering help explain these reactions. During feeding, diaper changing, and play, mothers of these infants seem cold and distant, at other times impatient and hostile (Hagekull *et al.*, 1997). In response, babies try to protect themselves by keeping track of the threatening adult's whereabouts and, when she approaches, avoiding her gaze. Often an unhappy marriage or parental

psychological disturbance contributes to these serious caregiving problems. And most of the time, the baby is irritable and displays abnormal feeding behaviors, such as poor sucking or vomiting, that both disrupt growth and lead parents to feel anxious and helpless, which stress the parent–infant relationship further (Batchelor, 2008; Linscheid *et al.*, 2009).

When treated early, by intervening in infant feeding problems, helping parents with their own life challenges, and encouraging sensitive caregiving, these babies show quick catch-up growth. But if the disorder is not corrected in infancy, most children remain small and show lasting cognitive and emotional difficulties (Drewett *et al.*, 2006; Black *et al.*, 2007).

Extreme emotional deprivation can interfere with the production of Growth hormone (GH) and lead to psychosocial dwarfism, a growth disorder that appears between 2 and 15 years of age. Typical characteristics include decreased GH secretion, very short stature, immature skeletal age, and serious adjustment problems, which help distinguish psychosocial dwarfism from normal shortness (Tarren-Sweeney, 2006).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 MATERIALS

Materials to use for this research work include:

- i. Weight scale (Hanson Company, Ireland)
- ii. Myo tape
- iii. Harpenden portable Stadiometer
- iv. Sliding caliper
- v. Holtain skinfold caliper
- vi. Tanner staging scale

3.2 RESEARCH PARTICIPANTS

The subjects that participated in the study were secondary school students from Takum Local Government Area, Taraba State. Random selection of secondary schools in Takum metropolis was made. Boys and girls from these schools were enrolled. Participants included junior and senior secondary schools' students.

3.4 METHODOLOGY

Data for this study was collected from participants (adolescents). An informed consent was taken from students who were between ten and twenty years old and willing to participate in the survey. In order to encourage more candid and reliable responses, participants were made to complete the self-administered questionnaire in confidence with their peers unable to see their answers. Systematic sampling method was used to select 600 students, 300 from each ethnic group.

Data were collected through self-administered questionnaires (Appendix IV). Data include: parents' ethnic group, socio-demographic variables, anthropometric parameters, and sexual maturation.

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

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

- i. **Demographics:** Data pertaining demographics Include current age (years), ethnic group, place of residence at childhood and at adolescent, number of siblings, birth order, type of school, parents' level of education, parents' occupation, and place of birth.
- ii. **Menarcheal status:** Menstruating or not, age at menarche, month of menarche, school grade at menarche.
- iii. **Anthropometric assessment:** Weight, height, BMI, mid upper arm circumference, waist circumference, hip circumference, waist-hip ratio, thigh circumference, neck circumference, chest circumference, subscapular skin-fold, triceps skin-fold thickness, 2D:4D ratio, hand length, hand breadth, foot length, foot breadth
- iv. **Sexual maturation assessment:** Pubic Hair Stage, Genital Stage and Breast Stage.

3.5 DATA COLLECTION TECHNIQUE

3.5.1 Anthropometric Assessment

- i. **Body Mass Index (BMI):** The BMI was calculated as follows: weight (kg)/ [height x height (m²)].
- ii. **Chest Circumference (cm):** This measurement was taken at the level of the middle of the sternum (breast-bone), with the tape passing under the arms. After the tape is in position, the arms should be relaxed by the side, and the measurement taken at the end of a normal expiration.
- iii. **Height (cm):** Standing height was measured taking the maximum distance from the floor to the highest point on the head, when the subject was facing forward. Shoes was put off, feet together, and arms by the sides. Heels, buttocks and upper back should also be in contact with the wall when the measurement is made. This measurement will be carried out using a stadiometer.
- iv. **Hip Circumference (cm):** The tape was wrapped over the largest part of the buttocks.
- v. **Mid Upper Arm Circumference (cm):** The bicep was flexed, while the tape is wrapped around the flexed bicep, half way between the shoulder and the elbow.
- vi. **Thigh Circumference (cm):** This circumference measure was taken at the level of the mid-point on the lateral (outer side) surface of the thigh, midway between trochanterion (top of the thigh bone, femur) and tibia lateral (top of the tibia bone).
- vii. **Triceps:** A pinch of skin fold was taken on triceps midway between the shoulder and elbow. The measurement was taken with the person standing upright, with arms hanging down loosely.

- viii. **Waist Circumference (cm):** The tape was used to circle the waist (like a belt would circle the waist) at the natural waistline, which is midpoint between the lowest rib and the iliac crest. The subject was asked to stand erect while measurements were taken.
- ix. **Weight (kg):** An overall measure of body size that does not distinguish between fat and muscle. Weight was measured to the nearest 0.1kg when the subject is standing and putting on light indoor clothes using the inner scan.

3.5.2 Nutritional Status Assessment

In order to assess the nutritional status of our sample, the weight and height of the boys and girls were compared to those of same aged boys and girls measured in WHO 2007 study. Stunting (a measure of chronic under-nutrition) is defined as height-for-age < 3rd percentile of the WHO 2007 percentiles, while obesity (a measure of over-nutrition) and thinness (a measure of present under-nutrition) are defined as BMI-for-age > 85th percentile and BMI-for-age < 5th percentile of WHO 2007 percentiles.

3.5.3 Sexual Maturation Assessment

The assessment of sexual maturation is based on secondary sex characteristics: breast development in girls, genital (penis and testes) development in boys, and pubic hair in both sexes. Development of the breasts, genitals, and pubic hair is most often rated on five-point scales described by Tanner (Tanner, 1962; Hall *et al.*, 2007). Stage 1 of each characteristic indicates the prepubertal state (absence of development) and stage 2 the initial, overt development of each characteristic that marks the transition into puberty. Stages 3 and 4 mark progress in maturation, and stage five 5 indicates the adult (mature) state (Beunen, 2001). Table 3.1 below shows how the two sexes are assessed. Self-

assessment of sexual maturation stage was adopted in this study, where the respondents are asked to tick the picture that correctly depicts their present state of sexual maturation.

Table 3.1: Description of the Tanner Stages

STAGES	MALE GENITALIA	FEMALE BREAST	MALE/FEMALE PUBIC HAIR
1	Prepubertal	Prepubertal	Prepubertal (can see velus hair similar to abdominal wall)
2	Enlargement of scrotum and testes; scrotum skin reddens and changes in texture	Breast bud stage with elevation of breast and papilla; enlargement of areola	Sparse growth of long, slightly pigmented hair, straight or curled, at base of penis or along labia
3	Enlargement of penis (length at first); further growth of testes	Further enlargement of breast and areola; no separation of their contour	Darker, coarser and more curled hair, spreading sparsely over junction of pubes
4	Increased size of penis with growth in breadth and development of glans; testes and scrotum larger, scrotum skin darker	Areola and papilla form a secondary mound above level of breast	Hair adult in type, but covering smaller area than in adult; no spread to medial surface of thighs
5	Adult genitalia	Mature stage: projection of papilla only, related to recession of areola	Adult in type and quantity, with horizontal distribution ("feminine")

3.6 SAMPLING SIZE DETERMINATION

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

$$[n = z^2 pq/d^2] \quad (\text{Naing } et al., 2006)$$

Where:

n= the desired sample size

z= the standard normal deviation, usually set at 1.96 (≈ 2.0)

p= the proportion in the target population having the particular trait (when no estimate 50% is used; i.e. 0.5)

q= 1.0 - p

d= degree of accuracy desired, usually set at 0.04

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

For the purpose of this study a total of 600 subjects for both ethnic groups will be used.

3.7 ETHICAL APPROVAL

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

3.8 INCLUSION AND EXCLUSION CRITERIA

3.8.1 Inclusion Criteria

The following will be used as inclusion criteria

- i. *Jukun* and *Kuteb* Students only
- ii. Subjects must be mentally and physically fit.
- iii. Respondent must be aged between 10-20 years old,

3.8.2 Exclusion Criteria

The following will be used as exclusion criteria

- i. Non-*Jukun* and non-*Kuteb* students.
- ii. Students whose age is not between 10-20 years.
- iii. Students with Mental disorders or chronic illness.

3.9 STATISTICAL ANALYSIS

Data were expressed as mean \pm standard deviation and percentages. Student's t-test was used to investigate differences between boys and girls and between *Jukun* and *Kuteb* ethnic groups. Chi square was used to check for association between different Tanner Stages and ages of boys and girls in *Jukun* and *Kuteb* ethnic groups. Pearson correlation was applied to determine the relationship between growth and sexual maturation parameters. Multiple regression was used to generate predictive equations among growth parameters. $P < 0.05$ was deemed to be statistically significant. SPSS 20 (IBM Corp, New York) for Windows was used for the statistical analyses.

CHAPTER FOUR

4.0 RESULTS

4.1 ANALYSIS OF STUDY POPULATION

A total of six hundred (n=600) adolescents from secondary school students in Takum Local Government Area, Taraba State were enrolled in this study. The study comprised of 300 (150 males and 150 females) subjects each of Jukun and Kuteb origin. The age range of the study subjects is 10 – 20 years, while their mean age was 15.05 ± 2.89 years.

4.2 GROWTH AND ANTHROPOMETRIC VARIABLES

Cross sectional data was collected from subjects using a pre-designed questionnaire. Descriptive statistics of the entire sample population is shown in Table 4.1. The mean age of Jukun and Kuteb Adolescents were 14.97 ± 2.86 and 15.14 ± 2.93 respectively. The results showed that Kuteb Adolescents have higher values compared to their Jukun counterparts except in Subscapular Skinfold, umbilical skinfold and waist-chest ratio, but these differences were not statistically significant.

Fig. 4.1 to 4.8 shows the comparison of anthropometric parameters of Jukun and Kuteb adolescents based on sex (Appendix V). The result showed that the females of the two ethnic groups had higher values in most of the anthropometric variables except in height, neck circumference and Waist-chest ratio (Kuteb only), most of these differences were statistically significant.

Comparison of boys of the two ethnic groups showed no statistical significant difference, but Kuteb boys had higher anthropometric values than Jukun boys in most of the variables except waist hip ratio, waist chest ratio, waist height ratio, subscapular skinfold and umbilical skinfold. Comparison of girls of the two ethnic groups also did not show any statistical significant difference, but Kuteb girls had higher values compared to their Jukun counterparts except in height, thigh circumference, waist-chest ratio, subscapular skinfold and umbilical skinfold.

4.3 Growth Charts

Fig. 4.9 to 4.14 shows the various growth curves of weight, height and BMI of male and females respectively. Figure 4.9 showed that the weights of the Jukun and Kuteb boys were lower compared to the other reference values. The Jukun and Kuteb females however had their value closer to the reference values (Fig. 4.10). Figure 4.11 also showed that from ages 10 to 12, the height of the Jukun and Kuteb adolescent boys were close to the reference values, but from ages 13 and above, there is a wide gap in height compared to the reference values. The females had values that were lower but close to the reference population (Fig. 4.12). The BMI of the boys were lesser than that of the reference, but there was no wide difference (Fig. 4.13). The Jukun and Kuteb females had high BMI values comparable with the reference and even more than the WHO values except at age 10 (Fig. 4.14).

4.4 Hand and Foot Anthropometry

Table 4.2 describes the hand and foot anthropometry of the sample population based on ethnic groups, it showed no statistical significant differences in the variables, but Jukun adolescents had higher values except in the right foot index, Left foot length and left foot breadth. Table 4.3 compared the variables based on sex, and it showed that the males from both ethnic groups had higher values than their female counterparts, and some of these differences were statistically significant. There was statistical significant difference in the Right Hand Index between boys of the two ethnic groups, while girls showed statistical significant difference in right and left 2D:4D ratios ($p < 0.05$).

Percentiles values of weight, height and BMI of the ethnic groups based on sex were generated in Tables 4.4 to 4.9, while reference anthropometric values were also generated for the ethnic groups in Tables 4.10 to 4.13.

4.5 Sexual Maturation Rating

Figures 4.15 and 4.16 shows the maturity rating of both ethnic groups. There were more females in the later stages of maturation, while more males were observed to be at the earlier stages of maturation. Chi-square analysis showed significant differences in PHS ($\chi^2 = 24.58$ $p = 0.017$), while The GS_BS also showed significant differences ($\chi^2 = 32.95$ $p = 0.001$).

Comparison of the ages at various Tanner Stages for PHS and GS_BS among the Jukun and Kuteb adolescents (Table 4.14) showed that the females from both ethnic groups have earlier onset of maturation into these stages. For stage 1, mean age for Jukun Females was at 10.14 for Pubic Hair and 10.17 for Breast Stage, while for Kuteb Females it was 10.17 for Pubic Hair and 10.50 for Breast Stage. Jukun Males had mean ages of 10.42 and 10.36 for Pubic Hair and Genital Size respectively, Kuteb male mean ages were 10.50 (Pubic Hair) and 10.50 (Genital Size).

The mean age for the appearance of Pubic hair was approximately 11.25 for Jukun girls and 11.50 for Kuteb girls. For the males, mean age at appearance of Pubic Hair was 11.77 and 11.88 for Jukun boys and Kuteb boys respectively. Age at onset of breast development (corresponding to stage 2) for females was 11.17 (Jukun) and 11.12 (Kuteb) respectively. For males, Age at entry of genital development was 11.65 for both Jukun and Kuteb boys.

Age at adult maturity (corresponding to stage 4) in PH and Breast size for females was 15.91 and 15.57 (Jukun); 15.77 and 15.58 (Kuteb) respectively. For males, age at adult maturity in Pubic Hair and Genital Size was 16.08 and 15.70 (Jukun), 16.40 and

15.83(Kuteb). There was statistical significant difference between males and females of both ethnic groups at stage 3 for PHS, and stage 3 and 5 for GS_BS.

Table 4.15 compares weight at various Tanner stages, it was observed that the Jukun males have lesser weights than Kuteb males, while Jukun Females had higher weights than the Kuteb female. Furthermore, it was noticed that the females generally were weightier from stage 1 to stage 4, but males tend to be weightier at stage 5. There was no statistical significant difference in weight across the stages among Kuteb male and females, but statistical significant difference was noticed between males and females of Jukun ethnic group and this was noticed in both the PHS and the GS_BS.

Table 4.16 compares the height at various tanner stages, Jukun females were taller in PHS 1, but subsequently the males were taller in the remaining stages. For GS_BS, the males were consistently taller. Jukun males tend to be significantly taller than their female counterparts, but they were not significantly shorter than Kuteb males. Kuteb males were taller than their females and also taller than Jukun males in some of the stages. Jukun females were taller than Kuteb females, and this was statistically significant at BS 4.

Table 4.17 compares BMI at various Tanner stages. The females had statistically significant higher values than their male counterparts across the stages. The Kuteb males had the lowest BMI of 15.67 in GS 1, while Kuteb Female had the highest BMI of 22.07 in PHS 5.

Table 4.18 compares the %body fat at various Tanner stages. The females had statistically significant % Body Fat than their male counterparts ($p < 0.001$) across all

the stages. Kuteb males had the lowest % Body Fat of 28.60 at PHS 1, while Kuteb Females had the highest %Body Fat of 40.86 in PHS 5.

4.6 Nutritional Assessment

Nutritional status of the population was assessed using WHO 2007 reference values. Thinness was observed to be more prevalent amongst the males, occurring only in ages 15 and 16 (Jukun only) for girls. On the other hand, overweight was more prominent in females than in males (Table 4.19). The prevalence of thinness was 11.7 % in boys and 1.1% in girls. It was highest in Jukun boys (12.1 %) and least in Kuteb girls (0.7 %) with Jukun girls and Kuteb boys having prevalence of 1.4 % and 11.4 % respectively. Jukun boys exhibited thinness in all the age categories except ages 13 and 19, with high prevalence observed in ages 10 (22.2 %), 12 (20.0 %) and 14 (21.4 %). Thinness was observed in Kuteb boys between age 10 to 16 (except 12), and it was most prominent in age 14 (30 %). Jukun girls were thin only in ages 15 (6.2 %) and 16 (5.3 %) while Kuteb girls were thin only in age 15 (5.0 %).

The incidence of overweight was 1.1 % for boys and 3.9 % for girls. The prevalence was highest in Kuteb girls (5 %) and least in Kuteb boys (0.7 %), with Jukun boys and girls having prevalence of 1.4 % and 2.9 % respectively. Overweight was noticed in age 12 (7.7 %) and age 19 (10.0 %) in Jukun boys, while in Kuteb boys, it was prevalent only in age 12 (9.1 %). Jukun girls were overweight in ages 12 (7.1 %), 16 (10.5 %) and 18 (6.7%), while Kuteb girls were overweight between ages 12 to 19, with the highest prevalence in age 12 (18.8 %).

The prevalence of stunting was 22.4 % in boys and 2.9 % in girls. 24.8 % of Jukun boys and 20% of Kuteb boys were stunted, while only 0.7 % of Jukun girls and 5 % of Kuteb girls were stunted. Stunting was observed in Jukun boys from age 10 to 18, and

it was more prevalent between ages 14 (46.4 %) and 15 (42.9 %). In Kuteb boys, stunting was observed between ages 13 to 16 and age 18, while it was most prominent in age 14 (40.0 %). Stunting in Jukun girls was observed only in age 11 (8.3 %), while it was observed between ages 14 to 19 (except 16) in Kuteb girls, with the highest prevalence of 12.5 % noticed in ages 18 and 19.

4.7 Correlations of Anthropometric Variables

Table 4.20 showed the overall correlation matrix of some anthropometric variables using Pearson's correlation coefficient. A great percentage of the parameters correlated at $p < 0.01$ and $p < 0.05$. Age correlated significantly with all parameters except with thigh circumference and left 2D:4D. Left 2D:4D correlated significantly with only height, neck circumference and Right 2D:4D. Height correlated significantly with all the parameters. BMI, chest circumference, arm circumference and hip circumference correlated significantly with all parameters except left and right 2D:4D. Waist Hip ratio and Waist Height ratio correlated negatively with all the parameters except with Waist Height ratio. Left and right 2D:4D have the least correlation with the other parameters.

Table 4.21 presented the correlation matrix of girls (down) and boys (up) of the population. Approximately 70% and over 85% of the adolescents have significant correlation in the matrix at $p < 0.01$ and $p < 0.05$ respectively. Age of the girls, BMI, chest circumference and hip circumference correlated with all the parameters except with left and right 2D:4D. Their weights correlated with all the parameters except left 2D:4D, while their height correlated with all the parameters. Furthermore, the waist and arm circumference of the girls correlated with all parameters except waist chest ratio, left and right 2D:4D. Their waist hip ratio and waist height ratio correlated

inversely with most of the parameters, while left 2D:4D showed no significant correlation with any of the variables.

For correlation among boys, age, BMI, correlated with all the parameters except left 2D:4D. Weight, arm, neck, thigh and hip circumferences correlated with all the parameters except waist height ratio; while their height correlated with all the parameters.

4.8 Linear Multiple Regression Model

Table 4.22 and 4.23 showed linear multiple regression equations for sexual maturation from some anthropometric variables. From the tables, weight together with height is a stronger possible predictor of sexual maturation for both PHS and GS_BS in boys and girls than the other variables. The R^2 value obtained for predicting PHS and GS_BS in boys using weight and height are 0.543 and 0.525 respectively, while for girls it was 0.625 and 0.624. Regression of Waist circumference and height circumference had lower R^2 values than BMI and % BF in boys in both PHS and GS_BS, while they then had higher R^2 values than BMI and % BF in girls in both PHS and GS_BS.

