PERCENTAGE BODY FAT OF SECONDARY SCHOOL ADOLESCENTS IN IBADAN NORTH LOCAL GOVERNMENT AREA, NIGERIA

BY

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DEDICATION

To God, the Father Almighty, who has always been my help in ages past and my hope for many more years to come.

ABSTRACT

Adolescence is a transitional phase from childhood to adulthood during which significant changes in body composition occur with a tendency towards excessive fat accumulation. Determining body fat proportions at this stage of life could give an insight into the need for early intervention. The actual body fat estimates of school adolescents have not been adequately researched in Nigeria. This study was carried out to determine the Percentage Body Fat (PBF) of secondary school adolescents in Ibadan North Local Government Area, Nigeria.

Using a three-stage random sampling method, 623 adolescents aged 10 to 19 years were selected from two private (141) and six public (482) secondary schools in a cross sectional study. A validated, structured interviewer-administered questionnaire was used to collect data on socio-demographic characteristics. Parents' socioeconomic status was grouped as high, middle and low using the combination of level of education and occupation. The PBF was assessed using a Bioelectric Impedance Analyser (BIA). The participants' PBF for age and sex were classified as low $<5^{th}$, normal 5^{th} – 95^{th} and high >95th percentiles of the study population respectively. Data were analysed using descriptive statistics, Chi-square test, Student's t-test, ANOVA and Pearson Correlation.

Overall mean age was 14.5±2.1 years and 60.0% were female. The participants were from families in low (19.6%), middle (51.7%) and high (28.7%) socioeconomic categories. Overall, mean PBF was 12.6±7.1%. Mean PBF for male 8.5±5.6% was lower than 14.9±6.7% for female ($p<0.05$). There was no significant correlation between PBF and age among female ($r = 0.064$, $p>0.05$) but a significant negative correlation was observed among male participants ($r = -0.224$, $p<0.05$). Among male participants, mean PBF of low (7.8±5.2%), middle (8.3±5.5%) and high (9.2±6.1%) socioeconomic status were not significantly different ($p>0.05$). Similarly, there were no differences in the mean PBF of low (15.2±6.9%), middle (14.8±6.9%) and high (14.9±6.7%) socioeconomic status among female participants ($p>0.05$). Proportion of adolescent PBF $<5^{th}$ and $>95^{th}$ percentiles were 3.9% and 19.9% respectively. Prevalence of PBF $>95^{th}$ percentile was higher among male (28.1%) than female (14.4%) adolescents ($p<0.05$). Slightly more female participants (4.3%) than male (3.2%) had PBF $<5^{th}$ percentile ($p<0.05$). More male participants in public (31.8%) compared with 15.8% among those in private schools had PBF $>95^{th}$ percentile ($p<0.05$). There was no significant difference in prevalence of PBF $>95^{th}$ percentile among female participants in private (10.7%) compared with those in public schools (15.5%). There was no significant difference in the proportion of respondents who had PBF $>95^{th}$ percentile in low (20.5%), middle (22.4%) and high (15.1%). Similarly, proportions of participants with PBF $<5^{th}$ percentile in low, middle and high socioeconomic groups were 3.3%, 4.3% and 3.4% respectively were not significantly different.

Male adolescents were likely to rise above 95^{th} percentile of percentage body fat estimates for age and sex irrespective of socioeconomic status especially in public school. There is the need to initiate programmes that may enhance early identification of adolescents with the tendency of accumulating excess fat.

Keywords: Body fat accumulation, Socio-economic status, Secondary school adolescents

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CERTIFICATION

This is to certify that this research titled: "**PERCENTAGE BODY FAT OF SECONDARY SCHOOL ADOLESCENTS IN IBADAN NORTH LOCAL GOVERNMENT AREA, NIGERIA**" is an original research work carried out by Oyom, Comfort Runyi under my supervision:

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LIST OF ABBREVIATIONS

BIA	Bioelectric Impedance Analysis
BMI	Body Mass Index
CT	Computed Tomography
DXA	Dual X-ray Absorptiometry
ECS	Extracellular Solids
ECW	Extracellular Water
FFM	Fat-free mass
HC	Hip Circumference
ICW	Intracellular Water
MRI	Magnetic Resonance Imaging
PBF	Percentage Body Fat
TBW	Total Body Water
UWW	Under-Water Weighing
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-hip ratio
WHtR	Waist-to-height ratio

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OPERATIONAL DEFINITIONS

The following terms were adopted as defined below for the purpose of this research:

1. Body composition: Body composition is the technical term used to describe all the different components that make up an individual's body weight (Quinn, 2012).
2. Body fat mass: Body fat mass is the compartment of the body which includes all extractable lipids from adipose and other tissues (Vella and Kravitz, 2002).
3. Body Mass Index (BMI): BMI is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m^2) [BMI = Weight (kg)/Height^2 (m^2)]. The World Health Organisation regards a BMI of less than 18.50 as underweight, 18.50 - 24.99 as normal range, 25.0 - 25.99 as overweight and greater than 30 as obese (WHO, 2012).
4. Fat Free Mass: The fat-free mass is the weight of the body excluding the body fat (Kyle et al, 2004)
5. Obesity: Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2012).
6. Percentage Body Fat (PBF): PBF is the fat mass that is expressed as a percent of total body weight (PBF = fat mass ÷ body weight x 100).

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CHAPTER ONE

INTRODUCTION

1.1 Background

Adolescence, 10 to 19 years, is a critical transitional phase in human life as a result of the multiple changes that take place between childhood and adulthood. It is a period characterized by a global acceleration of growth and maturation (Rodriguez, Moreno, Blay, Blay, Garagorri, Sarrı´a and Bueno, 2004). There is usually a rapid growth spurt including weight gain, increase in fat-free mass and bone mineral content during this period (Chumlea, Guo, Kuczmarski, Flegal, Johnson, Heymsfield, Lukaksi, Friedl and Hubbard, 2002). Though the onset of puberty generally begins earlier in females than in males, the amount of fat mass in adolescent girls is usually higher than in boys. In girls, independently of the chronological age, pubertal development is associated with increased body fat (Vizmanos and Martí-Henneberg, 2000). The body composition pattern in adolescent boys is characterized with decrease of body fat, higher peaks of height velocity and an increase of both shoulder span and leg-to-trunk length ratio. Sex differences in fat mass are apparent even long before puberty (Vizmanos and Martí-Henneberg, 2000; Rodríguez et al, 2004). The body composition and psycho-sociological changes in adolescents determine their nutritional requirements, eating habits and physical activity as well as behaviour modifications.

The assessment of body composition is useful for the screening of excess body fat and its related metabolic complications. Reliable measurements of body fatness and its distribution pattern are necessary in epidemiological, clinical and population studies, and in the management of overweight/obesity consequences (Rodríguez et al, 2004).

Obesity, defined as a body condition characterized by excessive or abnormal fat accumulation under the skin and within other organs is a known risk factor for many non-communicable diseases such as arteriosclerosis, hypertension, diabetes and cancers (Flynn et al, 2006). Subcutaneous fat and body mass especially proportions of fat in the body are established indices of obesity. Prevalence of obesity has been observed to have increased in developed countries such as United States (Hedley, 2004), Spain and United Kingdom

(Jackson-Leach and Lobstein, 2006; Plaza et al, 2009). A similar increasing trend in prevalence of overweight and obesity has also been reported in many developing countries as a result of changes in social, economic, life-style and dietary habits (Ofei, 2007; Buowari, 2010; Chukwuonye, Chuku, John, Ohagwu, Imoh, Isa, Ogah and Oviasu, 2013).

Obesity in childhood is a recognized predictor of obesity in adulthood. Childhood and adolescent obesity has been known to increase at an alarming rate over the years and there is the need for focused attention on accurate field methods to estimate body composition among youth (Akpa and Mato, 2008). Characterizing nutritional status during growth, and assessing effects of obesity prevention and treatment interventions among youth require measurement tools suitable for field applications.

Both deficient and excessive body fat pose health risks. Excessive body fat mass have also been shown to predict clinical outcome and prognosis for different diseases (Kyle et al, 2004) including coronary artery disease, hypertension, diabetes, cancer, strokes and other related illnesses. On the other hand, having a very low body fat percentage, particularly for women, can result in musculoskeletal problems and osteoporosis. It can also upset the hormonal balance causing loss of menstruation. Too little body fat could pose a health risk as found in individuals suffering from eating disorders, exercise addiction and certain diseases such as cystic fibrosis. This is because the body needs a certain amount of fat for normal daily function.

An ideal obesity classification should be based on a practical measurement of body fat, which can accurately predict disease risk and have application to patients from diverse ethnic backgrounds (Nwegbu, 2012). As direct measures of body fat such as underwater weighing or dual-energy x-ray absorptiometry (DEXA) scanning may be impractical for use in a clinical setting (Jonathan, 2003), indirect estimates of body fat are used. These indirect estimates including body mass index, or fat distribution indices like waist-hip ratio (WHR) and waist circumference (WC), remain the bedrock indices of obesity assessments.