Table 4.1: Descriptive statistics of anthropometric parameters of all subjects (n=600) and according to ethnic groups

Parameters	(All subjects, n= 600)		(Jukun, n=300)		(Kuteb, n = 300)		T	P
	Mean \pm SD	Min – Max	Mean \pm SD	Min – Max	Mean \pm SD	Min – Max		
Age (years)	15.05 \pm 2.89	10.00 – 20.00	14.97 \pm 2.86	10.00 – 20.00	15.14 \pm 2.93	10.00 – 20.00	- 0.73	0.46
Weight (kg)	47.96 \pm 10.12	21.00 – 81.50	47.83 \pm 10.40	21.00 – 81.50	48.09 \pm 9.85	27.00 – 75.00	- 0.31	0.75
Height (cm)	155.87 \pm 9.77	124.70 – 184.30	155.83 \pm 9.90	124.70 – 184.30	155.92 \pm 9.64	128.60 – 179.70	- 0.11	0.91
BMI (kg/m ²)	19.51 \pm 2.54	11.17 – 28.85	19.45 \pm 2.54	13.50 – 28.85	19.57 \pm 2.55	11.17 – 27.09	- 0.60	0.55
Waist Circumference (cm)	71.71 \pm 6.07	58.00 – 89.20	71.47 \pm 6.16	58.00 – 89.20	71.94 \pm 5.98	59.90 – 88.40	- 0.96	0.34
Hip Circumference (cm)	83.02 \pm 7.69	64.00 – 104.00	82.91 \pm 7.80	64.00 – 104.00	83.13 \pm 7.59	65.00 – 98.2	- 0.36	0.72
Arm Circumference (cm)	24.10 \pm 3.16	16.30 – 47.50	24.06 \pm 3.34	16.30 – 47.50	24.13 \pm 2.97	17.00 – 32.50	- 0.30	0.76
Neck Circumference (cm)	30.93 \pm 2.84	23.00 – 45.00	30.87 \pm 2.86	24.00 – 45.00	30.99 \pm 2.81	23.00 – 40.00	- 0.50	0.61
Chest Circumference (cm)	78.63 \pm 7.95	36.50 – 107.40	78.27 \pm 8.28	36.50 – 105.00	79.00 \pm 7.60	62.00 – 107.40	- 1.12	0.26
Thigh Circumference (cm)	42.93 \pm 4.99	21.50 – 58.50	42.81 \pm 5.00	27.50 – 55.00	43.05 \pm 4.97	21.50 – 58.50	- 0.60	0.55
Triceps Skinfold (mm)	9.07 \pm 3.34	2.50 – 25.00	8.97 \pm 3.41	2.50 – 20.00	9.17 \pm 3.27	3.50 – 20.00	- 0.72	0.47
Subscapular Skinfold (mm)	9.36 \pm 3.13	4.00 – 24.00	9.39 \pm 3.02	4.00 – 20.00	9.33 \pm 3.24	4.00 – 24.00	0.21	0.83
Umbilical Skinfold (mm)	9.68 \pm 3.48	4.00 – 25.00	9.79 \pm 3.02	4.00 – 22.00	9.58 \pm 3.47	4.00 – 25.00	0.76	0.45
Waist-Hip Ratio	0.87 \pm 0.04	0.71 – 1.31	0.86 \pm 0.04	0.71 – 1.02	0.87 \pm 0.05	0.75- 1.31	- 0.93	0.35
Waist-Chest Ratio	0.92 \pm 0.06	0.70 – 1.69	0.92 \pm 0.08	0.71 – 1.689	0.91 \pm 0.04	0.70 – 1.11	0.95	0.34
Waist-Height Ratio	0.46 \pm 0.03	0.37 – 0.58	0.46 \pm 0.03	0.37 – 0.58	0.46 \pm 0.03	0.373 – 0.571	-1.18	0.24
%Body Fat	35.71 \pm 4.37	26.41 – 51.96	35.53 \pm 4.40	26.41- 51.96	35.88 \pm 4.34	26.73 – 49.47	- 1.00	0.32

Table 4.2: Descriptive statistics of hand and foot anthropometry of all subjects (n=600) according to ethnic groups

Parameters	(All subjects, n=	Min – Max	(Kuteb,	Min – Max	(Jukun, n =	Min – Max	T	P
	600)		n=300)		300)			
	Mean ± SD		Mean ± SD		Mean ± SD			
Right 2D (cm)	6.087 ± 0.44	5.15 – 7.14	6.077 ± 0.42	5.17 – 6.74	6.097 ± 0.45	5.15 – 7.14	0.55	0.59
Right 4D (cm)	6.448 ± 0.43	5.52 – 8.78	6.445 ± 0.43	5.52 – 8.03	6.451 ± 0.44	5.70 – 8.78	0.15	0.88
Right 2D:4D Ratio	0.944 ± 0.03	0.82 – 1.07	0.943 ± 0.03	0.83 – 1.02	0.945 ± 0.03	0.82 – 1.07	0.89	0.37
Left 2D (cm)	6.102 ± 0.45	5.20 – 7.13	6.091 ± 0.44	5.20 – 6.86	6.113 ± 0.46	5.33 – 7.13	0.61	0.54
Left 4D (cm)	6.457 ± 0.44	5.49 – 7.66	6.453 ± 0.43	5.49 – 7.09	6.462 ± 0.45	5.68 – 7.66	0.27	0.79
Left 2D:4D Ratio	0.945 ± 0.03	0.80 – 1.07	0.944 ± 0.03	0.80 – 1.06	0.946 ± 0.03	0.86 – 1.07	0.85	0.41
Right Hand Length (cm)	17.216 ± 1.25	13.90 – 22.50	17.163 ± 1.17	13.90 – 21.60	17.269 ± 1.33	14.50 – 22.50	0.61	0.30
Right Hand Breadth (cm)	6.931 ± 0.68	4.80 – 8.40	6.886 ± 0.64	5.10 – 7.80	6.976 ± 0.71	4.80 – 8.40	1.62	0.11
Right Hand Index	40.259 ± 1.98	37.74 – 50.33	40.121 ± 2.05	37.74 – 50.33	40.396 ± 1.91	38.50 – 50.12	1.09	0.28
Left Hand Length (cm)	17.230 ± 1.26	13.70 – 21.50	17.209 ± 1.22	13.70 – 21.00	17.281 ± 1.30	14.60 – 21.50	0.40	0.69
Left Hand Breadth (cm)	6.926 ± 0.68	4.70 – 13.40	6.898 ± 0.66	5.20 – 7.60	6.955 ± 0.70	4.70 – 8.40	1.03	0.30
Left Hand Index	40.197 ± 1.98	43.59 – 60.77	40.084 ± 2.04	36.59 – 50.00	40.246 ± 1.91	37.34 – 50.77	1.12	0.26
Right Foot Length (cm)	22.512 ± 1.71	17.20 – 26.50	22.485 ± 1.71	18.20 – 26.50	22.536 ± 1.72	17.20 – 26.30	0.35	0.73
Right Foot Breadth (cm)	9.550 ± 0.99	6.70 – 13.30	9.549 ± 0.99	6.80 – 13.30	9.562 ± 0.99	6.70 – 12.50	0.16	0.87
Right Foot Index	42.422 ± 1.74	38.93 – 53.64	42.408 ± 1.92	38.93 – 53.64	42.430 ± 1.54	39.54 – 52.45	- 0.43	0.67
Left Foot Length (cm)	22.511 ± 1.72	17.00 – 26.20	22.514 ± 1.71	18.10 – 26.10	22.543 ± 1.72	17.00 – 26.20	- 0.05	0.96
Left Foot Breadth (cm)	9.548 ± 1.01	6.60 – 13.50	9.548 ± 1.01	6.80 – 13.50	9.547 ± 0.99	6.60 – 12.60	- 0.02	0.98
Left Foot Index	42.415 ± 1.77	38.12 – 52.26	42.409 ± 1.93	38.12 – 52.26	42.356 ± 1.60	39.26 – 52.00	0.03	0.97

Table 4.3: Comparison of hand and foot anthropometric parameters of males and females of Jukun and Kuteb ethnic groups

Parameters	Jukun		T	P	Kuteb		T	p
	(Male, n = 150)	(Female, n = 150)			(Male, n = 150)	(Female, n = 150)		
Right 2D (cm)	6.072 ± 0.59	6.121 ± 0.25	0.93	0.35	6.073 ± 0.54	6.080 ± 0.26	0.14	0.89
Right 4D (cm)	6.458 ± 0.56	6.443 ± 0.27	- 0.30	0.76	6.445 ± 0.53	6.445 ± 0.29	- 0.04	0.99
Right 2D:4D Ratio	0.940 ± 0.03	0.950 ± 0.02 [†]	3.06	0.02	0.942 ± 0.03	0.943 ± 0.02	0.50	0.62
Left 2D (cm)	6.100 ± 0.60	6.126 ± 0.27	0.48	0.63	6.096 ± 0.55	6.085 ± 0.28	- 0.20	0.84
Left 4D (cm)	6.471 ± 0.58	6.453 ± 0.27	- 0.35	0.72	6.455 ± 0.54	6.450 ± 0.28	- 0.10	0.92
Left 2D:4D Ratio	0.942 ± 0.03	0.949 ± 0.02 [†]	2.24	0.03	0.944 ± 0.03	0.943 ± 0.03	- 0.15	0.88
Right Hand Length (cm)	17.410 ± 1.58	17.128 ± 0.99	- 1.85	0.07	17.300 ± 1.40	17.026 ± 0.85	- 2.05	0.04
Right Hand Breadth (cm)	7.058 ± 0.84	6.893 ± 0.55	- 2.02	0.05	6.905 ± 0.78	6.867 ± 0.46	- 0.51	0.61
Right Hand Index	40.540 ± 2.07 [§]	40.244 ± 1.74	- 0.45	0.65	39.913 ± 2.27	40.332 ± 1.77	2.39	0.02
Left Hand Length (cm)	17.429 ± 1.55	17.132 ± 0.99	- 1.85	0.07	17.348 ± 1.44	17.071 ± 0.95	- 1.97	0.05
Left Hand Breadth (cm)	7.014 ± 0.82	6.895 ± 0.54	- 1.48	0.14	6.920 ± 0.78	6.875 ± 0.50	- 0.60	0.55
Left Hand Index	40.243 ± 1.98	40.246 ± 1.84	0.62	0.54	39.889 ± 2.22	40.273 ± 1.80	2.28	0.02
Right Foot Length (cm)	23.167 ± 1.94	21.905 ± 1.17	- 6.83	0.01	23.070 ± 1.97	21.900 ± 1.15	- 6.26	0.01
Right Foot Breadth (cm)	9.917 ± 1.10	9.207 ± 0.69	- 6.68	0.01	9.906 ± 1.07	9.192 ± 0.76	- 6.66	0.01
Right Foot Index	42.807 ± 1.61	42.031 ± 1.47	- 0.93	0.35	42.939 ± 2.19	41.973 ± 1.59	- 1.98	0.04
Left Foot Length (cm)	23.176 ± 1.95	21.909 ± 1.19	- 6.46	0.001	23.091 ± 1.97	21.137 ± 1.15	- 6.19	0.01
Left Foot Breadth (cm)	9.898 ± 1.13	9.195 ± 0.68	-6.52	0.01	9.906 ± 1.11	9.197 ± 0.75	- 6.42	0.01
Left Foot Index	42.830 ± 1.76	41.977 ± 1.41	- 1.32	0.19	42.900 ± 2.22	40.097 ± 1.57	- 1.82	0.07

§. t-statistics showed statistical significant difference ($p < 0.05$) for comparison between boys of the two ethnic groups

†. t-statistics showed statistical significant difference ($p < 0.05$) for comparison between girls of the two ethnic groups

Table 4.4: Comparison of weight-for-age percentiles of Jukun and Kuteb ethnic groups (male)

Age (yrs.)		Weight Percentiles (Male)							
		5	10	25	50	75	85	90	95
10	Jukun	21.00	21.00	28.25	30.00	31.75	34.75	36.47	36.95
	Kuteb	27.50	27.55	28.00	29.75	31.63	32.35	32.90	35.76
11	Jukun	27.00	27.20	29.38	31.40	37.13	39.18	39.45	42.35
	Kuteb	27.00	27.20	29.00	30.50	33.50	34.20	34.80	39.44
12	Jukun	25.50	26.70	32.00	39.00	40.75	42.35	51.50	52.65
	Kuteb	35.50	35.80	38.50	40.50	41.50	45.20	54.80	57.57
13	Jukun	36.50	36.50	36.63	37.50	39.88	41.18	43.45	45.85
	Kuteb	28.00	28.20	35.25	38.00	40.00	45.40	47.20	49.55
14	Jukun	31.35	33.45	35.25	39.50	46.50	49.83	54.55	56.93
	Kuteb	33.08	34.65	37.00	42.00	46.50	50.55	51.45	52.45
15	Jukun	37.55	38.20	39.25	44.50	47.00	49.40	54.00	61.30
	Kuteb	39.00	39.15	42.00	45.50	50.75	56.10	60.50	65.83
16	Jukun	42.00	42.40	47.25	51.00	54.25	58.25	58.50	60.37
	Kuteb	35.50	38.25	44.13	49.50	53.25	55.50	59.00	64.87
17	Jukun	48.50	49.50	53.25	57.50	61.50	63.90	64.90	66.78
	Kuteb	50.00	50.25	54.38	56.25	57.13	59.25	62.00	65.45
18	Jukun	43.00	44.05	53.00	57.50	62.63	70.12	71.68	74.58
	Kuteb	51.50	52.30	53.25	56.00	60.00	61.45	62.60	67.25
19	Jukun	53.00	53.55	58.88	61.25	62.75	70.78	79.85	81.50
	Kuteb	52..50	52.65	56.50	61.75	62.88	64.55	71.70	76.26
20	Jukun	52.00	52.00	56.00	61.00	63.50	65.00	69.85	75.68
	Kuteb	56.50	56.65	59.13	60.50	62.50	65.05	66.70	71.43

Table 4.5: Comparison of weight-for-age percentiles of Jukun and Kuteb ethnic groups (female)

Age (yrs.)		Weight Percentiles (Female)							
		5	10	25	50	75	85	90	95
10	Jukun	28.50	28.60	29.50	32.50	35.00	36.80	39.20	40.00
	Kuteb	29.50	29.50	29.88	30.75	32.25	33.18	33.45	34.06
11	Jukun	28.00	30.70	37.75	38.75	40.25	41.08	42.05	42.25
	Kuteb	37.50	37.50	37.88	39.00	40.13	41.03	41.85	42.20
12	Jukun	33.00	34.50	45.00	47.00	48.75	51.38	55.00	55.50
	Kuteb	33.00	36.15	40.00	41.25	54.25	55.73	56.15	57.55
13	Jukun	42.00	42.20	43.00	44.00	44.75	45.00	50.40	51.50
	Kuteb	36.00	36.40	46.00	47.00	48.50	50.40	54.60	54.95
14	Jukun	42.00	43.20	47.75	49.00	50.25	53.65	55.20	55.80
	Kuteb	35.50	39.70	47.25	48.00	50.00	51.85	52.00	52.50
15	Jukun	42.00	42.35	47.63	50.00	52.25	54.35	56.45	56.90
	Kuteb	43.10	45.40	50.13	51.50	54.63	55.50	57.75	64.18
16	Jukun	36.50	43.50	52.00	53.50	58.00	65.00	66.50	67.10
	Kuteb	47.00	48.00	51.25	53.50	54.00	54.90	59.20	60.85
17	Jukun	47.00	49.10	54.13	55.75	56.88	58.90	62.10	62.85
	Kuteb	52.00	53.50	54.50	56.00	56.50	58.50	61.30	62.90
18	Jukun	47.00	51.20	55.50	56.50	59.00	64.00	67.00	67.71
	Kuteb	43.50	44.55	53.00	55.50	56.50	59.00	59.90	62.50
19	Jukun	55.00	55.10	56.00	56.50	57.00	58.30	59.20	60.18
	Kuteb	48.50	48.85	52.38	56.25	58.50	60.85	62.95	63.50
20	Jukun	51.50	52.05	57.00	57.75	58.13	58.68	58.95	59.10
	Kuteb	57.00	57.00	57.38	57.75	58.00	58.35	58.90	60.50

Table 4.6: Comparison of height-for-age percentiles of Jukun and Kuteb ethnic groups (male)

Age (yrs.)		Height Percentiles (Male)							
		5	10	25	50	75	85	90	95
10	Jukun	124.70	124.70	130.55	136.80	145.15	147.70	148.25	148.38
	Kuteb	128.60	128.63	129.43	137.25	139.70	141.59	142.19	145.52
11	Jukun	129.50	130.78	142.53	144.00	145.48	149.38	154.22	157.36
	Kuteb	133.90	134.26	137.30	142.20	146.50	148.38	151.92	153.48
12	Jukun	129.20	130.84	140.40	145.70	150.15	151.33	159.86	159.94
	Kuteb	141.60	142.42	147.50	149.70	151.80	161.60	165.20	168.24
13	Jukun	143.60	144.11	146.23	149.15	151.23	152.59	157.59	158.60
	Kuteb	136.20	139.20	144.65	148.40	151.85	158.95	160.60	162.48
14	Jukun	141.15	142.60	145.63	153.00	158.48	164.60	166.82	167.22
	Kuteb	143.55	146.47	148.80	154.00	161.58	163.46	164.31	167.06
15	Jukun	147.14	147.66	150.90	156.60	158.20	161.90	165.30	169.15
	Kuteb	146.34	147.73	154.58	157.65	167.68	171.26	173.04	175.27
16	Jukun	151.90	154.62	161.90	163.50	164.85	166.08	171.48	173.68
	Kuteb	143.50	147.50	160.15	163.35	164.15	165.28	166.65	168.28
17	Jukun	154.30	155.06	163.05	166.50	168.80	173.12	173.90	175.25
	Kuteb	161.80	161.89	162.85	163.25	164.35	165.22	165.88	169.60
18	Jukun	155.30	155.33	159.53	169.50	174.03	175.37	181.48	185.55
	Kuteb	155.70	155.70	158.80	164.40	170.65	171.85	172.30	176.78
19	Jukun	165.10	165.25	171.18	174.40	175.90	176.31	176.47	177.87
	Kuteb	163.30	164.47	167.95	172.95	176.18	176.95	178.83	179.69
20	Jukun	159.00	159.00	163.30	168.90	171.80	176.25	180.57	185.38
	Kuteb	167.90	167.96	168.50	169.50	170.65	170.91	171.07	171.58

Table 4.7: Comparison of height-for-age percentiles of Jukun and Kuteb ethnic groups (female)

Age (yrs.)		Height Percentiles (Female)							
		5	10	25	50	75	85	90	95
10	Jukun	137.50	137.52	137.70	140.30	141.00	142.38	145.62	146.10
	Kuteb	137.50	137.57	138.35	140.10	141.50	141.57	141.68	141.72
11	Jukun	135.10	136.09	143.53	144.30	145.58	146.23	146.55	146.70
	Kuteb	138.90	139.26	143.33	144.30	145.60	148.53	152.65	153.55
12	Jukun	141.20	145.75	152.43	155.95	158.15	159.35	161.30	162.10
	Kuteb	141.20	143.93	147.65	149.50	155.18	157.85	161.03	161.54
13	Jukun	148.90	149.10	150.15	151.60	154.90	155.67	156.18	156.75
	Kuteb	148.20	148.60	152.50	153.60	156.50	156.72	157.08	157.17
14	Jukun	148.20	148.40	152.85	154.40	155.45	156.42	160.88	161.15
	Kuteb	140.70	144.90	152.10	153.10	153.70	155.15	160.22	160.39
15	Jukun	152.80	152.94	157.68	161.45	162.40	163.60	164.35	165.20
	Kuteb	145.87	154.77	156.83	162.55	163.65	164.73	165.07	167.57
16	Jukun	153.10	153.20	156.10	159.40	162.20	165.60	167.00	167.68
	Kuteb	151.40	151.40	158.55	159.40	162.15	165.19	165.74	167.55
17	Jukun	153.30	154.14	157.40	159.05	160.10	163.47	165.36	166.24
	Kuteb	150.40	152.80	157.60	159.20	159.90	162.94	167.22	167.69
18	Jukun	152.40	153.54	157.60	159.10	163.60	164.56	165.04	165.36
	Kuteb	148.60	149.58	153.33	157.05	158.43	159.31	162.16	163.45
19	Jukun	156.30	156.38	156.80	157.70	159.70	162.16	169.24	169.78
	Kuteb	148.20	149.11	154.13	158.20	159.25	159.75	160.52	161.63
20	Jukun	156.20	156.32	157.78	159.55	161.25	161.65	162.03	162.10
	Kuteb	156.10	156.28	159.25	160.05	161.20	162.10	162.10	162.97

Table 4.8: Comparison of BMI-for-age percentiles of Jukun and Kuteb ethnic groups (male)

Age (yrs.)		BMI Percentiles (Male)							
		5	10	25	50	75	85	90	95
10	Jukun	13.50	13.50	14.42	16.67	17.08	17.25	19.10	19.26
	Kuteb	13.83	13.86	15.03	16.74	17.37	17.86	18.62	20.24
11	Jukun	14.22	14.25	14.63	15.51	16.58	17.61	18.49	18.55
	Kuteb	13.76	13.95	14.84	15.21	15.84	16.18	16.19	16.22
12	Jukun	14.97	15.09	16.06	17.65	19.25	19.42	20.37	21.25
	Kuteb	15.61	15.64	17.70	17.91	19.05	19.64	20.62	21.41
13	Jukun	15.97	15.98	16.75	17.41	17.75	17.89	18.08	22.45
	Kuteb	11.17	12.74	16.54	17.21	18.35	19.21	20.24	20.97
14	Jukun	14.54	15.71	16.76	17.18	18.44	19.42	19.86	20.88
	Kuteb	15.65	15.70	16.11	17.40	18.26	19.55	20.25	20.35
15	Jukun	15.09	15.54	17.52	18.15	18.86	19.37	21.15	21.94
	Kuteb	14.30	15.96	18.10	18.48	19.30	19.96	20.49	21.42
16	Jukun	16.20	16.38	18.29	18.64	19.23	21.67	22.71	25.36
	Kuteb	16.58	16.91	17.75	18.56	19.31	20.22	21.86	22.43
17	Jukun	17.39	17.94	19.07	21.13	22.38	23.08	23.43	25.69
	Kuteb	18.89	19.01	20.48	21.03	21.31	21.99	22.57	23.64
18	Jukun	17.83	18.08	19.41	20.41	21.25	21.64	23.03	23.42
	Kuteb	18.27	19.19	19.93	20.52	21.63	22.68	23.50	23.84
19	Jukun	19.44	19.47	19.75	19.94	21.14	23.30	26.36	27.12
	Kuteb	18.38	18.45	19.82	19.97	22.24	22.44	22.97	23.12
20	Jukun	18.19	18.19	19.80	21.21	23.11	24.73	27.85	29.41
	Kuteb	19.53	19.60	20.67	21.12	21.69	22.66	22.85	25.68

Table 4.9: Comparison of BMI-for-Age Percentiles of Jukun and Kuteb ethnic groups (female)

		BMI Percentiles (Female)							
Age (yrs.)		5	10	25	50	75	85	90	95
10	Jukun	14.52	14.54	15.36	16.85	17.78	18.67	18.91	18.99
	Kuteb	15.19	15.20	15.41	15.58	16.56	16.85	16.91	16.99
11	Jukun	15.34	16.19	18.20	18.64	19.33	19.67	19.72	19.88
	Kuteb	17.85	17.87	18.08	18.68	19.21	19.48	19.66	19.72
12	Jukun	15.94	16.24	18.45	19.46	19.89	19.98	21.84	21.95
	Kuteb	16.55	17.38	17.95	18.78	20.84	23.02	23.31	23.87
13	Jukun	18.37	18.39	18.49	18.56	19.71	19.93	21.20	21.54
	Kuteb	16.39	16.48	19.20	19.78	19.99	20.81	23.05	23.25
14	Jukun	19.12	19.50	20.21	20.62	20.86	20.96	21.99	22.20
	Kuteb	17.93	18.54	19.92	20.64	20.93	20.98	21.70	21.96
15	Jukun	16.51	17.69	18.42	19.14	20.26	21.33	22.06	22.31
	Kuteb	16.64	18.01	19.20	19.75	21.76	22.59	22.78	26.29
16	Jukun	15.57	18.49	20.67	21.15	22.09	23.00	25.34	25.49
	Kuteb	18.25	19.15	20.72	21.06	21.24	21.57	22.15	22.57
17	Jukun	18.47	19.82	21.52	21.96	22.19	23.75	23.97	24.42
	Kuteb	19.09	20.32	21.64	21.94	22.99	24.05	24.60	24.89
18	Jukun	18.31	20.33	21.79	22.32	22.75	23.98	26.39	27.05
	Kuteb	18.73	19.01	21.48	22.59	23.49	24.06	24.29	25.35
19	Jukun	20.21	20.47	21.96	22.52	22.86	23.16	23.60	23.69
	Kuteb	20.69	20.78	21.86	22.23	23.90	24.84	25.54	26.13
20	Jukun	21.11	21.20	22.26	22.53	23.10	23.22	23.23	23.35
	Kuteb	22.07	22.08	22.29	22.43	22.78	23.32	23.73	24.16

Table 4.10: Reference growth and anthropometric values for girls

Age (yrs)		WT(kg)	HT(cm)	BMI (kg/m ²)	TSF (mm)	SSF (mm)	USF (mm)	% BF
	N	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
10	21	31.91 ± 2.72	140.05 ± 2.13	16.26 ± 1.21	11.69 ± 1.44	11.69 ± 0.84	11.50 ± 0.67	33.67 ± 1.13
11	22	38.66 ± 2.79	144.06 ± 3.48	18.61 ± 0.94	10.82 ± 1.05	10.73 ± 1.08	10.73 ± 1.20	33.55 ± 0.89
12	30	45.48 ± 6.88	152.92 ± 5.68	19.35 ± 1.94	10.33 ± 2.12	10.87 ± 2.91	11.48 ± 2.84	35.70 ± 2.78
13	24	45.35 ± 4.27	153.03 ± 2.70	19.34 ± 1.48	8.81 ± 2.24	9.42 ± 1.95	9.88 ± 2.11	34.64 ± 2.22
14	26	48.48 ± 3.81	153.59 ± 4.28	20.52 ± 0.89	12.28 ± 2.16	10.88 ± 1.70	11.17 ± 2.29	37.96 ± 1.75
15	36	51.10 ± 4.47	160.31 ± 4.51	19.91 ± 1.91	11.98 ± 2.55	11.79 ± 2.71	12.41 ± 2.32	39.67 ± 2.59
16	32	53.98 ± 6.24	159.66 ± 4.38	21.14 ± 1.89	11.70 ± 3.03	11.41 ± 2.46	13.25 ± 2.93	39.47 ± 3.27
17	31	55.85 ± 3.63	159.30 ± 4.16	22.02 ± 1.38	11.78 ± 2.63	11.82 ± 2.60	13.03 ± 3.08	41.15 ± 2.63
18	31	55.98 ± 4.99	157.92 ± 4.40	22.45 ± 1.90	12.44 ± 2.78	13.27 ± 3.12	13.91 ± 3.40	41.68 ± 2.98
19	27	56.13 ± 3.46	157.61 ± 4.17	22.61 ± 1.41	12.20 ± 1.69	12.09 ± 1.71	13.26 ± 1.26	40.72 ± 1.40
20	20	57.48 ± 1.53	159.64 ± 1.81	22.55 ± 0.56	12.45 ± 1.32	13.18 ± 0.96	14.00 ± 0.97	41.10 ± 1.12
Overall Mean ± SD	300	49.78 ± 8.50	155.09 ± 7.22	20.54 ± 2.34	11.53 ± 2.45	11.58 ± 2.44	12.31 ± 2.66	38.38 ± 3.69

WT= weight HT = Height BMI = Body Mass Index TSF = Triceps Skinfold SSF = Subscapular Skinfold USF = Umbilical Skinfold % BF = Percentage body fat

Table 4.11: Reference growth and anthropometric values for girls

Age (yrs)	n	WC(cm)	HC (cm)	AC (cm)	NC (cm)	CC (cm)	TC (cm)	WHpR	WCR	WHtR
		Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
10	21	63.69 \pm 2.05	72.43 \pm 3.03	21.67 \pm 0.92	26.75 \pm 1.08	68.35 \pm 1.84	40.41 \pm 1.05	0.88 \pm 0.03	0.93 \pm 0.01	0.45 \pm 0.01
11	22	64.55 \pm 0.93	73.30 \pm 1.99	22.36 \pm 1.28	28.44 \pm 1.16	69.85 \pm 1.80	40.84 \pm 1.76	0.88 \pm 0.02	0.92 \pm 0.02	0.45 \pm 0.01
12	30	71.01 \pm 5.10	80.77 \pm 4.67	23.29 \pm 1.96	29.83 \pm 1.57	78.15 \pm 4.71	42.65 \pm 2.25	0.88 \pm 0.04	0.91 \pm 0.04	0.46 \pm 0.03
13	24	70.60 \pm 1.96	81.57 \pm 3.76	23.12 \pm 1.32	30.28 \pm 0.97	75.62 \pm 3.83	42.25 \pm 3.39	0.87 \pm 0.03	0.94 \pm 0.04	0.46 \pm 0.01
14	26	71.91 \pm 1.39	85.51 \pm 2.95	24.22 \pm 1.22	30.11 \pm 1.04	78.07 \pm 2.56	44.36 \pm 2.45	0.84 \pm 0.03	0.92 \pm 0.03	0.47 \pm 0.02
15	36	76.76 \pm 3.45	88.14 \pm 4.25	25.17 \pm 1.85	30.54 \pm 1.05	83.71 \pm 3.29	45.07 \pm 2.86	0.87 \pm 0.04	0.92 \pm 0.04	0.48 \pm 0.03
16	32	76.10 \pm 4.71	88.02 \pm 5.76	25.30 \pm 2.24	32.16 \pm 1.30	83.09 \pm 8.05	46.28 \pm 2.84	0.87 \pm 0.04	0.93 \pm 0.15	0.48 \pm 0.02
17	31	80.01 \pm 3.34	90.68 \pm 4.01	28.17 \pm 3.90	31.74 \pm 0.93	86.53 \pm 2.66	47.84 \pm 3.28	0.88 \pm 0.03	0.93 \pm 0.04	0.50 \pm 0.02
18	31	79.45 \pm 4.54	90.33 \pm 6.60	26.74 \pm 1.53	31.75 \pm 1.01	86.84 \pm 4.17	48.26 \pm 3.08	0.88 \pm 0.09	0.92 \pm 0.04	0.50 \pm 0.03
19	27	76.56 \pm 2.94	91.53 \pm 3.36	26.80 \pm 1.32	31.89 \pm 1.07	85.79 \pm 3.12	47.59 \pm 1.83	0.84 \pm 0.03	0.89 \pm 0.03	0.49 \pm 0.02
20	20	76.44 \pm 0.76	91.75 \pm 1.04	25.36 \pm 0.38	30.24 \pm 0.38	89.75 \pm 0.33	47.09 \pm 0.34	0.83 \pm 0.01	0.85 \pm 0.01	0.48 \pm 0.01
Overall Mean	300	73.97 \pm 6.04	85.48 \pm 7.51	24.93 \pm 2.69	30.51 \pm 1.05	81.06 \pm 7.42	45.01 \pm 3.64	0.87 \pm 0.05	0.92 \pm 0.06	0.48 \pm 0.03

WC = Waist Circumference HC = Hip Circumference AC = Arm Circumference NC = Neck Circumference CC = Chest Circumference TC = Thigh Circumference WHpR = waist hip ratio WCR = waist chest ratio WHtR = waist height ratio

Table 4.12: Reference growth and anthropometric values for boys

Age (yrs)	N	WT(kg)	HT(cm)	BMI (kg/m ²)	TSF (mm)	SSF (mm)	USF (mm)	%BF
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
10	19	29.87 ± 3.19	136.42 ± 6.56	16.06 ± 1.49	5.00 ± 1.49	4.92 ± 1.13	4.97 ± 1.11	28.06 ± 1.57
11	21	31.66 ± 3.51	142.85 ± 5.75	15.49 ± 1.07	5.40 ± 1.08	5.29 ± 0.83	5.79 ± 1.37	29.36 ± 1.04
12	24	39.38 ± 7.16	147.96 ± 8.36	17.85 ± 1.69	5.46 ± 1.19	5.83 ± 1.49	5.65 ± 1.29	30.65 ± 1.56
13	25	38.10 ± 4.32	149.08 ± 5.47	17.15 ± 1.69	6.45 ± 1.18	6.72 ± 1.12	6.88 ± 1.34	31.69 ± 1.51
14	48	41.53 ± 6.75	153.65 ± 7.73	17.48 ± 1.52	6.55 ± 1.84	6.73 ± 1.78	6.83 ± 1.60	32.14 ± 2.06
15	43	45.92 ± 6.87	157.78 ± 7.58	18.37 ± 1.59	6.81 ± 2.19	7.21 ± 1.49	7.23 ± 1.68	33.01 ± 2.03
16	27	49.76 ± 5.97	162.16 ± 5.76	18.88 ± 1.72	6.96 ± 2.14	7.28 ± 1.74	7.24 ± 1.33	34.09 ± 1.77
17	23	56.61 ± 4.41	164.69 ± 4.41	20.88 ± 1.50	7.58 ± 2.02	8.37 ± 2.06	8.19 ± 1.58	36.03 ± 2.00
18	29	54.84 ± 7.50	165.36 ± 7.76	20.69 ± 1.50	6.69 ± 1.80	8.38 ± 1.61	8.16 ± 1.67	34.77 ± 2.47
19	22	61.66 ± 6.51	172.59 ± 4.49	20.68 ± 1.84	8.26 ± 2.85	8.93 ± 1.61	8.16 ± 2.36	37.11 ± 3.21
20	19	60.53 ± 3.92	168.92 ± 4.12	21.24 ± 1.64	7.16 ± 2.27	8.82 ± 1.28	8.13 ± 1.43	36.57 ± 1.80
Overall Mean ± SD	300	46.13 ± 11.24	156.66 ± 11.73	18.55 ± 2.35	6.61 ± 2.04	7.14 ± 1.93	7.06 ± 1.83	33.03 ± 3.20

WT= weight HT = Height BMI = Body Mass Index TSF = Triceps Skinfold SSF = Subscapular Skinfold USF = Umbilical Skinfold %BF = Percentage body fat

Table 4.13: Reference growth and anthropometric values for boys

Age (yrs)	n	WC(cm)	HC (cm)	AC (cm)	NC (cm)	CC (cm)	TC (cm)	WHpR	WCR	WHtR
		Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
10	19	62.12 \pm 2.09	70.75 \pm 3.70	19.38 \pm 1.36	27.29 \pm 1.05	67.58 \pm 2.34	33.52 \pm 2.14	0.88 \pm 0.03	0.92 \pm 0.03	0.46 \pm 0.02
11	21	64.27 \pm 1.79	71.98 \pm 3.64	19.30 \pm 0.99	27.80 \pm 1.01	67.62 \pm 1.52	34.40 \pm 1.95	0.89 \pm 0.03	0.95 \pm 0.02	0.45 \pm 0.02
12	24	67.15 \pm 3.23	75.23 \pm 4.78	20.89 \pm 2.16	28.53 \pm 2.04	72.29 \pm 4.66	37.50 \pm 4.80	0.89 \pm 0.04	0.93 \pm 0.04	0.45 \pm 0.02
13	25	67.30 \pm 2.80	75.88 \pm 3.75	20.95 \pm 1.45	29.34 \pm 1.23	71.02 \pm 3.35	39.94 \pm 4.34	0.89 \pm 0.04	0.95 \pm 0.04	0.45 \pm 0.03
14	48	67.72 \pm 3.99	78.43 \pm 4.89	21.89 \pm 2.42	29.99 \pm 2.20	74.28 \pm 6.60	39.83 \pm 3.66	0.86 \pm 0.03	0.91 \pm 0.04	0.44 \pm 0.01
15	43	68.95 \pm 4.88	80.27 \pm 4.26	23.07 \pm 2.25	30.95 \pm 2.39	75.53 \pm 9.13	41.34 \pm 3.71	0.86 \pm 0.05	0.92 \pm 0.12	0.44 \pm 0.03
16	27	71.03 \pm 3.61	82.22 \pm 4.23	23.91 \pm 1.75	31.54 \pm 2.42	78.70 \pm 4.41	40.10 \pm 4.57	0.86 \pm 0.03	0.90 \pm 0.03	0.44 \pm 0.02
17	23	74.53 \pm 4.05	87.61 \pm 2.70	25.67 \pm 1.30	34.01 \pm 1.96	25.67 \pm 1.30	34.01 \pm 1.96	0.85 \pm 0.03	0.91 \pm 0.05	0.45 \pm 0.02
18	29	72.19 \pm 4.60	86.40 \pm 4.11	26.29 \pm 2.74	34.16 \pm 2.92	26.29 \pm 2.74	34.16 \pm 2.92	0.84 \pm 0.04	0.89 \pm 0.06	0.44 \pm 0.03
19	22	74.79 \pm 4.07	90.55 \pm 3.87	27.05 \pm 1.75	35.35 \pm 2.02	27.05 \pm 1.75	35.35 \pm 2.02	0.83 \pm 0.02	0.89 \pm 0.06	0.43 \pm 0.02
20	19	74.96 \pm 2.42	87.31 \pm 2.92	28.61 \pm 1.67	37.46 \pm 2.34	28.61 \pm 1.67	37.46 \pm 2.34	0.86 \pm 0.02	0.88 \pm 0.03	0.44 \pm 0.02
Overall \pm SD	300	69.45 \pm 5.22	80.55 \pm 7.07	23.26 \pm 3.37	31.35 \pm 3.53	23.26 \pm 3.37	31.35 \pm 3.53	0.86 \pm 0.04	0.92 \pm 0.06	0.44 \pm 0.02

WC = Waist Circumference HC = Hip Circumference AC = Arm Circumference NC = Neck Circumference CC = Chest Circumference TC = Thigh Circumference WHpR = waist hip ratio WCR = waist chest ratio WHtR = waist height ratio

Table. 4.14: Comparison of age at various Tanner Stages among Jukun and Kuteb ethnic groups.

Sexual Stages	Jukun Male			Jukun Female			Kuteb Male			Kuteb Female	
	PHS	n	Mean ± SD	n	Mean ± SD	P	n	Mean ± SD	n	Mean ± SD	p
Stage 1		12	10.42 ± 0.52	7	10.14 ± 0.38	0.20	10	10.50 ± 0.53	6	10.17 ± 0.41	0.18
Stage 2		22	11.77 ± 0.87	24	11.25 ± 0.90	0.06	24	11.88 ± 1.42	22	11.50 ± 1.14	0.33
Stage 3		43	14.19 ± 1.08	30	13.33 ± 1.21	0.002	47	14.40 ± 1.73	27	12.89 ± 1.42	0.001
Stage 4		40	16.08 ± 1.86	33	15.91 ± 1.88	0.71	35	16.40 ± 2.00	35	15.77 ± 1.56	0.15
Stage 5		33	18.09 ± 1.40	56	17.68 ± 1.43	0.19	34	18.21 ± 1.25	60	17.80 ± 1.59	0.18
GS_BS											
Stage 1		11	10.36 ± 0.51	6	10.17 ± 0.41	0.426	8	10.50 ± 0.54	6	10.50 ± 0.84	1.00
Stage 2		17	11.65 ± 0.86	18	11.17 ± 1.04	0.148	23	11.65 ± 1.43	17	11.12 ± 1.11	0.209
Stage 3		41	13.71 ± 1.15	35	12.77 ± 1.22	0.001	39	14.10 ± 1.89	28	12.57 ± 0.96	0.001
Stage 4		46	15.70 ± 1.69	28	15.57 ± 1.69	0.759	40	15.83 ± 1.75	26	15.58 ± 1.98	0.596
Stage 5		35	18.23 ± 1.31	63	17.63 ± 1.45	0.047	40	18.13 ± 1.38	73	17.44 ± 1.68	0.029

PHS=Pubic Hair Stage; GS_BS= Genital Stage (boys) and Breast Stage (girls).

Table 4.15: Comparison of weight at various Tanner Stages among Jukun and Kuteb ethnic groups.

PHS	Jukun Male		Jukun Female			Kuteb Male			Kuteb Female	
	N	Mean ± SD	N	Mean ± SD	p	n	Mean ± SD	n	Mean ± SD	p
Stage 1	12	31.11 ± 4.96	7	35.37 ± 3.95	0.07	10	31.55 ± 1.92	6	33.25 ± 3.83	0.25
Stage 2	22	35.86 ± 7.03	24	38.23 ± 6.01	0.23	24	36.04 ± 7.95	22	38.30 ± 6.29	0.30
Stage 3	43	41.72 ± 6.92	30	48.38 ± 6.69	0.001	47	44.85 ± 8.86	27	47.48 ± 5.82	0.17
Stage 4	40	50.83 ± 10.55	33	52.30 ± 5.55	0.45	35	51.01 ± 8.91	35	51.61 ± 4.88	0.73
Stage 5	33	57.56 ± 6.25	56	55.77 ± 4.50	0.16	34	57.21 ± 5.82	60	55.62 ± 3.93	0.16
GS_BS										
Stage 1	11	31.05 ± 5.19	6	36.18 ± 3.63	0.049	8	31.69 ± 2.14	6	33.83 ± 3.39	0.171
Stage 2	17	35.25 ± 4.50	18	37.47 ± 7.41	0.295	23	35.13 ± 7.98	17	37.00 ± 6.02	0.423
Stage 3	41	41.59 ± 8.22	35	45.24 ± 4.75	0.023	39	44.44 ± 9.38	28	46.21 ± 6.50	0.390
Stage 4	46	48.05 ± 10.47	28	53.45 ± 5.81	0.006	40	49.35 ± 8.82	26	51.19 ± 6.05	0.318
Stage 5	35	58.07 ± 5.98	63	55.46 ± 5.09	0.025	40	56.26 ± 6.54	73	54.94 ± 3.74	0.243

PHS=Pubic Hair Stage; GS_BS= Genital Stage (boys) and Breast Stage (girls)

Table 4.16: Comparison of height at various Tanner Stages among Jukun and Kuteb ethnic groups.