The Body Mass Index (BMI) is a simple index of obesity, estimated from weight and height. Epidemiologic studies commonly use the BMI as an indicator of overweight and obesity. International classifications and definitions for overweight and obesity are based on BMI (WHO, 2010; Expert Panel on the identification, Evaluation and Treatment of Overweight in Adults, 1998), as weight and height can easily and accurately be measured. The principle of BMI works on the assumption that at a given height, higher weight is associated with increased fatness (Benn, 1971). However, BMI does not directly measure body composition as it does not measure fat mass The widely used BMI alone is not sufficient for determining if an individual is obese, because it may not correspond to the same degree of fatness in different individuals (WHO, 2010). The Waist-Hip ratio (WHR) measures central or abdominal obesity (Ojofeitimi, 2009). It is calculated by dividing the waist size by the hip measurement. The use of WHR that measures abdomen obesity has been associated with cardiovascular diseases, stroke, adult diabetes mellitus, forms of cancers, including colorectal, breast and prostate cancers. In females WHR should be less than 0.81 for normal WHR and anything above 0.81 is an indicator of obesity. In males, the ratio should be less than 1; anything above this ratio is a sign for abdominal obesity. Waist-height ratio for both males and females should not be greater than 0.50. The waist size is also an indicator of obesity. When the waist line for adult male is greater than 102 cm and 88cm for adult female, it is classified as obesity (Ojofeitimi, 2009).

A good alternative to these indices is the direct determination of body fat mass or proportion. Body fat percentage or percentage body fat (PBF) is regarded as a better measure of obesity and an individual's fitness level, as it is a body measurement which directly calculates the particular individual's body composition.

Bioelectric impedance analysis (BIA), which was introduced over a decade ago, is now being used to assess body mass composition across the globe. It is increasingly becoming popular and has been shown to give an estimate close to dual X-ray absorptiometry (DXA), which is considered the Gold Standard (Wong et al, 2004). It has also been proven to have a high precision and therefore can be used to measure body composition in children (Lim et al, 2009). BIA is a simple, rapid, convenient and inexpensive method for assessing body composition, which has gained increasing popularity in the past decade (Sung et al, 2009). It measures body composition by sending a low, safe electrical current through the body. The current passes freely through the fluids contained in muscle tissue, but encounters resistance when it passes through fat tissue. This resistance of the fat tissue to the current is termed 'bioelectrical impedance', and is measured by body fat analyzers. When set against a person's height, gender and weight, the device can then compute their body fat percentage. From this, the lean body mass and body water values can be estimated.

It is important to document the health and nutrition status across the lifespan of Nigerians in order to provide the basis for future policy decisions regarding allocation of health care resources. Oftentimes, adolescents are left out of the data mix because they are assumed to be healthy relative to more vulnerable age groups (Blum, 1991; Senderowitz, 1995). Presently, there are few anthropometric data available for adolescents in Nigeria and there are few studies on relative height and weight for this age group (Ayoola et al, 2009).

1.2 Statement of the problem

Obesity, described as an excess of body fat, is increasing at an alarming rate worldwide and is a major public health problem in the 21st century. According to the World Health Organization (WHO) at least 20 million children under the age of 5 years were overweight globally in 2005. The WHO further projects that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese. Worldwide trends reveal that obesity, which was previously seen as a disease of developed countries, is now prevalent in developing countries including Nigeria (Prentice, 2006; Chukwuonye et al, 2013).

Generally, the fat content of the human body has physiological and medical importance and excess or too little body fat results in a lot of health risks. Obesity and patterns of fat are risk factors for diabetes mellitus, hypertension, atherosclerosis and mortality from coronary heart disease in adulthood. About 40 per cent of obese children become obese adults (Campaigne et al, 1994). Recent findings suggest a range of risk factors evident in the paediatric population, though these were once thought to be evident only in adults (Reilly, Armstrong, Dorosty, Emmett, Ness, Rogers, Steer, Sherriff, 2005). With the increasing prevalence of paediatric obesity (Senbanjo and Adejuyigbe, 2007; Bundred, Kitchiner, and Buchan, 2001; Ogden, Flegal, Carrol, and Johnson, 2002) and health conditions associated with it (Baker, Olsen, and Sørensen, 2007), there is the need to introduce effective intervention strategies, especially at an early stage.

Body Mass Index (BMI) is widely used to assess overweight and obesity in adults. BMI cut-off points have been also developed for children by International Obesity Task Force (IOTF) (Cole, Bellizzi, Flegal, and Dietz, 2000). However, BMI and other indices such as WHR do not distinguish between increased lean mass, bone and fat. Since the pathology associated with obesity is related very strongly with excess body fat, the ideal tool should assess adiposity (Fortuno et al, 2003). Adolescents are at a stage of life where they experience changes in body composition usually with a tendency towards increased fat accumulation particularly in females. They are therefore a vulnerable group at risk of excessive body fat and its related consequences. Most times, adolescents are usually considered healthy their health needs are overlooked as the focus is usually on children and adults. Determining body fat proportions at this stage of life could give an insight into the need for early intervention for obesity prevention and its health-related consequences. However, actual body fat estimates of school adolescents have not been adequately researched in Nigeria.

1.3 Rationale for the study

Though several studies have assessed the nutritional status of Nigerian children and adolescents, few have focused on body fat proportion. It is important to know about body fat proportion in individuals because of its role in aetiology of many chronic/non-communicable diseases. For instance, a high body fat percentage predisposes one to cardiovascular diseases including hypertension and coronary heart diseases.

Another reason why this study is necessary is the increasing trend in the prevalence of obesity and overweight in Nigerian population. Information is needed to describe overweight or underweight in smaller geographic areas for local health planning. There is the need to estimate for body fat by impedance that can be used for Nigerian population because of racial differences. Reliable measurements of body fatness and its distribution pattern are necessary in epidemiological, clinical and population studies, and in the management of overweight/obesity consequences.

1.4 Objectives of the Study

Broad objective

The broad objective of this research is to determine the percentage body fat of secondary school adolescents in Ibadan North Local Government of Oyo State.

Specific objectives

1. To estimate the average percentage body fat of adolescents in secondary schools in Ibadan North LGA.
2. To determine the relationship between the anthropometric indices (height, weight, WC, HC, BMI, WHtR and WHR) and percentage body fat in adolescents.
3. To determine the association between percentage body fat and socio-demographic characteristics (age, gender and socioeconomic class).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

2.1.1 Body Composition and Body Fat

Body Composition

Body composition is the technical term used to describe all the different components that make up an individual's body weight (Quinn, 2012). The human body is composed of various tissues and numerous body cavities filled with body fluids. The body is composed primarily of about 70% water, while the other components include protein, fat, bone and other minerals. The measurement of body composition is an important component of nutritional assessment in clinical and public health nutrition (Wood, Johnson and Streckfus, 2003). This is because it helps to establish accurate measurement of body constituents including fat, protein, water and body cell mass and also to screen for over- or under-nutrition. The main structural and functional component of the body is termed the fat-free mass (FFM). The fat-free mass is devoid of any fat content; rather, it consists of proportions of water (72%), proteins (21%) and bone minerals (7%).

Body Fat

The fat compartment of the body consists of the absolute amount of body fat which includes all extractable lipids from adipose and other tissues. This is known as fat mass (FM). Fat mass consists of about 20% water and 80% adipose tissue. There are two types of fat in the body: essential fat and nonessential or storage fat. Essential fat is needed for normal physiological and biological functioning. It is found in bone marrow, the brain, spinal cord, cell membranes, muscles, and other internal organs. The essential fat is approximately 3% of the total body weight for men and 12% of the total body weight for women (Vella and Kravitz, 2002). Women have a higher essential body fat because of gender-specific fat deposits in breast tissue and the area surrounding the uterus. When essential fat drops below a critical mass, normal physiological and biological function may be impaired (Heyward and Wagner, 2004).

Nonessential (storage) fat functions basically as an insulator to retain body heat, as an energy substrate during rest and exercise and as padding against trauma. It is typically layered below the skin and is referred to as subcutaneous fat. It is also found surrounding internal organs in the abdominal cavity and this fat is referred to as visceral fat. Generally, older people tend to have less subcutaneous fat and more visceral fat than younger people (Heyward and Wagner, 2004).

Relative Body Fat

Generally, to classify body fatness, the relative body fat or the percentage body fat is calculated. The terms relative body fat and percentage body fat (PBF) may be used interchangeably. Relative fat is the fat mass that is expressed as a percent of total body weight. This can easily be calculated if the body fat mass is known.

$$PBF = \text{fat mass} \div \text{body weight} \times 100$$

Assessment of relative fat PBF is commonly used for categorization in health and sports performance.

Body fat mass is an indicator of obesity. Body fat mass usually varies among individuals in terms of the absolute amount. For instance, an obese individual will have a higher amount of fat in his body than a lean individual. Usually, in obese individuals, fat mass may be the largest component of the body. The higher the amount of fat in an individual, the greater the tendency is towards obesity.