Sexual Stages		Jukun Male			Jukun Female			Kuteb Male			Kuteb Female	
PHS	n	Mean ± SD	N	Mean ± SD	P	n	Mean ± SD	n	Mean ± SD	p		
Stage 1	12	138.67 ± 7.44	7	141.50 ± 3.41	0.27	10	141.41 ± 5.70	6	140.58 ± 2.47	0.74		
Stage 2	22	145.88 ± 8.46	24	145.53 ± 6.20	0.87	24	145.18 ± 10.31	22	145.72 ± 6.14	0.83		
Stage 3	43	152.60 ± 7.25	30	155.04 ± 4.43	0.08	47	156.62 ± 9.21	27	153.30 ± 4.49	0.04		
Stage 4	40	162.73 ± 10.06	33	159.18 ± 4.61	0.05	35	161.35 ± 8.15	35	157.20 ± 5.50	0.02		
Stage 5	33	166.65 ± 6.06	56	159.25 ± 3.59	0.01	34	166.76 ± 6.48	60	158.84 ± 4.14	0.001		
GS_BS												
Stage 1	11	138.07 ± 7.50	6	141.60 ± 3.72	0.301	8	142.26 ± 5.39	6	140.98 ± 2.31	5.98		
Stage 2	17	144.91 ± 6.01	18	145.46 ± 7.36	0.811	23	144.27 ± 11.07	17	144.44 ± 5.36	0.955		
Stage 3	41	152.16 ± 8.52	35	152.76 ± 5.56	0.722	39	155.03 ± 9.03	28	151.96 ± 5.02	0.081		
Stage 4	46	159.94 ± 9.84	28	159.24 ± 4.30 [†]	0.673	40	160.49 ± 8.28	26	156.37 ± 5.49	0.018		
Stage 5	35	167.58 ± 6.20	63	159.24 ± 3.73	0.001	40	166.39 ± 6.57	73	158.89 ± 4.17	0.001		

†. t-statistics showed statistical significant difference ($p < 0.05$) for comparison between girls of the two ethnic groups

PHS=Pubic Hair Stage; GS_BS= Genital Stage (boys) and Breast Stage (girls)

Table 4.17: Comparison of BMI at various Tanner Stages among Jukun and Kuteb ethnic groups.

Sexual Stages	Jukun Male			Jukun Female			Kuteb Male			Kuteb Female	
PHS	n	Mean ± SD	N	Mean ± SD	P	n	Mean ± SD	n	Mean ± SD	p	
Stage 1	12	16.08 ± 1.45	7	17.64 ± 1.48	0.04	10	15.80 ± 0.98	6	16.79 ± 1.40	0.12	
Stage 2	22	16.71 ± 1.75	24	17.94 ± 1.70	0.02	24	16.93 ± 1.89	22	17.91 ± 1.62	0.07	
Stage 3	43	17.81 ± 1.64	30	20.08 ± 2.11	0.001	47	18.13 ± 2.09	27	20.15 ± 1.82	0.001	
Stage 4	40	18.98 ± 2.14	33	20.62 ± 1.76	0.001	35	19.44 ± 2.01	35	20.89 ± 1.81	0.002	
Stage 5	33	20.72 ± 1.97	56	21.99 ± 1.65	0.002	34	20.55 ± 1.51	60	22.07 ± 1.77	0.001	
GS_BS											
Stage 1	11	16.17 ± 1.48	6	18.01 ± 1.19	0.020	8	15.67 ± 0.90	6	17.00 ± 1.22	0.037	
Stage 2	17	16.76 ± 1.59	18	17.52 ± 1.84	0.196	23	16.70 ± 1.67	17	17.63 ± 1.78	0.100	
Stage 3	41	17.79 ± 1.88	35	19.36 ± 1.40	0.001	39	18.31 ± 2.23	28	19.93 ± 1.90	0.003	
Stage 4	46	18.56 ± 2.20	28	21.07 ± 2.00	0.001	40	19.03 ± 2.20	26	20.90 ± 1.88	0.001	
Stage 5	35	20.67 ± 1.86	63	21.86 ± 1.78	0.003	40	20.27 ± 1.55	73	21.80 ± 1.82	0.001	

PHS=Pubic Hair Stage; GS_BS= Genital Stage (boys) and Breast Stage (girls)

Table 4.18: Comparison of % Body Fat at various Tanner Stages among Jukun and Kuteb ethnic groups.

Sexual Stages	Jukun Male			Jukun Female			Kuteb Male			Kuteb Female		
PHS	n	Mean ± SD	N	Mean ± SD	P	n	Mean ± SD	n	Mean ± SD	P		
Stage 1	12	29.02 ± 1.93	7	33.84 ± 1.45	0.001	10	28.60 ± 1.25	6	33.50 ± 0.95	0.001		
Stage 2	22	29.90 ± 1.56	24	33.74 ± 1.13	0.001	24	30.13 ± 1.98	22	34.37 ± 1.58	0.001		
Stage 3	43	32.20 ± 1.78	30	37.01 ± 3.73	0.001	47	32.97 ± 2.64	27	36.33 ± 2.96	0.001		
Stage 4	40	34.06 ± 3.11	33	39.24 ± 2.69	0.001	35	34.66 ± 2.13	35	39.72 ± 3.28	0.001		
Stage 5	33	35.48 ± 2.55	56	40.76 ± 2.65	0.001	34	35.70 ± 2.85	60	40.86 ± 2.08	0.001		
GS_BS												
Stage 1	11	29.08 ± 2.01	6	34.19 ± 1.21	0.001	8	28.78 ± 1.20	6	33.14 ± 1.45	0.001		
Stage 2	17	29.59 ± 1.31	18	33.58 ± 1.21	0.001	23	29.78 ± 2.02	17	34.30 ± 1.17	0.001		
Stage 3	41	31.96 ± 1.90	35	35.77 ± 2.39	0.001	39	32.68 ± 2.40	28	36.12 ± 3.07	0.001		
Stage 4	46	33.60 ± 2.99	28	40.22 ± 3.32	0.001	40	34.13 ± 2.52	26	39.26 ± 3.53	0.001		
Stage 5	35	35.55 ± 2.52	63	40.43 ± 2.79	0.001	40	35.77 ± 2.65	73	40.63 ± 2.27	0.001		

PHS=Pubic Hair Stage; GS_BS= Genital Stage (boys) and Breast Stage (girls)

Table 4.19: Nutritional assessment of the population

	Thinness				Stunting				Overweight			
	JM	KM	JF	KF	JM	KM	JF	KF	JM	KM	JF	KF
10	22.2	20.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	20.0	9.1	0.0	0.0	10.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
12	7.7	0.0	0.0	0.0	23.1	0.0	0.0	0.0	7.7	9.1	7.1	18.8
13	0.0	15.4	0.0	0.0	8.3	30.8	0.0	0.0	0.0	0.0	0.0	9.1
14	21.4	30.0	0.0	0.0	46.4	40.0	0.0	7.7	0.0	0.0	0.0	0.0
15	9.5	13.6	6.2	5.0	42.9	31.8	0.0	5.0	0.0	0.0	0.0	5.0
16	15.4	14.3	5.3	0.0	15.4	21.4	0.0	0.0	0.0	0.0	10.5	0.0
17	7.7	0.0	0.0	0.0	15.4	0.0	0.0	6.7	0.0	0.0	0.0	6.7
18	8.3	0.0	0.0	0.0	25.0	35.3	0.0	12.5	0.0	0.0	6.7	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	10.0	0.0	0.0	6.2
Total	12.1	11.4	1.4	0.7	24.8	20.0	0.7	5.0	1.4	0.7	2.9	5.0

JM: Jukun Male KM: Kuteb male JF: Jukun Female KF: Kuteb Female

Table 4.20: Correlation matrix of anthropometric characteristics of study population

	Age	WT	HT	BMI	WC	HC	AC	NC	CC	TC	WHR	WCR	WHTR	%BF	L2D:4D	R2D:4D
Age	-															
WT	0.81 ^a	-														
HT	0.73 ^a	0.85 ^a	-													
BMI	0.67 ^a	0.87 ^a	0.49 ^a	-												
WC	0.66 ^a	0.83 ^a	0.63 ^a	0.80 ^a	-											
HC	0.76 ^a	0.90 ^a	0.72 ^a	0.84 ^a	0.85 ^a	-										
AC	0.69 ^a	0.85 ^a	0.67 ^a	0.79 ^a	0.76 ^a	0.81 ^a	-									
NC	0.68 ^a	0.81 ^a	0.77 ^a	0.61 ^a	0.62 ^a	0.67 ^a	0.72 ^a	-								
CC	0.71 ^a	0.86 ^a	0.67 ^a	0.81 ^a	0.83 ^a	0.85 ^a	0.76 ^a	0.67 ^a	-							
TC	0.62	0.77 ^a	0.56 ^a	0.77 ^a	0.72 ^a	0.78 ^a	0.75 ^a	0.54 ^a	0.72 ^a	-						
WHR	-0.28 ^a	-0.28 ^a	-0.28 ^a	-0.21 ^a	0.11 ^a	-0.43 ^a	-0.22 ^a	-0.20 ^a	-0.18 ^a	-0.23 ^a	-					
WCR	-0.23 ^a	-0.26 ^a	-0.22 ^a	-0.22 ^a	-0.02	-0.23 ^a	-0.20 ^a	-0.24 ^a	-0.54 ^a	-0.17 ^a	0.39 ^a	-				
WHTR	0.17 ^a	0.26 ^a	-0.13 ^a	0.56 ^a	0.69 ^a	0.41 ^a	0.35 ^a	0.08	0.43 ^a	0.40 ^a	0.41 ^a	0.18 ^a	-			
%BF	0.61 ^a	0.75 ^a	0.47 ^a	0.80 ^a	0.86 ^a	0.81 ^a	0.73 ^a	0.43 ^a	0.75 ^a	0.77 ^a	-0.05	-0.06	0.65	-		
L2D:4D	0.05	0.07	0.09 ^b	0.01	0.01	0.04	0.03	0.10 ^b	0.04	0.03	-0.04	-0.02	-0.07	0.02	-	
R2D:4D	0.10 ^b	0.10 ^b	0.11 ^a	0.05	0.04	0.05	0.07	0.13 ^a	0.06	0.05	-0.02	-0.03	-0.05	0.04	0.72 ^a	-

WT = Weight (kg), HT = Height (cm), WC = Waist circumference (cm), HC = Hip circumference (cm), BMI = Body mass index (kg/m²), MUAC = mid upper arm circumference (cm), NC = Neck circumference (cm), CC = Chest circumference (cm), TC = Thigh circumference (cm), R2D:4D = right second to fourth digit ratio, L2D:4D = left second to fourth digit ratio, WHR = waist-hip ratio, WCR = waist-chest ratio, WHTR = waist-height ratio, %BF = Percentage Body Fat. a. = correlation is significant at the 0.01 level (2-tailed), b = correlation is significant at the 0.05 level (2-tailed)

Table 4.21: Correlation matrix of anthropometric characteristics of females (Down) and males (Up) in the study population

	Age	WT	HT	BMI	WC	HC	AC	NC	CC	TC	WHR	WCR	WHTR	%BF	L2D:4D	R2D:4D
Age	-	0.85 ^a	0.82 ^a	0.71 ^a	0.68 ^a	0.80 ^a	0.81 ^a	0.79 ^a	0.69 ^a	0.68 ^a	-0.40 ^a	-0.26 ^a	-0.21 ^a	0.77 ^a	0.09	0.16 ^a
WT	0.80 ^a	-	0.91 ^a	0.89 ^a	0.86 ^a	0.94 ^a	0.91 ^a	0.89 ^a	0.86 ^a	0.78 ^a	-0.38 ^a	-0.33 ^a	-0.09	0.83 ^a	0.14 ^b	0.19 ^a
HT	0.67 ^a	0.83 ^a	-	0.63 ^a	0.75 ^a	0.86 ^a	0.81 ^a	0.79 ^a	0.76 ^a	0.69 ^a	-0.41 ^a	-0.29 ^a	-0.37 ^a	0.74 ^a	0.14 ^b	0.17 ^a
BMI	0.72 ^a	0.90 ^a	0.52 ^a	-	0.80 ^a	0.84 ^a	0.81 ^a	0.79 ^a	0.79 ^a	0.73 ^a	-0.29 ^a	-0.31 ^a	0.22 ^a	0.75 ^a	0.09	0.16 ^a
WC	0.72 ^a	0.85 ^a	0.74 ^a	0.74 ^a	-	0.83 ^a	0.79 ^a	0.82 ^a	0.81 ^a	0.67 ^a	0.03	-0.13 ^b	0.33 ^a	0.86 ^a	0.10	0.15 ^a
HC	0.78 ^a	0.90 ^a	0.76 ^a	0.80 ^a	0.82 ^a	-	0.87 ^a	0.84 ^a	0.82 ^a	0.79 ^a	-0.53 ^a	-0.30 ^a	-0.06	0.82 ^a	0.12 ^b	0.16 ^a
AC	0.61 ^a	0.76 ^a	0.54 ^a	0.74 ^a	0.71 ^a	0.73 ^a	-	0.88 ^a	0.80 ^a	0.75 ^a	-0.35 ^a	-0.31 ^a	-0.05	0.77 ^a	0.14 ^b	0.21 ^a
NC	0.63 ^a	0.82 ^a	0.71 ^a	0.73 ^a	0.75 ^a	0.76 ^a	0.64 ^a	-	0.82 ^a	0.69 ^a	-0.27 ^a	-0.33 ^a	0.02	0.75 ^a	0.15 ^b	0.21 ^a
CC	0.80 ^a	0.87 ^a	0.75 ^a	0.77 ^a	0.82 ^a	0.86 ^a	0.67 ^a	0.72 ^a	-	0.67 ^a	-0.24 ^a	-0.65 ^a	0.05	0.70 ^a	0.14 ^b	0.16 ^a
TC	0.69 ^a	0.78 ^a	0.59 ^a	0.74 ^a	0.73 ^a	0.75 ^a	0.69 ^a	0.64 ^a	0.71 ^a	-	-0.41 ^a	-0.26 ^a	-0.04	0.73 ^a	0.15 ^b	0.15 ^a
WHR	-0.17 ^a	-0.18 ^a	-0.12 ^b	-0.20 ^a	0.17 ^a	-0.41 ^a	-0.12 ^b	-0.11	-0.17 ^a	-0.10	-	0.34 ^a	0.63 ^a	-0.17 ^a	0.14 ^b	-0.05
WCR	-0.20 ^a	-0.16 ^a	-0.13 ^b	-0.16 ^a	0.08	-0.19 ^a	-0.06	-0.08	-0.47 ^a	-0.07	0.44 ^a	-	0.23 ^a	-0.08	0.11	-0.37
WHTR	0.51 ^a	0.56 ^a	0.27 ^a	0.65 ^a	0.84 ^a	0.58 ^a	0.58 ^a	0.51 ^a	0.59 ^a	0.58 ^a	0.34 ^a	0.22 ^a	-	0.14 ^b	-0.05	-0.29
%BF	0.73 ^a	0.83 ^a	0.63 ^a	0.78 ^a	0.87 ^a	0.82 ^a	0.74 ^a	0.66 ^a	0.80 ^a	0.74 ^a	-0.02	-0.06	0.74 ^a	-	0.16 ^a	0.22 ^a
L2D:4D	0.08	-0.10	0.01	-0.03	-0.04	-0.01	-0.09	0.02	-0.03	-0.03	-0.04	0.01	0.07	-0.04	-	0.76 ^a
R2D:4D	0.05	-0.01	-0.01	-0.03	-0.03	-0.03	-0.08	-0.01	-0.02	0.06	0.01	0.11 ^b	0.05	-0.06	0.68 ^a	-

WT =

Weight (kg), HT = Height (cm), WC = Waist circumference (cm), HC = Hip circumference (cm), BMI = Body mass index (kg/m²), MUAC = mid upper arm circumference (cm), NC = Neck circumference (cm), CC = Chest circumference (cm), TC = Thigh circumference (cm), R2D:4D = right second to fourth digit ratio, L2D:4D = left second to fourth digit ratio, WHR = waist-hip ratio, WCR = waist-chest ratio, WHTR = waist-height ratio, %BF = Percentage Body Fat. a. = correlation is significant at the 0.01 level (2-tailed), b = correlation is significant at the 0.05 level (2-tailed)

Table 4.22: Linear Multiple regression equation (boys)

Predictive Equation	R	R ²	SEE	p
PHS				
$(-3.412) + (0.050 \times \text{WT}) + (0.029 \times \text{HT})$	0.737	0.543	0.813	0.0001
$(-4.869) + (0.138 \times \text{BMI}) + (0.173 \times \% \text{BF})$	0.689	0.475	0.872	0.0001
$(-5.966) + (-0.01 \times \text{WC}) + (0.117 \times \text{HC})$	0.686	0.471	0.875	0.0001
GS				
$(-4.502) + (0.035 \times \text{WT}) + (0.041 \times \text{HT})$	0.724	0.525	0.819	0.0001
$(-4.616) + (0.085 \times \text{BMI}) + (0.199 \times \% \text{BF})$	0.674	0.455	0.877	0.0001
$(-5.354) + (-0.009 \times \text{WC}) + (0.118 \times \text{HC})$	0.671	0.450	0.880	0.0001

PHS= Pubic Hair Stage, GS= Genital Size, WT = Weight, HT = Height, BMI = Body Mass Index, % BF = Percentage Body Fat, WC = Waist Circumference, HC = Hip Circumference

Table 4.23: Linear Multiple Regression equation (girls)

Predictive Equation	R	R²	SEE	p
PHS				
$(-6.708) + (0.085 \times \text{WT}) + (0.011 \times \text{HT})$	0.790	0.625	0.760	0.0001
$(-5.531) + (0.143 \times \text{BMI}) + (0.165 \times \% \text{BF})$	0.725	0.526	0.854	0.0001
$(-8.128) + (0.071 \times \text{WC}) + (0.078 \times \text{HC})$	0.782	0.612	0.772	0.0001
BS				
$(-7.008) + (0.080 \times \text{WT}) + (0.045 \times \text{HT})$	0.790	0.624	0.749	0.0001
$(-5.096) + (0.143 \times \text{BMI}) + (0.157 \times \% \text{BF})$	0.713	0.508	0.857	0.0001
$(-7.722) + (0.68 \times \text{WC}) + (0.77 \times \text{HC})$	0.776	0.603	0.770	0.0001

PHS= Pubic Hair Stage, BS= Breast Size, WT = Weight, HT = Height, BMI = Body Mass Index, % BF = Percentage Body Fat, WC = Waist Circumference, HC = Hip Circumference

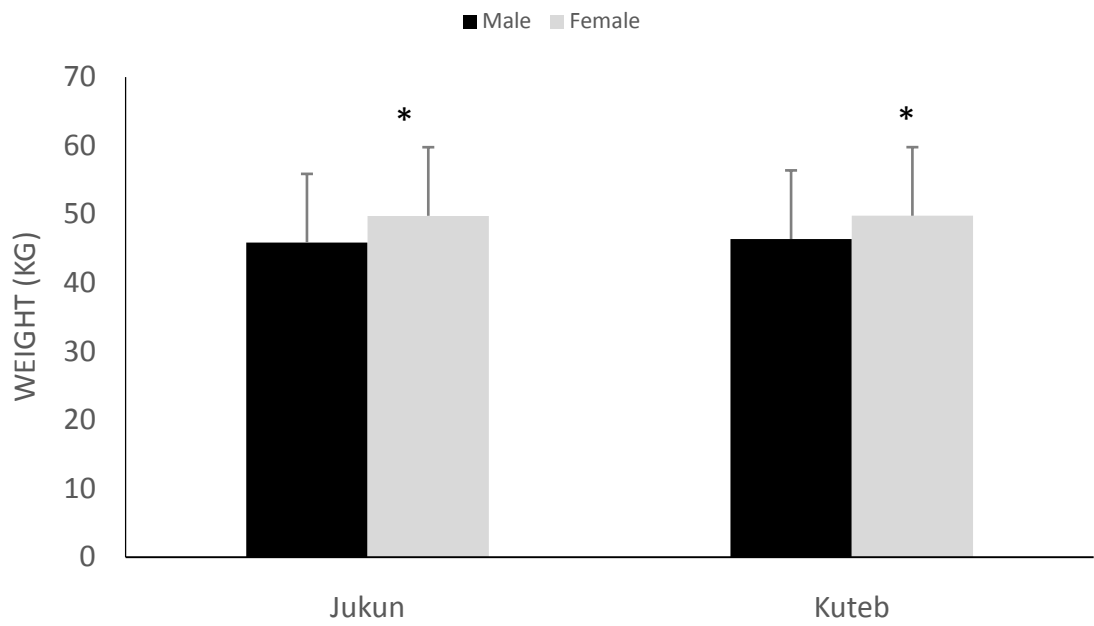


Fig. 4.1. Comparison of weight of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb females were significantly weightier than their male counterparts with $t = 3.29$, $p < 0.01$ and $t = 3.03$, $p = 0.03$ respectively. Sex with different superscript are significantly different