2.1.2 Implications of low or high body fat

Overweight and obesity are the terms used to describe excess body fat. Overweight and obesity are defined as "abnormal or excessive fat accumulation that presents a risk to health" (WHO, 2012). Once considered a problem only in high income countries, overweight and obesity are now on the rise in low- and middle-income countries, particularly in urban settings (WHO, 2012).

Individuals who are overweight or obese have a higher chance of developing cardiovascular, pulmonary and metabolic diseases, as well as osteoarthritis and certain types of cancer (U.S Department of Health and Human Services, 2000a). Elevated percentage body fat tends to increase the risk of coronary heart disease, diabetes and high blood pressure. Moreover, overweight children are at a risk of developing various chronic conditions later in life (Lynch and Smith, 2005), and this risk may exist even independently of obesity in adult life (Daniels, 2006). Central fat distribution appears to influence lipid levels (Snijder MB, Van Dam RM, Visser M and Seidell JC, 2006) and may be related to insulin resistance (Karelis, St-Pierre, Conus, Rabasa-Lhoret and Poehlman, 2004). Obesity is also associated with increased risk of non-insulin dependent diabetes mellitus in adults (Lynch and Smith, 2005) and in obese children and adolescents (Daniels, 2006).

Also, some researches suggest that excessive accumulation of fat at specific body sites may be an important health risk factor (Ardern, Katzmarzyk, Janssen and Ross, 2003; Grundy, 2004). For instance, it appears that extra fat around the abdomen and waist is associated with higher risk of diabetes, heart disease, and hyperlipidemia. Individuals who accumulate body fat in the abdominal area (android body type or apple-shaped) are usually men while those who develop most of their fat in the hip and thigh regions (gynoid body type or pear-shaped) are usually women. Android body type individuals are usually more at risk than the gynoid body type individuals (Vella and Kravitz, 2002).

Underweight status has been associated with higher rates of morbidity and mortality, although to a lesser extent than obesity (Stang and Story, 2005). Underweight individuals with low body fat levels tend to be malnourished and have a relatively high risk of fluid-electrolyte imbalances, renal and reproductive disorders, osteoporosis, osteopenia and muscle wasting (Mafra, Guebre-Egziabher and Fouque, 2008). Being underweight could also lead to infertility in women. The female athlete triad highlights the problem that women who lose too much body fat risk injury, decreased performance and health issues (Quinn, 2012). These health issues include eating disorders and low energy availability, amenorrhea and menstrual disorders, decreased bone mass and increased risk of stress factors and osteoporosis (Quinn, 2012).

2.2 Historical perspective

2.2.1 Conceptual Models of Body Composition

Accurate assessment of body composition is essential to obesity research. Over the years, the human body mass has been conceptually divided into numerous fractional masses by assuming the different qualities of body tissues, water holding qualities and differential densities of various tissues. Many contemporary scientists contributed to the field of body composition research as it exist today even though the interest in the topic extends back several thousands of years (Heymsfield, 2005). On the basis of these qualities, the models may be conceived as ranging from a single-compartment to multi-compartment. The division of the body mass can be made by considering the major components of the body, e.g., fatty tissue, muscular tissue, skeletal tissue and connective tissue. These studies on body composition would, therefore, assess quantitatively the amount of tissues. Human cadavers and animals can become the subjects for the direct analysis of body composition; however, indirect methods are required to obtain information about the body composition in living persons. A survey of the literature for the last 50 years shows that there has been an evolutionary process from the basic 2-C models to the presently popular 4-C models of body composition. The following is the nomenclature of the different conceptual body masses.

Two-Compartment Models

Some of the earliest information about the composition of the human body was based on chemical analyses of specific organs, and occasionally of the whole body. The basic two compartment (2-C) model divides the body into two parts. One consists of body fat, and all the remaining tissues are lumped together into the part known as the fat-free mass (FFM). The direct measurement of body fat mass has never been easy and remains a significant challenge for most body composition techniques. However, in order to estimate the body fat, the difference between the body weight and the total FFM can be obtained. In the basic 2-C model, the body is divided into two parts. The 2-C model, which has been used in body composition research for more than 50 years, continues to serve a vital role, especially in the evaluation of newer technologies focusing on body fat assessment. The earliest and probably the most frequently used 2-C model is based on the measurement of total body density. The most common method is hydro densitometry or under-water weighing (UWW), which can be traced to the pioneering work of Behnke and co-workers (Behnke et al, 1942). This method primarily evolved at universities with a special focus on body fitness, often relating the measurement to human kinetics, exercise, and sports performance. At the same time, two nuclear-based methods, 40K counting and dilution with radioactive water, each of which required more sophisticated technologies than UWW, were also emerging for use with the 2-C body composition model. For the assessment of body fatness with either of these nuclear-based models, the water or potassium content of the FFM had to be measured, and their relative concentrations were assumed to be constant for all ages and the density of the FFM for the 2-C model was assumed constant. As long as healthy young white adults were being studied, use of these three constants was satisfactory. However, when the populations included very young or old subjects, different ethnic groups, or subjects with certain diseases, it quickly became evident that these constants were, at best, only average values that were often population specific (Ellis, 2000).