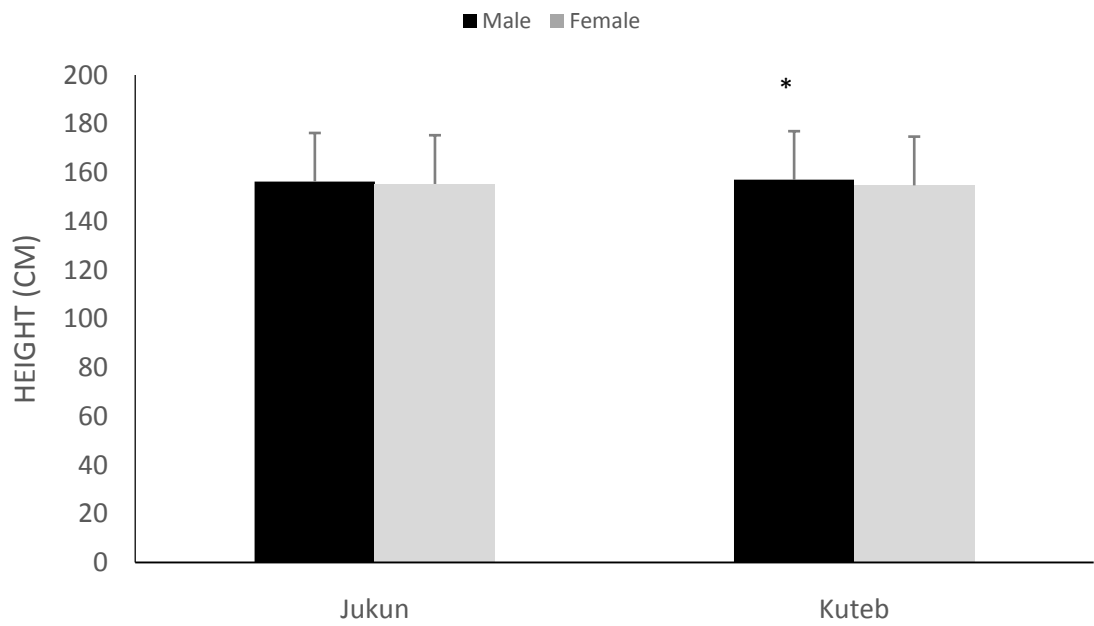


Figure 4.2. Comparison of height of Jukun and Kuteb boys and girls. Kuteb males are significantly taller than Kuteb females. $t = 2.01$, $p < 0.05$

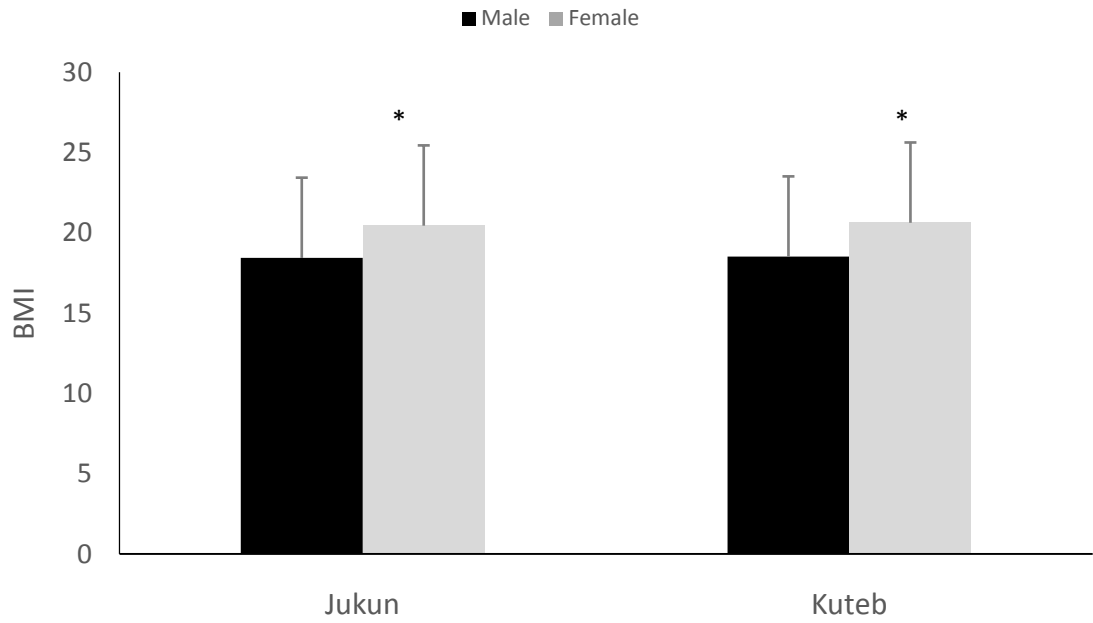


Fig. 4.3. Comparison of BMI of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb girls had significant higher values than the boys with $t = 7.43$, $p < 0.001$ and $t = 7.87$, $p < 0.001$ respectively.

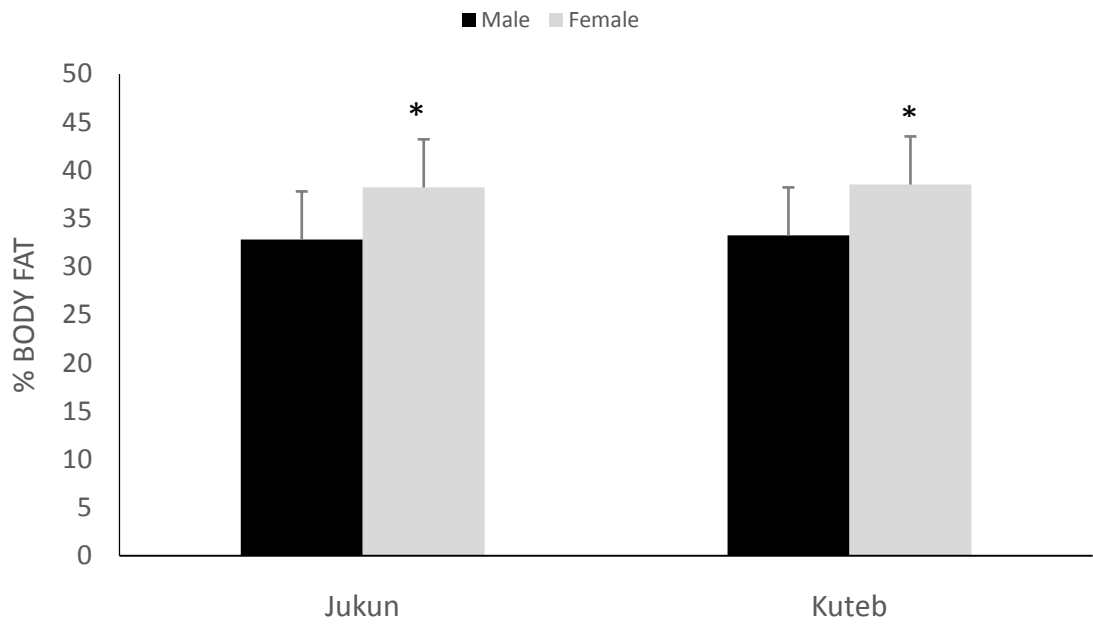


Fig. 4.4. Comparison of %body fat of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb females had significant higher values than their male counterparts with $t = 13.47$, $p < 0.001$ and $t = 13.35$, $p < 0.001$ respectively.

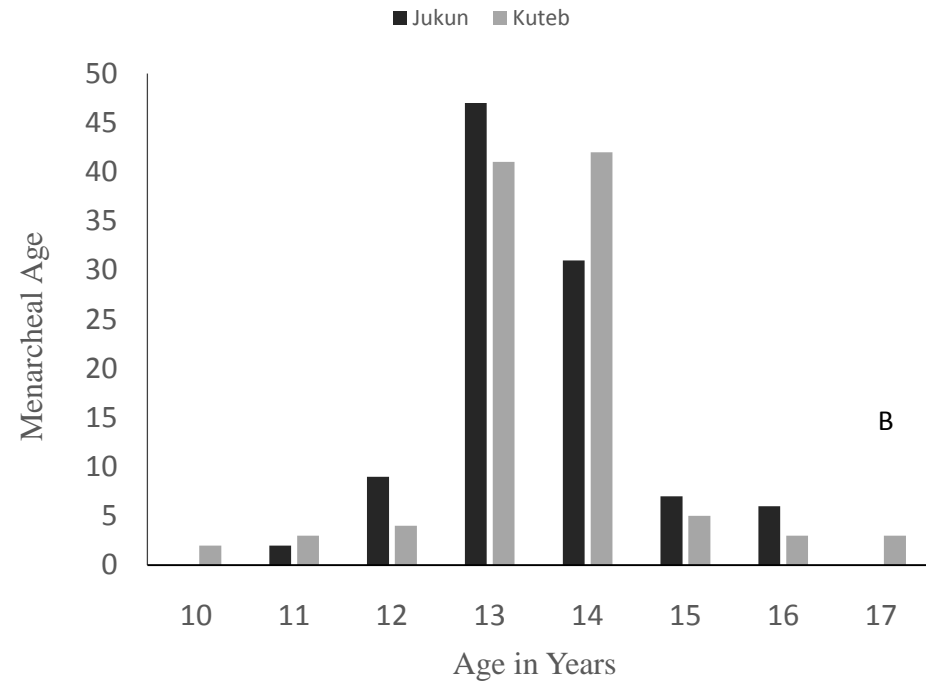
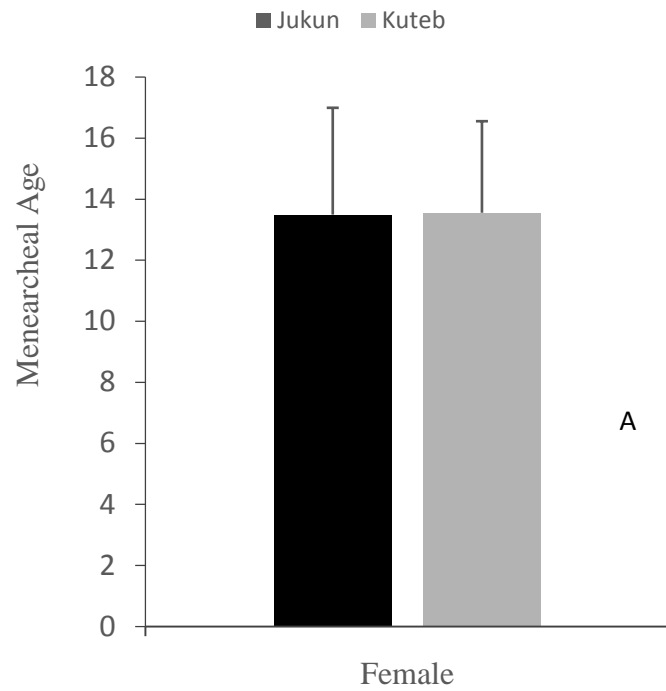


Fig. 4.5. A and B shows mean menarcheal age between Jukun and Kuteb girls. The minimum menarcheal age was 10 years while the maximum was 17 years. At age 15, 94% of girls in all the ethnic groups have reached their menarche. t -test = -0.41, $p = 0.68$, $\chi^2 = 10.518$ $p = 0.161$.

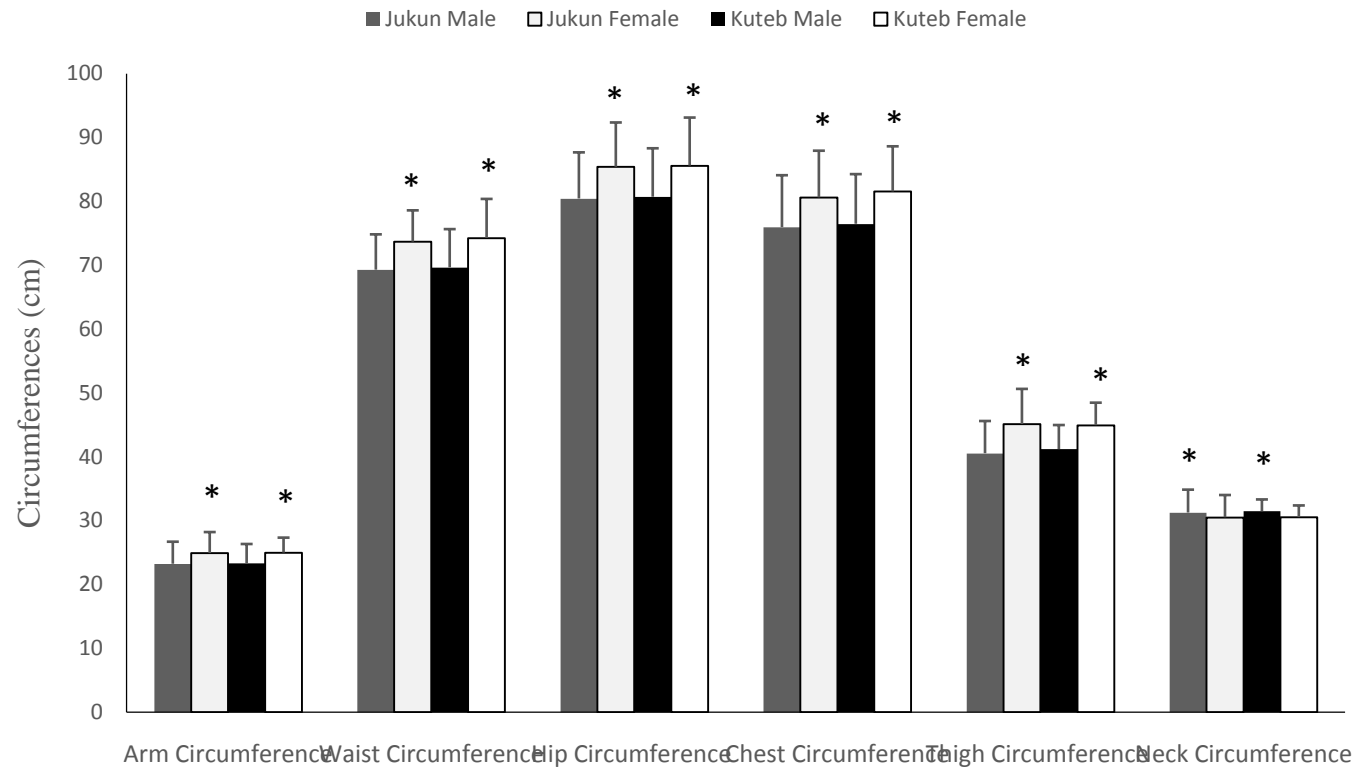


Fig. 4.6. Comparison of circumferences of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb females had significant higher values than their male counterparts in all the circumferences except neck circumference where they had significant lower values of $t = -2.26, p < 0.05$ and $t = -2.90, p < 0.01$ respectively.

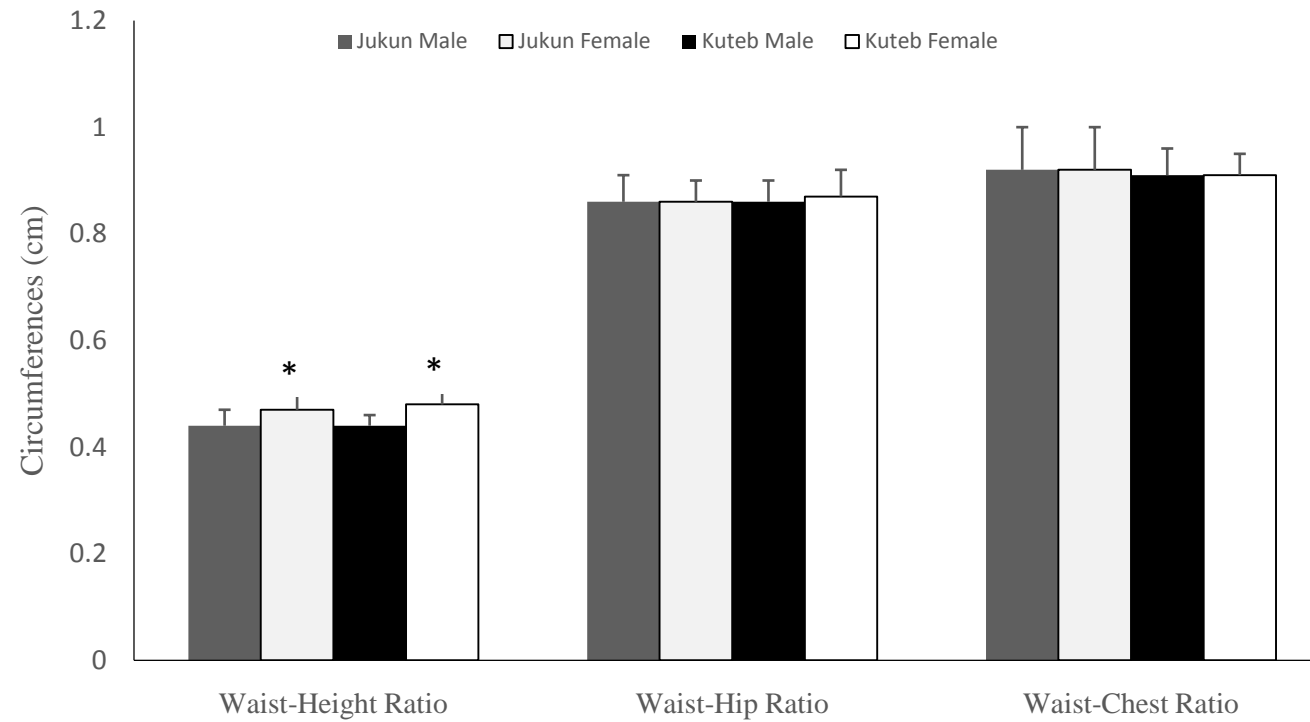


Fig. 4.7. Comparison of body ratios of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb females showed significant higher ratios than their male counterparts in waist-height ratio at $t = 10.15$, $p < 0.001$ and $t = 12.24$, $p < 0.001$ respectively.

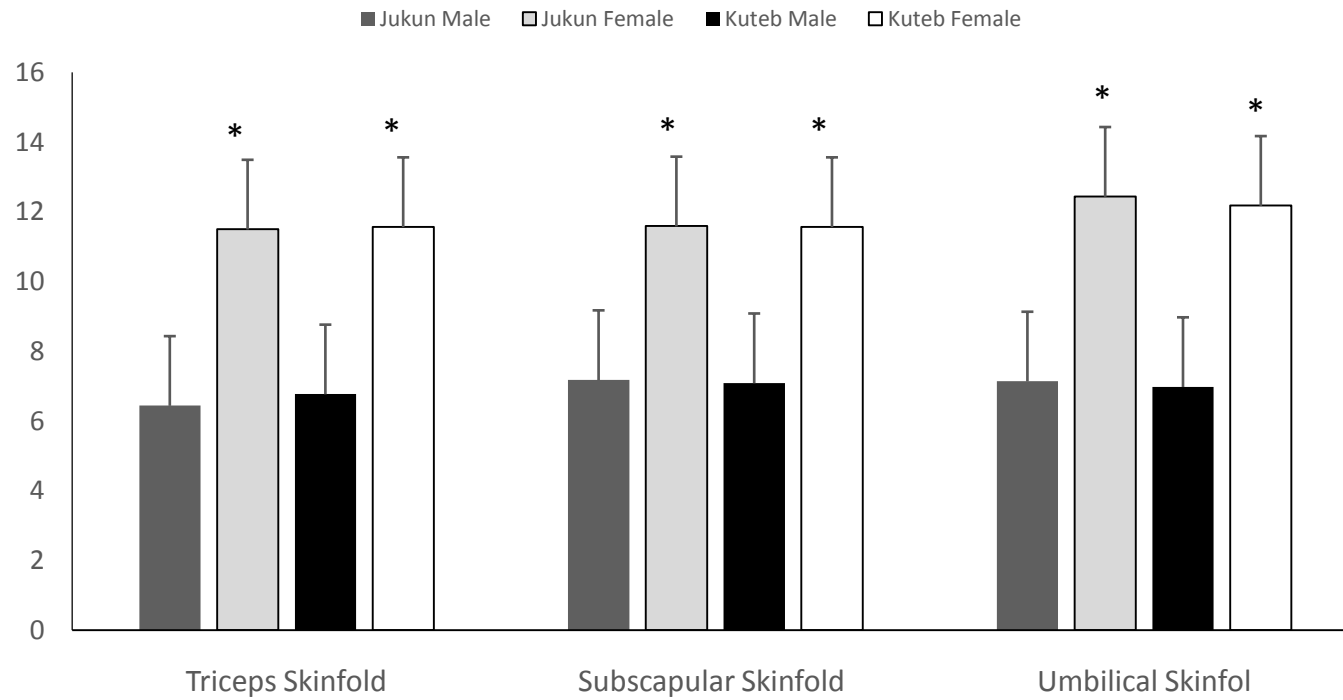


Fig. 4.8. Comparison of skinfolds of Jukun and Kuteb ethnic groups based on sex. Jukun and Kuteb females had significant higher values than their male counterparts in all the skinfolds at $p < 0.001$.

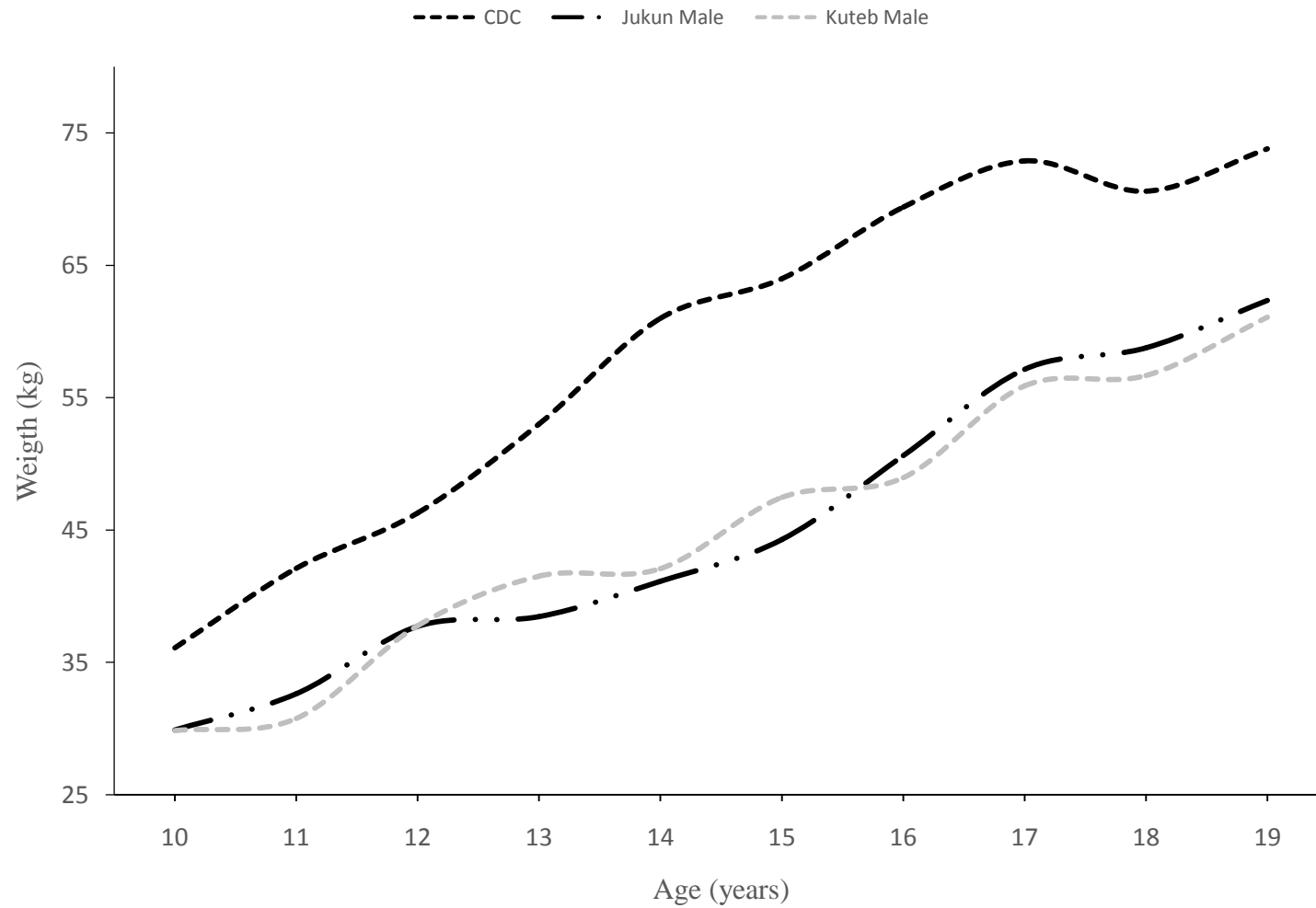


Fig. 4.9. Comparison of 50th weight percentile of males of Jukun and Kuteb ethnic groups with international standards

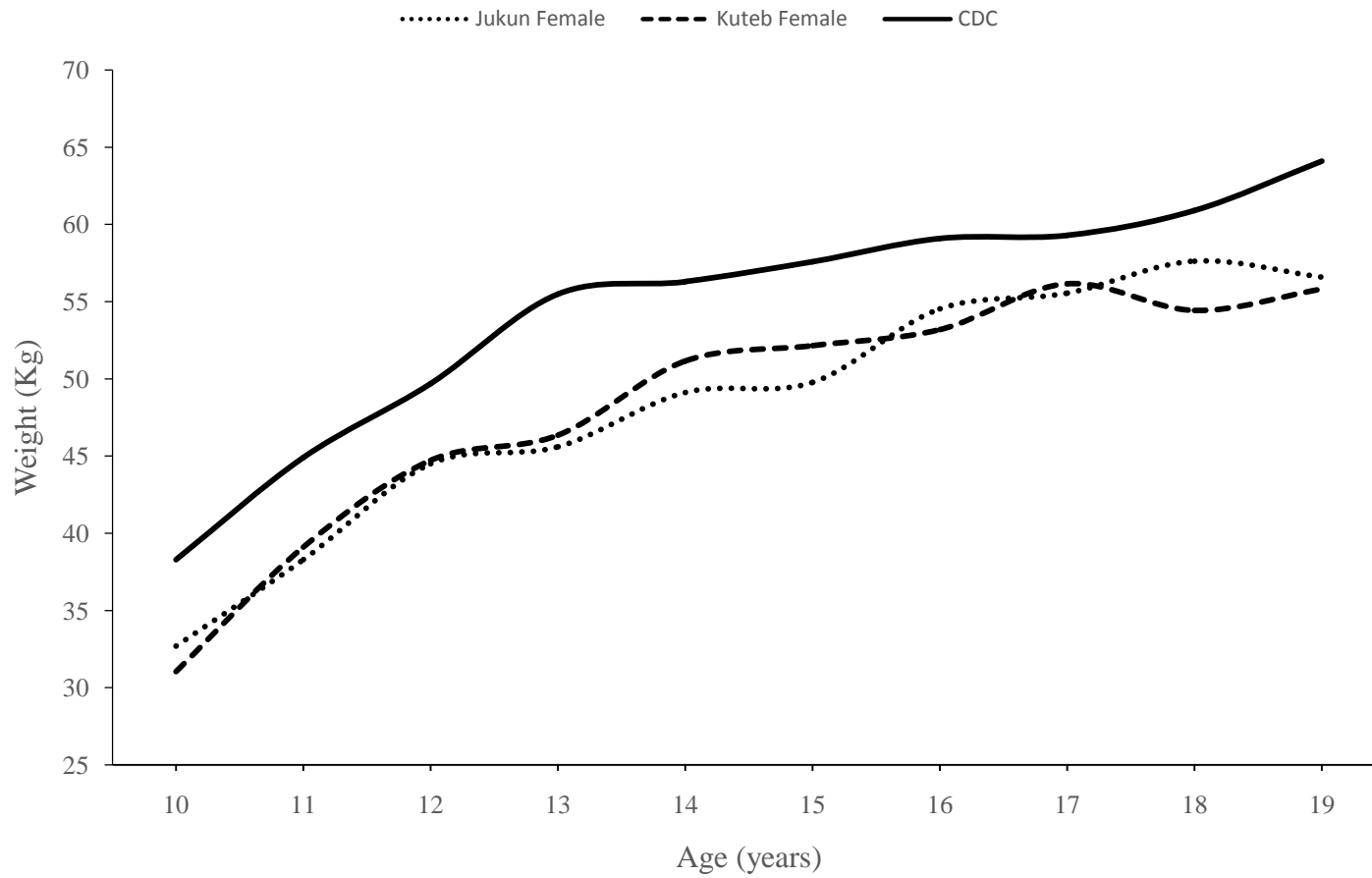


Fig. 4.10. Comparison of 50th weight percentile of females of Jukun and Kuteb ethnic groups with international standards

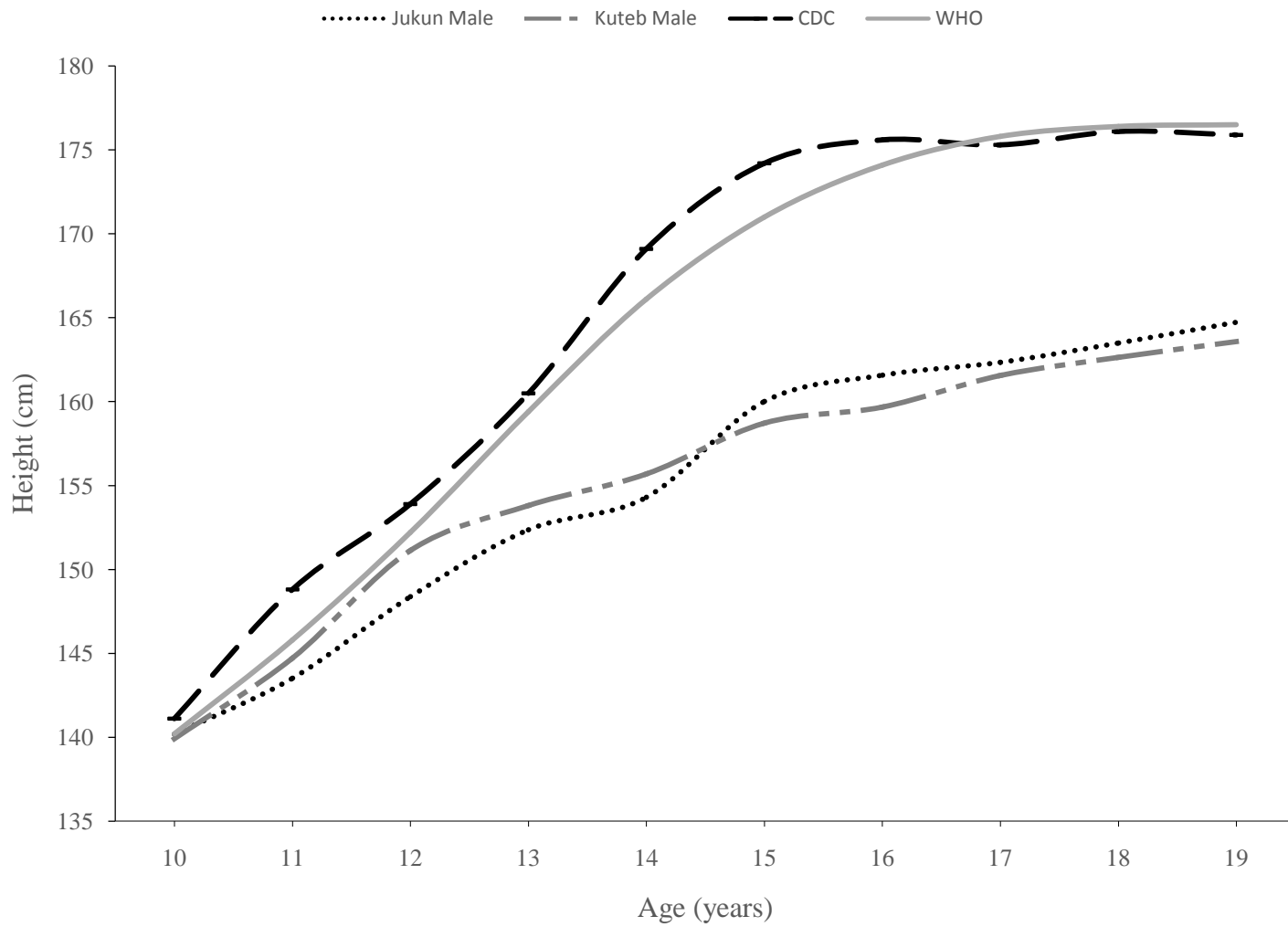


Fig. 4. 11. Comparison of 50th height percentile of males of Jukun and Kuteb ethnic groups with international standards

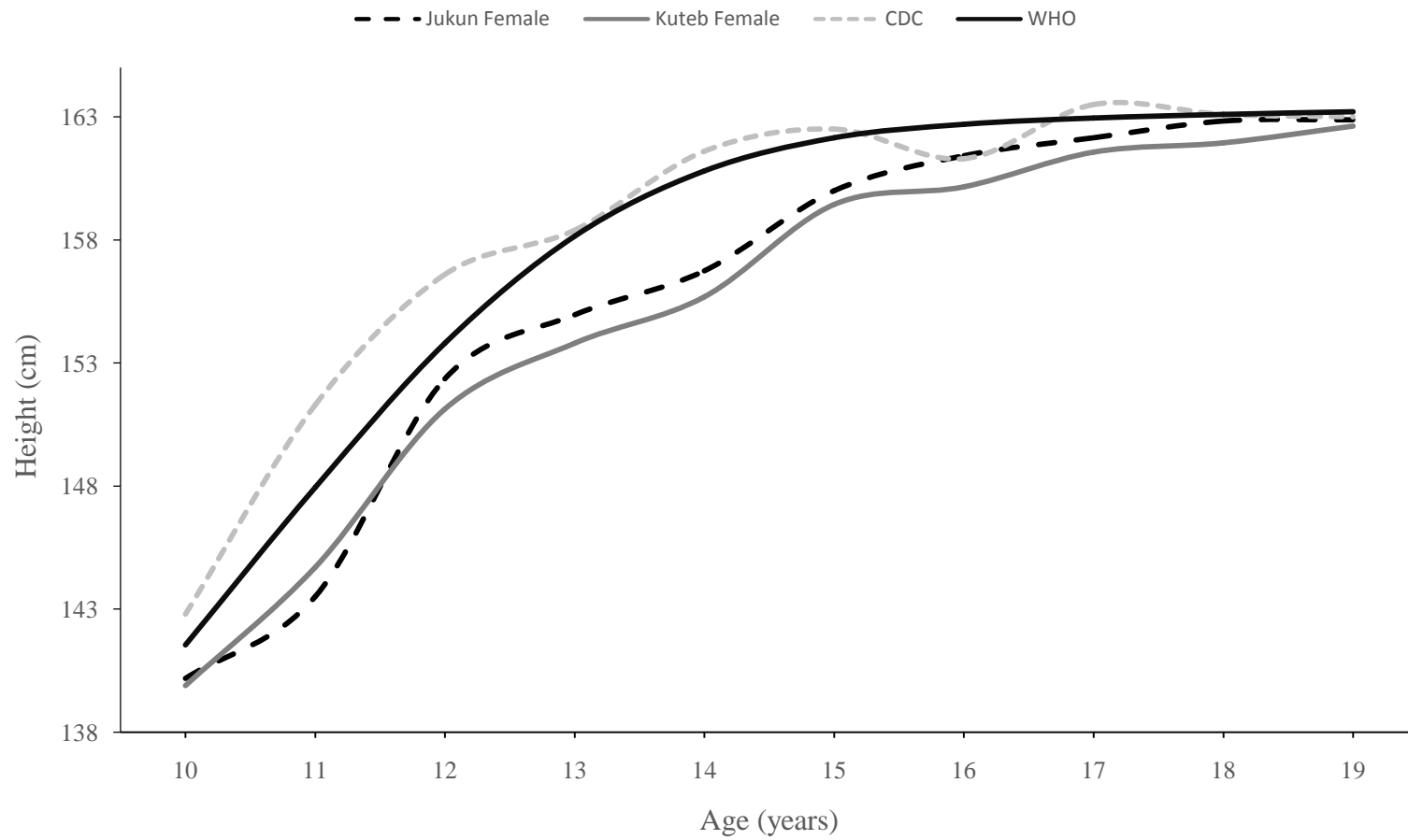


Fig. 4. 12. Comparison of 50th height percentile of females of Jukun and Kuteb ethnic groups with international standards

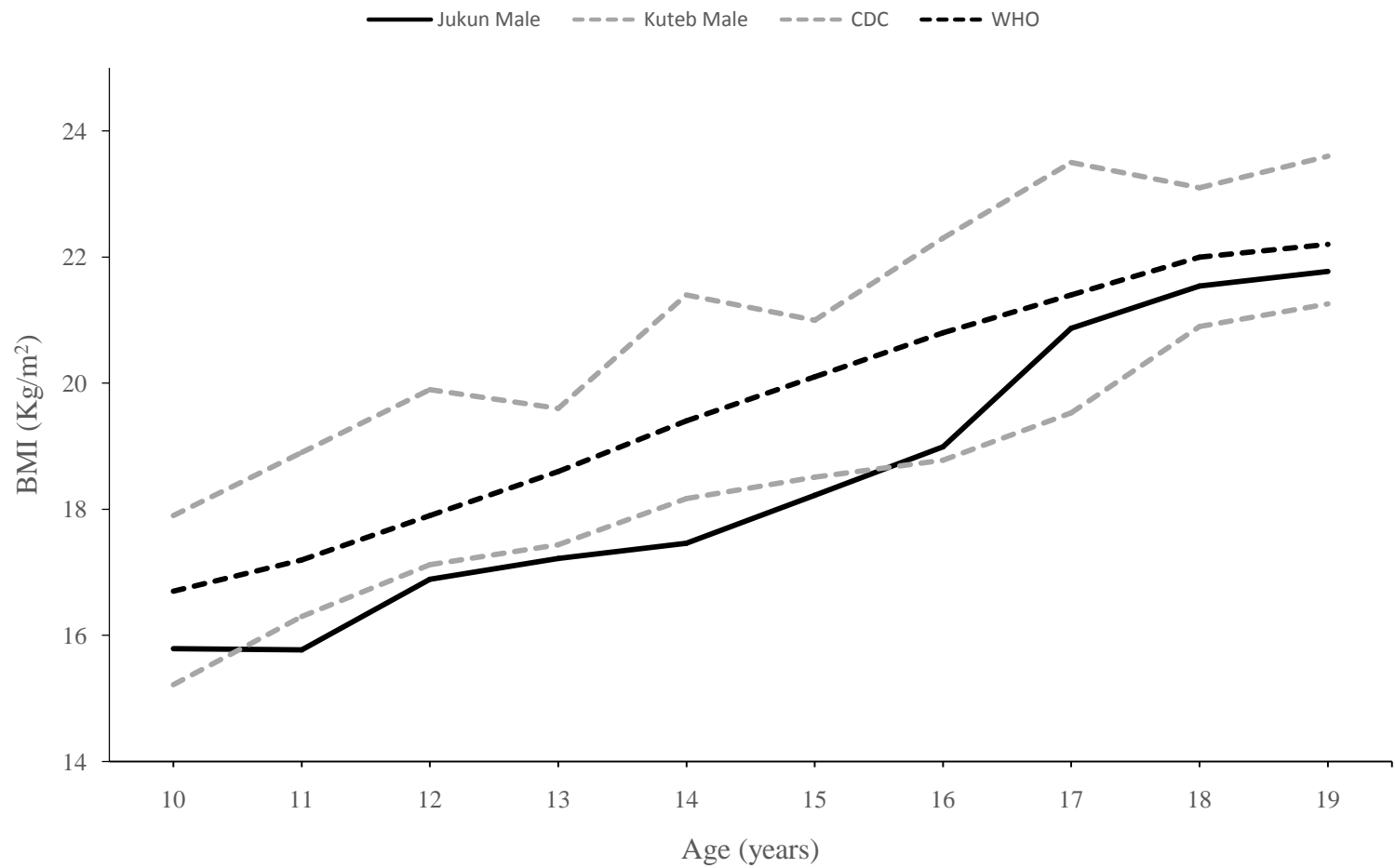


Fig. 4. 13. Comparison of 50th BMI percentile of males of Jukun and Kuteb ethnic groups with international standards