Three-Compartment Models

In order to reduce the limitations encountered with the 2-C models, a three-component (3-C) configuration was proposed which included a measurement of total body water (TBW). In this 3-C model, the FFM is divided into two parts: its water content and the remaining solids (predominately protein and minerals). Also in this model, the density of water, fat, and body solids are used. The results obtained using this model provided some improvement over the basic 2-C model for healthy adults and older children. However, for patients with significantly depleted body protein mass and/or bone mineral mass, the estimated values for the density for the solids compartment would be incorrect; thus the final estimate of body fat mass was also inaccurate (Ellis, 2000).

Four Compartment Models

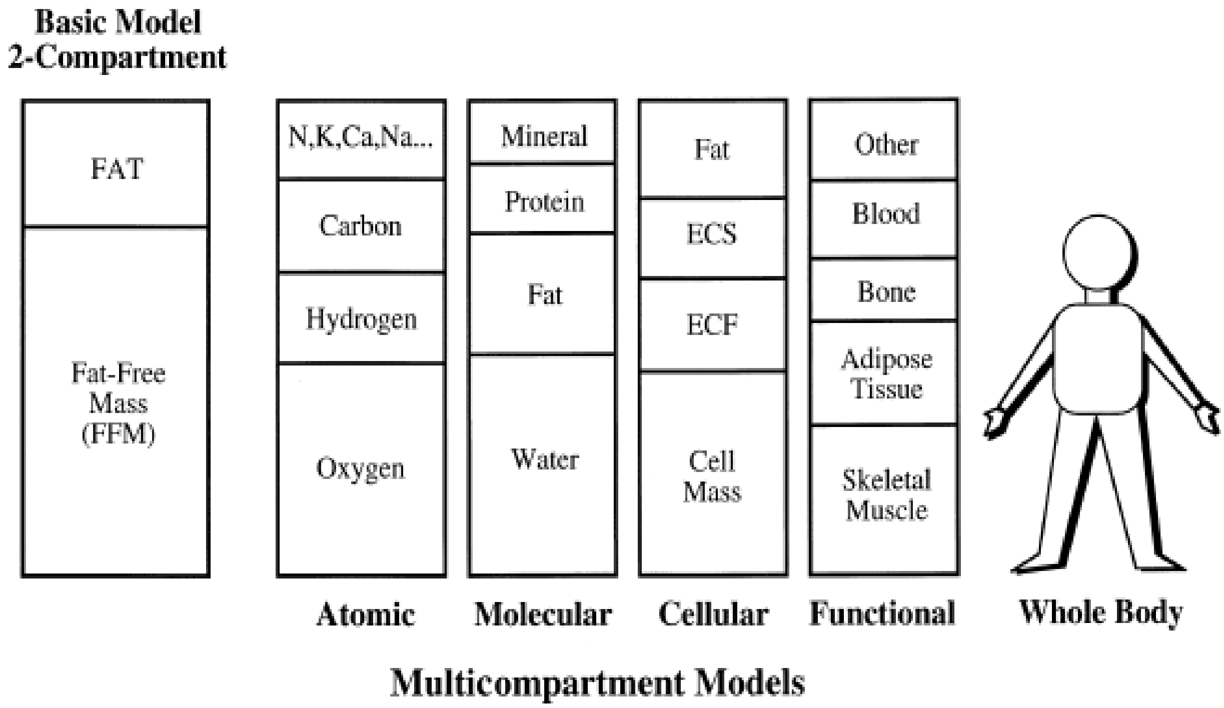
To adjust for the limitations of a 3-C model, a four-compartment (4-C) model was proposed. In addition to body water, an accurate measure of the protein and mineral compartments that make up the FFM was included. For this four-component (4-C) UWW model, the densities for body protein and bone mineral can be assumed as 1.34 and 3.075 kg/l, respectively (Synder et al, 1984). However, to obtain a measure of the mass of each of these body compartments, two additional measurements [neutron activation analysis for body protein and dual-energy X-ray absorptiometry (DXA) for bone mineral content] would be needed. This requirement, therefore, introduces somewhat of a dilemma with the use of the 4-C UWW model because if these two additional techniques are used, then they can be used directly to provide an accurate estimate for the body fat mass without the need for the UWW measurement. It is more common practice with the 4-C UWW model that the protein mass is assumed proportional to the bone mineral mass, independent of age and gender. However, changes in the mass of the protein component may be of a concern if not accounted for accurately.