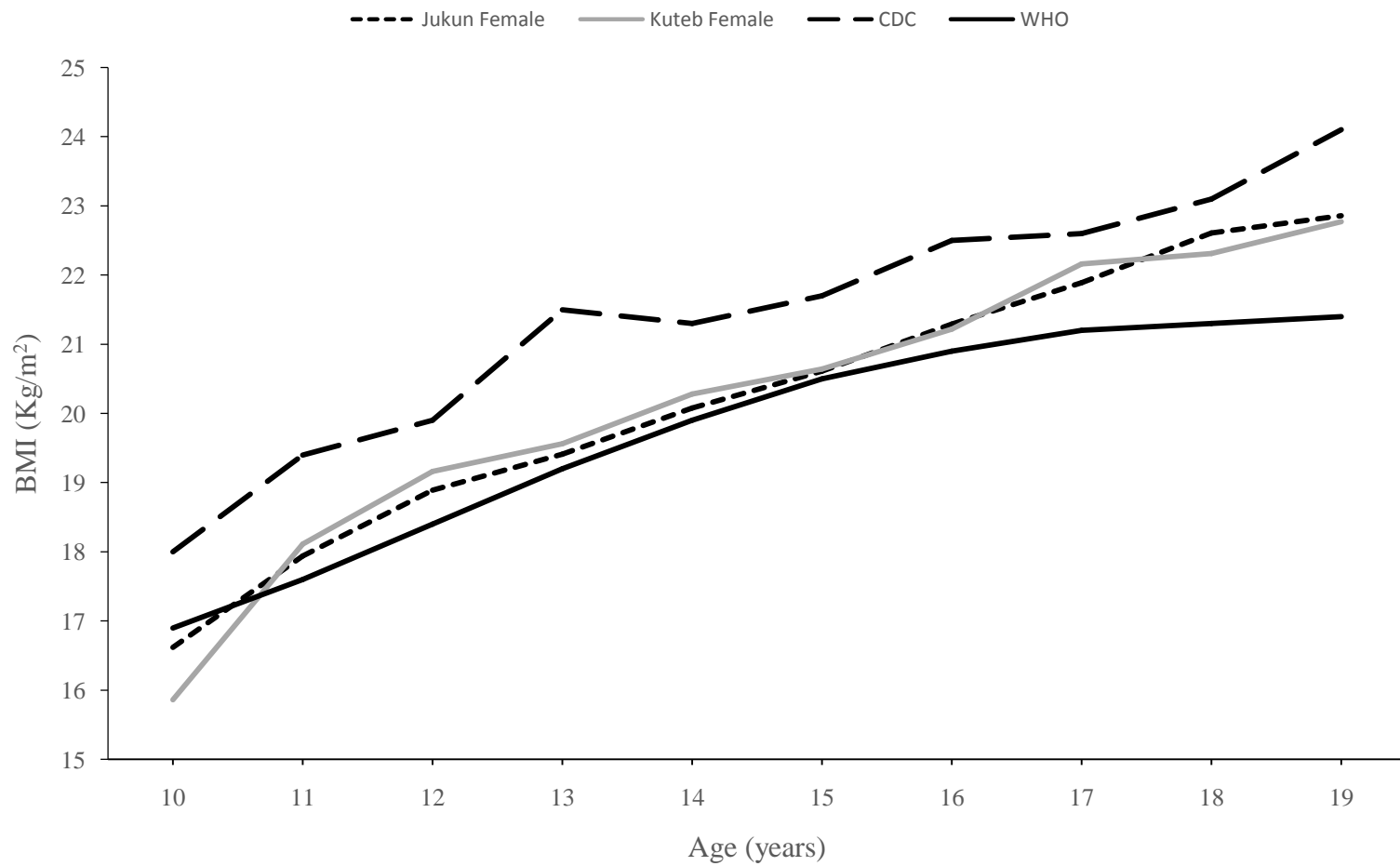


Fig. 4.14. Comparison of 50th BMI percentile of females of Jukun and Kuteb ethnic groups with international standards

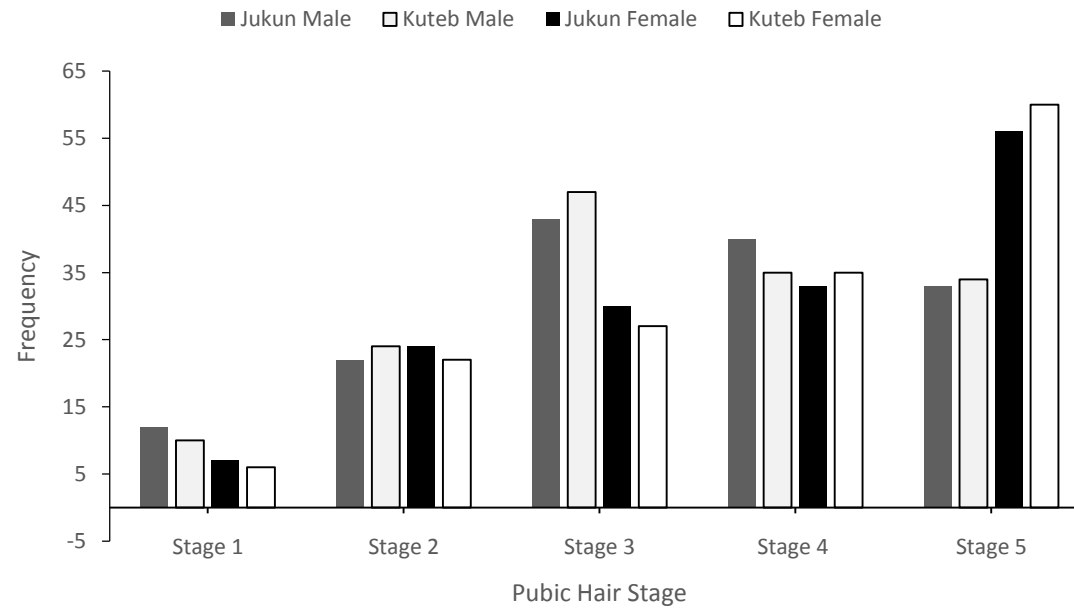


Fig. 4.15. Comparison of PHS based on sex and ethnic group. The females had higher maturity rating than the males of both ethnic groups. Chi-square test indicates statistical significant difference between PHS rating with sex and ethnicity. $\chi^2 = 24.58$, $p=0.017$

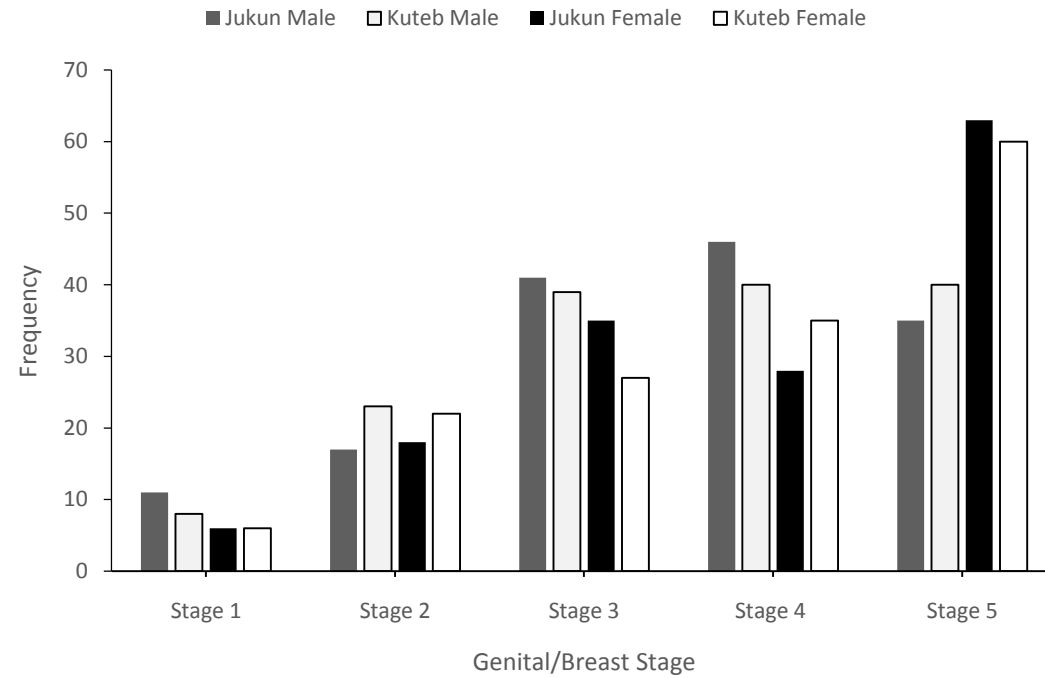


Fig. 4.16. Comparison of GS_BS based on sex and ethnicity. The Females had higher maturity rating than the males of both ethnic groups. Chi-square test indicates statistical significant difference between GS_BS rating with sex and ethnicity. $\chi^2 = 32.95$ $p=0.001$

CHAPTER FIVE

5.0 DISCUSSION

The beginning of biological growth and development during adolescence is signified by the onset of puberty, which is often defined as the physical transformation of a child into an adult (Kaplowitz *et al.*, 2001). A myriad of biological changes occur during puberty including sexual maturation, increase in height and weight, completion of skeletal growth accompanied by a marked increase in skeletal mass, and changes in body composition (Marshall, 1978; Sisk and Foster, 2004). The succession of these events during puberty is consistent among adolescents (Hazen *et al.*, 2008, Mei *et al.*, 2008), however, there may be a great deal of deviation in the age of onset, duration, and tempo of these events between and within individuals (Rogole *et al.*, 2002; Gasser *et al.*, 2000).

In this study of Jukun and Kuteb adolescents, their growth parameters and anthropometric measurements showed no statistical significant difference based on ethnicity, indicating that they might be genetically a homogenous group, but there was statistical significant difference based on sex in most of the variables, showing that the population exhibits sexual dimorphism as will be expected. The boys had higher values than girls in only height, neck circumference and waist-chest ratio.

The comparison of the height for age curves of the present sample with international references (CDC 2000; WHO 2007) indicates that adolescents from this study are not as tall as their peers from these references. For boys, their heights between ages 10 to 12 coincided with the 50th percentiles of the references, while at ages 13 to 15, it was around the 15th percentiles. From ages 16 and above, it was observed that the heights of the boys was around the 3rd percentile values of the international reference. The females from this sample had values that were very close to the reference and their heights coincided with

the 50th percentile of reference from across all the ages. This is because females tend to show a higher growth rate during the first half of second decade while in males it is during the second half of the second decade (Tortura and Anagnostakos, 1990; Malina, 1991). Thus males have additional time for growth since the age of puberty is 2 years late in males as compared to females.

The mean height of boys of the two ethnic groups was 156.29cm and 157.07cm, while the mean height of the girls was 155.37cm and 154.80cm for Jukun and Kuteb respectively. There was no statistical significant difference in height among the males and females of the two ethnic groups. This may be due to the fact that body physique is influenced by climatic, hereditary, nutritional and racial factors (Rastogi *et al.*, 2008), it was also reported that the ratios of various body parts to stature differ from one population to another (Duyar and Pelin, 2010) and that ethnic differences and environmental factors can influence body proportion (Malina, 1991; Numan *et al.*, 2013).

In comparing height-for-age, the females at age 10 were taller than their male counterparts up till age 13. The values were almost equal at age 14, but the boys were taller, while the girls were still taller at age 15. From age 16 onwards, the boys appeared taller than the females. This agrees with previous reports by Akinpelu *et al.* (2009); Oyewale *et al.* (2010); Fetuga *et al.* (2011); Goon *et al.* (2011) that showed girls having higher values during the pubertal ages before being overtaken in later adolescent ages by the boys. This could be because the onset of puberty is earlier in girls than in boys, girls experience early adolescent growth spurt (2 years earlier but with lesser magnitude) than boys (Didia and Ogunranti, 1986; Shamssain 1991; Oyewale *et al.*, 2010), and

epiphyseal fusion also ceases about 2 years earlier in girls than in boys thus resulting in height difference (Tanner, 1989; Bogin 1999).

The prevalence of stunting was 22.4% in boys and 2.9% in girls. 24.8 % of Jukun boys and 20% of Kuteb boys were stunted, while only 0.7% of Jukun girls and 5% of Kuteb girls were stunted. This figures tallies with the prevalence of stunting between the sexes in some reports (Ejike *et al.*, 2010, Jackson *et al.*, 2002, Venkaiah *et al.*, 2002, Ukegbu *et al.*, 2007, and Wamani *et al.*, 2007), but it was lower compared with some other studies (Badenhorst *et al.*, 1993; Abidoye and Ihebuzor, 2001; Rao *et al.*, 2005; Somet *et al.*, 2007; Bose *et al.*, 2008; Ekpo *et al.*, 2008; Dutta *et al.*, 2009; Kandala *et al.*, 2011). This study was also consistent with other studies in sub-Saharan Africa (Ngare and Muttunga, 1999; Lwambo *et al.*, 2000; Espo *et al.*, 2002; Ukwuani and Suchindran, 2003; Wamani *et al.*, 2004; Semproli and Gualdi-Russo, 2007; Ukegbu *et al.*, 2007; Wamani *et al.*, 2007; Fetuga *et al.*, 2011; Akinpelu *et al.*, 2014) and other parts of the world (Jackson *et al.*, 2002; Venkaiah *et al.*, 2002; Rao *et al.*, 2005; Mikki *et al.*, 2009; El Mouzan *et al.*, 2010) that showed stunting to be higher in males than in female children.

The comparison of the weight for age curves of the present study with international reference (CDC 2000) indicates that adolescents from this study have lower weight than their peers from this reference. For the boys, their weight at age 12 almost matched with the 50th percentiles of the references, while at other ages it was significantly lower than the reference values. The girls from this study had values that were very close to the reference and their weight coincided with the 50th percentile of reference at all ages. The mean weight of the boys from the two ethnic groups was 45.88 kg (Jukun) and 46.39 kg (Kuteb), while the mean weight of the girls was 49.77 kg and 49.78 kg for Jukun and Kuteb respectively. In comparing weight-for-age, the girls at age 10 were weightier than

their male counterparts up till age 18 (except at age 17, where the males were weightier). The boys were weightier at age 19 and 20. There was corresponding increase in weight with age for girls except between ages 12 to 13, the highest observed increase was between ages 10 to 11 and ages 11 to 12. Boys also had corresponding increase in weight with age except between ages 12 to 13 and ages 19 to 20. This study was similar to other studies that showed girls were weightier than boys (Ejike *et al.*, 2010; Maruf *et al.*, 2010; Fetuga *et al.*, 2011; Goon *et al.*, 2011).

The comparison of the BMI for age curves of the present sample with international references (CDC 2000; WHO 2007) indicates that adolescent boys from this study have lower BMI values than their peers from these references, but there is no wide difference as was noticed in weight and height comparisons. The girls from this sample had values that were very close to the reference and their BMI was higher than WHO at all ages except age 10. In comparing BMI-for-age, girls had higher values than the boys' at all corresponding ages. The prevalence of thinness was 11.7 % in boys and 1.1 % in girls, this prevalence is low compared with previous studies (Bovet *et al.*, 2011; Fetuga *et al.*, 2011; Goon *et al.*, 2011; Akinpelu *et al.*, 2014), but they agreed with this study that boys were thinner than girls.

The Prevalence of overweight/obesity in this study (1.1% for boys and 3.9% for girls) is also low compared with other previous studies in Nigeria (Ben-Bassey *et al.*, 2007; Fetuga *et al.*, 2011; Akinpelu *et al.*, 2014) and abroad (de Onis and Blössner, 1997; Martorell *et al.*, 1998). This study also agrees with some studies (Dietz, 1998; Jackson *et al.*, 2002; and Monyeki *et al.*, 2008) that reported higher prevalence of overweight and obesity in girls, but disagrees with the works of Ukegbu *et al.*, 2007 and Ejike *et al.*, 2011. The fact that considerably high percentage of the population was stunted and only a

very small proportion was thin suggests suggests that the cause of the expressed undernutrition is as a result of chronic malnutrition (Ejike *et al.*, 2011). This may be as a result of imbalance in the food intake of the population in taking lots of starchy carbohydrates (rice, cassava, maize, yam)(Goon *et al.*, 2011).

Investigations have reported association between personality characteristics and the rate of sexual maturation, but the study populations have been small. It has been very difficult to collect the physiologic data in non medical settings. Staging of secondary sex characteristics according to Tanner has provided a means of assessing sexual development but requires that the teenager undress and submit to clinical examination. Validity of self-assessment by teenager indicates favorable professional interrater agreement ranging from 49% to 86% for the Tanner breast stage (Duke *et al.*, 1980; Neinstein, 1982; Schlossberger *et al.*, 1962; Hergenroeder *et al.*, 1999; Wu *et al.*, 2001), from 58% to 86% for girls' Tanner pubic hair stage (Duke *et al.*, 1980; Neinstein, 1982; Schlossberger *et al.*, 1962; Hergenroeder *et al.*, 1999; Wu *et al.*, 2001; Bonat *et al.*, 2002), from 48% to 78% for boys' Tanner pubic hair stage (Neinstein, 1982; Schlossberger *et al.*, 1962; Williams *et al.*, 1988; Bonat *et al.*, 2002), and from 27% to 45% for the Tanner genitalia stage (Duke *et al.*, 1980; Neinstein, 1982; Schlossberger *et al.*, 1992).

This study shows that there were more boys in the earlier stages of sexual maturation, while more girls dominated the latter maturation stages. There were significant associations noted among the sexes in both PHS and the GS_BS. Girls from both ethnic groups have earlier age of onset of maturation than their male counterparts. Age at adult maturity was also observed to be earlier in girls than in boys. Statistical significant difference was noticed between boys and girls of both ethnic groups at stage 3 for pubic

hair, and stage 3 and 5 for GS_BS. The earlier onset of maturation seen in girls, with higher age at onset of pubic hair compared to genital/breast is similar to the previous works that have been carried out (Jimenez *et al.*, 1966; Emodi, 1989; Olambiwonnu *et al.*, 1975; Platt *et al.*, 1984; Oyedeji, 1995), but age at adult maturity is late compared with the previous studies. Implicating factors for this phenomenon may include hormonal, haematological, socio-economic, nutritonal, medicare, infections, trace elements and vitamin deficiencies (Sergeant, 1985),

Comparing the height and weight of this study population showed that girls were shorter than the boys in both PHS and GS_BS stages except during PHS 1. Jukun females were significantly shorter than Jukun males, but they were not significantly taller than Kuteb females (significant at BS 4). Boys tend to be weightier than girls in stage 5 of PHS and GS_BS only, the girls had higher values in the other stages. Jukun boys also had lesser weight than Kuteb boys, while Jukun girls had higher weight than their Kuteb counterparts. In this study, mean weight and height increased from lower age group to higher age group within the same stage of sexual development. This may be due to the effect of chronological age on somatic growth. On the other hand, within the same age group the mean weight as well as height also increased according to the current stage of sexual development. This increase may be the effect of endocrine controlled somatic growth that occurs during adolescence.

Comparison of the BMI and %body fats of the adolescents showed that the girls had significantly higher values than the boys in all the stages of maturation, the Kuteb girls have the highest values while Kuteb boys had the lowest values.

The hand and foot anthropometry of this study showed that boys from the two ethnic groups showed statistically significant higher values than their female counterparts. The

right hand index of the boys from both ethnic groups was significantly different, while girls showed statistical significant difference in their right and left 2D:4D ratio.

The mean values of right and left 2D:4D ratio in this study was 0.940 and 0.942 for Jukun boys, Kuteb boys had 0.942 and 0.944. For females, Jukun girl's right and left 2D:4D was 0.950 and 0.949, while Kuteb girls had ratios of 0.943 for both hands. This result also shows that Jukun girls had significantly higher values compared with the rest of the population. It was observed from the present study that second digit length in males was shorter than fourth digit length which was not significantly different when compared among the sexes. This finding agrees with the reports of Manning (1998), Manning *et al.* (2000), Mcadden and Shubel, (2002), Holm *et al.* (2005), Danborno *et al.* (2007), Oladipo *et al.* (2009) and Ibegbu *et al.* (2012) who reported that second digits in the males tend to be shorter than fourth digits. These digits lengths are influenced by testosterone and estrogen in-utero (Manning *et al.*, 2000). This sexual dimorphism in 2D:4D ratios are influenced by prenatal testosterone concentrations. This hormone is thought to modify developmental rate such as epidermal ridges of the digits during fourth week of fetal development (Geschwind and Galaburda, 1985; McFadden and Shubel, 2002; Neave *et al.*, 2003; Manning *et al.*, 2004; Wallien *et al.*, 2008). High concentrations of fetal testosterone indicate a low 2D:4D ratios, which therefore indicate a high prenatal testicular activity which also influences higher long bone development and determines the height of the individual. On the other hand 2D:4D ratio is positively correlated with oestrogen in men and women (Williams *et al.*, 2000; Malas *et al.*, 2006; Paulet *et al.*, 2006).

The mean values of the right and left hand index in this study was 40.540 ± 2.07 and 40.243 ± 1.98 for Jukun boys, Kuteb boys had values of 39.913 ± 2.27 and $39.889 \pm$

2.22. For females, Jukun girls had right and left hand indexes of 40.244 ± 1.74 and 40.246 ± 1.84 , while Kuteb girls had indexes of 40.332 ± 1.77 and 40.273 ± 1.80 . Kuteb boys had significantly lower index compared with other groups of the population ($p < 0.01$). The males from this population had higher hand lengths and breadths values, which agrees with the reports of Danborno and Elupko (2008); Ilayperuma *et al.*, (2009); Krishan *et al.*, 2011; El-morsi and Al Hawary, (2012). .These population variations may be attributed to genetic and environmental factors (Eveleth and Turner, 1976; Malina *et al.*, 1983; Abdel-Malek *et al.*, 1990).

The mean values of the right and left foot index in this study was 42.807 ± 1.61 and 42.830 ± 1.76 for Jukun boys, Kuteb boys had values of 42.939 ± 2.19 and 42.900 ± 2.22 . For females, Jukun girls had right and left foot indexes of 42.031 ± 1.47 and 41.977 ± 1.41 , while Kuteb girls had indexes of 41.973 ± 1.59 and 40.097 ± 1.57 . Kuteb boys had significantly higher index compared with Kuteb girls, while both boys from the two ethnic groups have significantly higher right and left foot length and foot breadths than their female counterparts ($p < 0.01$). This agrees with the works of Baba (1975); Ashizawa *et al.* (1997), Fessler *et al.*(2005); Ozden *et al.* (2005); Danborno and Elupko (2008) and Kanchan *et al.* (2008), but disagrees with the reports of Ismaila (2009).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

The present cross sectional study investigated the growth and sexual maturation of adolescents of Jukun and Kuteb ethnic groups of Taraba State, the influence of some anthropometric measurements on growth was studied, an estimate was made of the mean menarcheal age of the respondents while also assessing their sexual maturation and nutritional status. Materials used in the study included weighing scale, skinfold caliper, myo tape and the Tanner staging scale.

Results of the growth parameters and anthropometric measurements of the adolescents showed no statistical significant difference based on ethnicity, showing that they might be a homogenous group genetically, but there was statistical significant difference based on sex in most of the variables, showing that the population exhibits sexual dimorphism. The boys had higher values than girls in only height, neck circumference and waist-chest ratio.

The plotted growth curves of BMI, height and weight of the population with international references showed that the boys had lower values than the reference population and in some cases matching the 15th percentile of the reference population, while the girls from both ethnic groups had values similar and in some cases such as BMI higher than the reference population.

The nutritional assessment of the population also showed that the prevalence of stunting, thinness and overweight among boys and girls was 22.4%, 11.7% and 1.1% in boys, and 2.9%, 1.1% and 3.9% in girls respectively.

Results of the study showed late maturation among the adolescents, especially among males. The mean age at onset of sexual maturation in pubic hair was 11.77 ± 0.87 for Jukun boys and 11.88 ± 1.42 for Kuteb boys. For females, it was 11.25 ± 0.90 for Jukun girls and 11.50 ± 1.14 for Kuteb girls. Age at onset of breast development (corresponding to stage 2) for females was 11.17 ± 1.04 (Jukun) and 11.12 ± 1.11 (Kuteb) respectively. For males, age at entry of genital development was 11.65 ± 0.86 (Jukun) and 11.65 ± 1.43 (Kuteb). The age at onset of puberty of this study corresponded with other previous, but it took longer time for the population to reach adult size, hence there is a form of delay in the other higher maturation stages. Age at completion of sexual development in PH and BS for females was 17.68 ± 1.43 and 17.63 ± 1.43 (Jukun); 17.80 ± 1.59 and 17.44 ± 1.68 (Kuteb) respectively. For males it was 18.09 ± 1.40 and 18.23 ± 1.31 (Jukun), 18.21 ± 1.25 and 18.13 ± 1.38 (Kuteb). There was statistical significant difference between boys and girls of both ethnic groups at stage 3 for PHS, and stage 3 and 5 for GS_BS.

Comparison of the sexual maturation with height and weight of this study population showed that girls were shorter than the boys in both PHS and GS_BS stages except during PHS 1. Boys tend to be weightier than girls in stage 5 of PHS and GS_BS only, the girls had higher values in the other stages. The girls of this study also had BMI and % body fat values significantly higher than the boys at each stage of the PHS and GS_BS.

The Hand and Foot anthropometry showed that boys from the two ethnic groups showed statistically significant higher values than their female counterparts. The right hand index of the boys from both ethnic groups was significantly different, while girls showed statistical significant difference in their right and left 2D:4D ratio.

6.2 CONCLUSION

In this study of Jukun and Kuteb adolescents, their growth parameters and anthropometric measurements showed no statistical significant difference based on ethnicity, showing that they might be a homogenous group genetically, but there was statistical significant difference based on sex in most of the variables, showing that the population exhibits sexual dimorphism.

The result of this study has shown that the weight and BMI of girls of the two ethnic groups were significantly higher than their boys, while boys had higher values for height than the girls, this difference was statistically significant among Kuteb boys and Kuteb girls.

Comparison of the height, weight and BMI of the population with international reference showed that the boys had very low values compared with these references, while the girls had values that were close to the reference and even exceeding the reference values at some age categories.

The mean menarcheal age of Jukun and Kuteb girls was 13.49 ± 1.02 and 13.55 ± 1.17 respectively. Jukun girls had lower age at menarche, but this difference was not statistically significant.

The present study showed that the age at onset of puberty for PH and GS_BS was early and compared favorably with other studies, but there was late maturation into adult size.

At the end of the study, a growth reference table with some anthropometric variables were generated for both sexes.

6.3 RECOMMENDATION

Based on the findings of this study, the following recommendations are made:

- i. improvement of the nutritional level of adolescents should be given top priority.
- ii. Further research on individual and group variations in timing, tempo and duration of sexual maturation process should be carried out.
- iii. There should be introduction of growth monitoring/promotion activities not only at child health clinics, but in all schools also.

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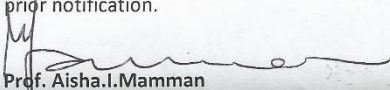
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APPENDIX I

ETHICAL CLEARANCE

	HEALTH RESEARCH ETHICS COMMITTEE AHMADU BELLO UNIVERSITY TEACHING HOSPITAL SHIKA - ZARIA, NIGERIA.
E-mail: abuthshika@yahoo.com	website: www.abuth.org
Chairman of Board: Chief. Shuaib Oyedokun Afolabi <i>Fnil</i>	
Chief Medical Director: Prof. Lawal Khalid, <i>MBBS, FMCS, FWACS, FRCS(ED) mnl</i>	
Chairman, Medical Advisory Committee: Prof. Abdullahi Mohammed, <i>MBBS, FWACP, FICS</i>	
Director of Administration: Barr. Ishak Bello, <i>LL.B, BL., LL.M, PGDM, AHAN, FCAI</i>	
ABUTH/HREC/TRG/36	31 st December, 2014
Our Ref: _____	Date: _____
Your Ref: _____	ABUTH HREC FULL ETHICAL CLEARANCE CERTIFICATE
RE: "Growth and Sexual Maturation of Adolescents amongst Jukun and Kuteb Ethnic Groups of Taraba State."	
ABUTH Ethics Committee assigned number: -	ABUTH/HREC/M15/2014
Name of the principal Investigator: -	Mr. David Philip Dangoji,
Address of the Principal Investigator: -	Department of Human Anatomy, Faculty of Medicine, A.B.U Zaria
Date of receipt of valid application: -	2/9/14
Date of meeting when final determination	
On ethical approval was made: -	30 th December, 2014
<p>This is to inform you that the research described in the submitted protocol, the consent forms, and other participant information materials have been reviewed and given full approval by the ABUTH Ethics Committee.</p> <p>Please note: this approval dates from 31st December, 2014 to 31st December, 2015. No participant recruitment into this research may be conducted outside these dates.</p> <p>All informed consent forms in this study must carry the ABUTH HREC number assigned to this research and the duration of ABUTH HREC approval of the study.</p> <p>This HREC expects that you submit your application as well as an annual report for ethical clearance renewal 3 months prior to expiration of study dates. This is to enable you obtain renewal of your approval and avoid interruption of your research.</p> <p>If there is delay in starting the research, please inform the ABUTH HREC so that starting dates can be adjusted accordingly.</p> <p>No changes are permitted in the research without prior approval by ABUTH HREC, except in circumstances outlined in national code for Health Research Ethics: http://www.nhrec.net.</p> <p>ABUTH HREC reserves the right to conduct compliance assessment visits to your research site without prior notification.</p>	
 Prof. Aisha I. Mamman Chairperson, ABUTH HREC	

APPENDIX II

INFORMATION SHEET

A study of Growth and Sexual Maturation of Adolescents amongst *Jukun* and *Kuteb* ethnic groups of Taraba State

INTRODUCTION

You are kindly being asked to participate in a research study conducted by Dangoji David Philip for a Master of Science degree under the supervision of Dr. B. Danbornu, and Dr. W.O Hamman, from the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria.

If you have any questions or concerns about the research, please feel free to contact: Dangoji David Philip, Faculty of Medicine, Tel: 07068697971; Dr. B. Danbornu, Faculty of Medicine, Tel: 08139429300, or Dr. W. O. Hamman, Tel: 0806230007, Faculty of Medicine, ABU Zaria.

PURPOSE OF THE STUDY

The purpose of this preliminary study is primarily to assess growth and sexual maturation among *Jukun* and *Kuteb* ethnic groups using anthropometric variables. This study is in partial requirement for the award of M.Sc degree in Human Anatomy Department in Ahmadu Bello University, Zaria.

WHY ARE YOU BEEN ASKED TO PARTICIPATE?

You are being invited because you are a 10 -20 year old secondary school student.

WHAT WILL HAPPEN DURING THIS STUDY?

Information pertaining to growth, demographics (i.e. age, ethnicity, etc.), and sexual maturation will be collected using a questionnaire. Your anthropometric measures will also be taken.

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 in assessing the growth and sexual maturation between the two ethnic groups and how it is influenced by anthropometric

indexes, demography, nutrition, and parental level of education. This research work can also be used in planning, evaluation and advocacy in Southern Taraba, and can lead to the implementation of interventions to improve child health and survival.

WILL THERE BE ANY COST FOR PARTICIPATING?

Aside from your time, there are no costs in taking part in the study.

REMUNERATION FOR PARTICIPATION

Participation will not attract any financial benefit.

CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information provided by participants in this study. You will not be identified in any reports or publications resulting from the 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 warrants 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 any questions regarding your rights as a research participant, you can obtain further information about the research or voice your concerns to:

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

APPENDIX III

INFORMED CONSENT SHEET

**A study of growth and sexual maturation of Adolescents amongst
Jukun and Kuteb ethnic groups of Taraba State.**

I have read the information proved above (it has been adequately explained to me).

I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I voluntarily accept to participate/allow my ward or children to participate in this study and understand that I have the right to withdraw from the study at any time, without compromising the quality of care I deserve.

Yes [] No []

.....
Signature/thumb print of research respondent

.....
Date

.....
Printed name of Research Subject's legal guardian

.....
Signature/thumb print of person obtaining consent

.....
Date

Dangoji David Philip
Department of Human Anatomy,
Faculty of Medicine,
Ahmadu Bello University, Zaria.
07068697971

APPENDIX IV

Questionnaire for the Study of Growth and sexual maturation of Adolescents amongst *Jukun* and *Kuteb* Ethnic groups of Taraba State

Please tick or circle the appropriate letter where necessary below:

DEMOGRAPHY OF PARTICIPANT

1. Research I.D. _____
2. How old are you? _____ (yrs)
3. Date of Birth: ____/____/_____(DD/MM/YYYY)
4. Place of Birth: _____
5. Have you spent your whole life there? Yes [] No []
If no, where else have you lived? _____
6. Where do you live now? _____
7. What's your birth order?
 - a. Firstborn [] b. Second born [] c. Third born [] d. Later born []
8. Type of school attending:
 - A. Private []
 - B. Public []
9. Your State of origin _____
10. Ethnic group _____

ETHNIC BACKGROUND

11. Mother's Ethnic Group _____
12. Grand Mother's Ethnic Group _____
13. Father's Ethnic Group _____
14. Grand Father's Ethnic Group _____
15. Which of your parents are you closer to in your childhood?
 - A. Mother [] B. Father []
16. Which of your parents are you closer to as an adolescent?
 - A. Mother [] B. Father []

PARENTS' EDUCATIONAL BACKGROUND

17. Mother's level of education
 - A. None []
 - B. Primary school []
 - C. Secondary school []
 - D. Tertiary []
18. Father's level of education
 - A. None []
 - B. Primary school []
 - C. Secondary school []
 - D. Tertiary []

PARENTS' OCCUPATION

19. Mother's occupation _____
20. Father's occupation _____

ANTHROPOMETRIC MEASUREMENTS

21. Birth Weight _____
22. Weight _____ (kg)
23. Height _____ (m)
24. BMI _____ (kg/m^2)
25. Waist circumference _____ (cm)
26. Hip circumference _____ (cm)
27. Waist-Hip ratio _____
28. Mid upper arm circumference _____ (cm)
29. Neck circumference _____ (mm)
30. Chest circumference _____ (mm)
31. Thigh circumference _____ (cm)
32. Triceps skin fold _____ (mm)
33. Subscapular skin fold _____ (mm)
34. Umbilical skin fold _____ (mm)

HAND ANTHROPOMETRY

35. Length of digits (mm)

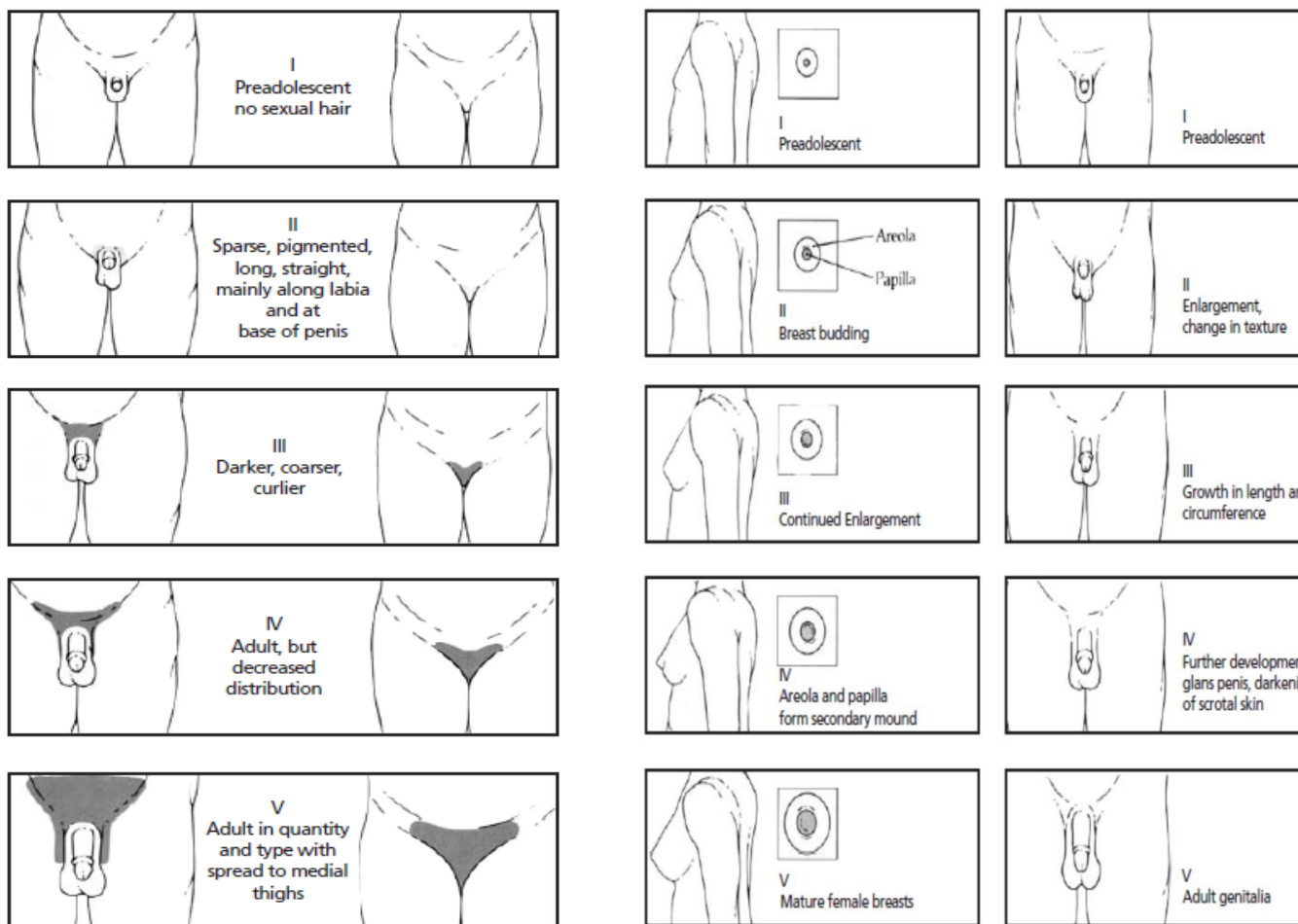
Hand	Fingers	
	II	IV
Right		
Left		

36. HAND AND FOOT LENGTH

HAND LENGTH AND BREADTH		
	Right	Left
Length		
Breadth		
FOOT LENGTH AND BREADTH		
Length		
Breadth		

SEXUAL MATURATION ASSESSMENT

37. Tick beside the picture that correctly depicts your present sexual development



MENARCHEAL AGE ASSESSMENT

The following questions are applied to girls alone.

38. "Have you already had your menstrual periods?"

- "No, I haven't yet" []
- "Yes, I have at the age of: _____ (yrs)

The following questions are applied to menstruating girls alone.

- What year? _____
- What month? _____
- What class were you at first menstrual cycle? _____
- What class are you now? _____

43. What is the average length of your menstrual cycle in the past 6 months?
- A. less than 21days
 - B. between 22 and 23 days
 - C. Between 24-25 days
 - D. 27-28 days
 - E. Greater than 29
 - F. Irregular pattern
44. How many days do you bleed? _____

You have finished the questionnaire

Thank you

APPENDIX V

Comparison of anthropometric parameters between males and females of the two ethnic groups

Parameters	Jukun		t	P	Kuteb		t	p
	(Male, n = 150)	(Female, n = 150)			(Male, n = 150)	(Female, n = 150)		
	Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD		
Age (years)	14.89 ± 2.76	15.04 ± 2.96	0.44	0.66	15.07 ± 2.90	15.21 ± 2.98	0.43	0.666
Weight (kg)	45.88 ± 11.57	49.77 ± 8.69	3.29	0.01	46.39 ± 10.93	49.78 ± 8.33	3.03	0.030
Height (cm)	156.29 ± 11.97	155.37 ± 7.29	- 0.81	0.42	157.03 ± 11.52	154.80 ± 7.17	- 2.01	0.046
BMI (kg/m ²)	18.44 ± 2.36	20.45 ± 2.32	7.43	0.001	18.52 ± 2.28	20.63 ± 2.36	7.87	0.001
Menarcheal Age		13.49 ± 1.02				13.59 ± 1.17		
Waist Circumference (cm)	69.27 ± 5.53	73.67 ± 5.99	6.62	0.001	69.63 ± 4.89	74.26 ± 6.09	7.26	0.001
Hip Circumference (cm)	80.42 ± 7.22	85.39 ± 7.59	5.81	0.001	80.69 ± 6.93	85.58 ± 7.51	5.89	0.001
Arm Circumference (cm)	23.22 ± 3.45	24.89 ± 3.01	4.46	0.001	23.30 ± 3.29	24.97 ± 2.34	5.06	0.001
Neck Circumference (cm)	31.24 ± 3.58	30.50 ± 1.83	- 2.26	0.03	31.46 ± 3.48	30.52 ± 1.83	- 2.90	0.004
Chest Circumference (cm)	75.93 ± 8.13	80.60 ± 7.77	5.06	0.001	76.46 ± 7.30	81.53 ± 7.06	6.06	0.001
Thigh Circumference (cm)	40.52 ± 5.05	45.10 ± 3.76	8.90	0.001	41.18 ± 5.50	44.92 ± 3.52	7.01	0.001
Waist-Hip Ratio	0.86 ± 0.05	0.86 ± 0.40	0.19	0.85	0.86 ± 0.04	0.87 ± 0.05	0.90	0.368
Waist-Chest Ratio	0.92 ± 0.08	0.92 ± 0.08	0.07	0.94	0.91 ± 0.05	0.91 ± 0.04	- 0.26	0.796
Waist-Height Ratio	0.44 ± 0.03	0.47 ± 0.03	10.15	0.001	0.44 ± 0.02	0.48 ± 0.03	12.24	0.001
Triceps Skinfold (mm)	6.44 ± 1.92	11.50 ± 2.62	19.05	0.001	6.77 ± 2.15	11.57 ± 2.28	18.75	0.001
Subscapular Skinfold (mm)	7.18 ± 1.91	11.59 ± 2.20	18.55	0.001	7.09 ± 1.95	11.57 ± 2.68	16.54	0.001
Umbilical Skinfold (mm)	7.14 ± 1.86	12.44 ± 2.61	20.29	0.001	6.98 ± 1.79	12.18 ± 2.72	19.56	0.001
%Body Fat	32.82 ± 3.15	38.23 ± 3.77	13.473	0.001	33.24 ± 3.25	38.53 ± 3.61	13.35	0.001

t-test showed no statistical significant difference ($p < 0.05$) for comparison between boys and comparison between girls of the two ethnic groups.

APPENDIX VI

Sexual Maturation Rating of the Two Ethnic Groups

PHS	Jukun Male	Kuteb Male	Jukun Female	Kuteb Female
Stage 1	12	10	7	6
Stage 2	22	24	24	22
Stage 3	43	47	30	27
Stage 4	40	35	33	35
Stage 5	33	34	56	60
$\chi^2 = 24.58$ p=0.017				
GS_BS				
Stage 1	11	8	6	6
Stage 2	17	23	18	22
Stage 3	41	39	35	27
Stage 4	46	40	28	35
Stage 5	35	40	63	60
$\chi^2 = 32.95$ p=0.001				

APPENDIX VII

Menarcheal Ages of the Two Ethnic Groups

Age	Jukun	Kuteb
10	0	2
11	2	3
12	9	4
13	47	41
14	31	42
15	7	5
16	6	3
17	0	3
Total	102	103

Chi square= 10.518, p = 0.161