An alternate 4-C model, which does not require the UWW measurement, has also been developed. In this model, the body's FFM is divided into three basic cellular or physiological compartments: body cell mass (BCM), extracellular water fluid or water (ECW), and extracellular solids (ECS). One of the limitations with this model for estimating FFM is that the measurement errors are cumulative and transfer directly in mass units to the final estimate for body fat mass (Ellis, 2000).

Multi-Compartment Models

With each additional measurement it may be possible to extend the number of compartments in the body composition model. Each additional measurement, however, must be compositionally independent of the previous measurements as they can provide separate confirmations for ECW volume that may not be obtained with a single measurement technique. If only one method is used, then there are technical or model limitations resulting in increased uncertainties associated with that method. Whenever possible, it is best to use repetitive or overlapping methods if confirmation of a normal or abnormal status is the targeted outcome. Techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) also provide useful information about anatomical structure and can be used to monitor specific organs. These two latter scanning techniques should not be viewed as equivalent to the basic chemical composition model, because in many diseases the apparent volume can be normal, when the chemical composition is significantly abnormal. The pioneering work of Wang and others in 1992, helped to collate all of this information and to present it as a comprehensive, five-level model of body composition (Heymsfield, 2009). This five-level model has become the standard for body composition research. The five levels of the model are as follows: atomic/elemental, molecular, cellular, tissue systems, and total body. It is interesting to note that the basic 2-C models tend to start at each end of the spectrum. As each model includes more measurements, it tends to migrate toward the cellular or physiological model. Consequently, the reconstruction of body composition from the elemental level is often more reliable and minimizes the assumptions related to tissue density, hydration, and/or structure. In many ways, an accurate in vivo chemical profile of the human body can serve as a replacement for the classical wet chemistry assays used previously to study human cadavers.

Figure 2.1: Basic two-compartment model and five-level multicompartment model of body composition



Source: Ellis, 2000

2.2.2 Measurement of body fat

Earliest studies on body composition were conducted on animals with a view to analyze the quality of flesh and describe its composition. Studies were conducted involving changes in body fat and lean body mass as a result of feeding animals, and it was noticed that the amount of fat varied inversely with the amount of body water (Singh and Mehta, 2009).

Analyses of tissue biopsies have long been a part of the practice of medicine and have contributed greatly to the fundamental knowledge of the basic physiology and metabolism of the human body. Although it is difficult to extrapolate from a single tissue sample to a complete organ or the whole body, extrapolation is often the source of substantial error when estimating total body composition. Notwithstanding this limitation, most of the information about the composition of the human body have been derived in this manner and has been compiled over the years into the concept of the Reference Man (Snyder et al, 1984).

Albert Behnke (1942) made pioneering efforts at distinguishing overweight from obesity. It had earlier been understood that anybody whose weight was beyond certain defined limits was overweight, and hence, had unwanted amounts of fat. As the densities of fat and lean body mass differ, therefore, it is possible to differentiate their relative amounts if the density of the body could be measured. Behnke applied Archimedes' principle to evaluate body density, and then to convert it into the amounts of fat and lean body mass. This was followed by a fervent activity at standardizing the techniques for assessing the body density by underwater weighing and by water displacement methods. Detailed experimentations were conducted by Keys and Brozek in 1953 to measure the body density, correct it for residual lung volumes and to devise formulae for the calculation of percentage of fat and lean body mass (LBM) (Singh and Mehta, 2009).

As early as 1940s, weight-for-height standards were used by the insurance companies and the military authorities to assess the desirable weight of persons. However, Behnke was able to expose the fallacy of such weight for height standards in designating people who were overweight and fat. From the body composition studies of elite football players who were designated as too fat and overweight on the basis of height-weight standards, Behnke found them highly muscular and extremely fit individuals with very little amount of fat. Terming them as physically unfit for being overweight was improper as they were the best by virtue of their body composition analysis (Singh and Mehta, 2009). This landmark study opened new vistas in body composition research which later found wide applications in the fields of physical fitness, sports science and medicine.

Methods used to estimate and measure the body fat range from relatively simple field methods using anthropometrics, such as BMI, WC,WHR and WHtR to highly sophisticated approaches requiring specialized laboratories and equipment such as densitometry, air displacement plethysmography, hydrometry dual-energy X-ray absorptiometry (DXA), bioelectric impedance analysis, magnetic resonance imaging (MRI) and computed tomography (Quinn, 2012).

Anthropometry

Anthropometric measurements can then be used in population-specific prediction equations to estimate various components of body composition. For example, mid-arm and mid-thigh circumferences can be used to estimate muscle mass in the absence of more direct methods. Waist and hip circumferences can be used to characterize the distribution of body fat on the torso – an important independent risk factor for heart disease and diabetes mellitus. Anthropometric methods, as measures of subcutaneous fat and rough estimates of muscle mass, are, however, indirect in their ability to estimate total body composition. In addition, considerable training to take measurements as well as to monitor patients is required to achieve sufficiently high reliability for scientific research purposes.

Body mass index (BMI), defined as weight in kilograms divided by square of height in meters, is often used to determine overweight and obesity in the clinical environment, usually by comparison of an individual to age- and sex-specific percentiles from a reference population (Flegal, Ogden, Wei, Kuczmarski and Johnson , 2001). Although the BMI values are widely applied to both children and adults, there are serious limitations regarding the use of BMI as an index of adiposity in children. BMI in adults is largely independent of stature; it is not, however, independent of stature in children and is quite sensitive to body build. For example, children and youths with undersized legs for their height will have higher BMI values compared with children with longer leg lengths relative to their height. Furthermore, despite high positive correlations between measures of BMI and adiposity, such as total body fat (TBF) and percentage body fat (PBF) across all age groups, BMI also has a strong positive correlation with FFM in children (Siervogel et al, 2000).

Because of the differences in body composition between men and women, at the same BMI women will tend to have a considerably higher percentage of body fat than men (Ogden, Yanovski, Carroll and Flegal, 2007). Similarly, older persons tend to have a higher percentage of body fat than younger people at the same BMI because of changes in body composition with age. A given value of BMI may be numerically the same for men and women and for people of different ages, but may not represent the same percentage of body fat, the same degree of risk, or even necessarily the same degree of overweight relative to weight standard (Ogden, Yanovski, Carroll and Flegal, 2007).

Abdominal obesity is generally assessed by either waist circumference (WC) or waist hip ratio (WHR). Waist measurement is best undertaken using a specially designed tape measure. The tape should be placed around the abdomen at the midpoint between the lower rib margin and iliac crest (right or left protrusions of the pelvic bone) and the measurement should be made horizontally at the end of gentle expiration (Ayvaz and Çimen, 2011). Waist circumference (WC) has been shown to be a highly sensitive and specific marker of upper body fat accumulation in children (Taylor, Jones, Williams and Goulding , 2000).WC is an important independent measure in the assessment of obesity-related health risk (Health Canada, 2003). It is used to assess obesity-associated cardio-metabolic risk in clinical practice (Klein, Allison, Heymsfield, Kelley, Leibel, Nonas C,Kahn, 2007), as well as in epidemiological studies (Pischon, Boeing, Hoffmann, Bergmann, Schulze, Overvad, van der Schouw, Spencer, Moons, et al , 2008).

The waist-to-height ratio (WHtR) of a person is defined as the person's waist circumference, divided by the person's height. WHtR is emerging as a new anthropometric index with a potential for global application (Ashwell and Hseih, 2005). The WHtR is a measure of the distribution of body fat. Higher values of WHtR indicate higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity (Lee, Huxley, Wildman and Woodward, 2008). The use of waist-to-height ratio (WHtR) for detecting central obesity and its associated health risks was first proposed in the mid 1990s (Ashwell and Browning, 2011). Interest in the practicality and effectiveness of this measure is rising in both adults and children (Ashwell and Hseig, 2005; Schneider, Glaesmer, Klotsche, *et al* 2007; Freedman, Kahn, Mei, Grummer-Strawn, Dietz, Srinivasan, and Bernson, 2007). A previous study systematically reviewed the evidence supporting the use of WHtR, a proxy for abdominal fatness, as a predictor of cardiovascular disease (CVD) and diabetes, and their risk factors. In order to put the relationships into context, the review drew on evidence from prospective and cross-sectional studies, in adults and in children, which reported relationships between WHtR and either body mass index (BMI) or waist circumference (WC), or both. The analyses showed that WHtR and WC were significant predictors of these cardiometabolic outcomes more often than BMI, with similar odds ratios; sometimes being significant predictors after adjustment for BMI (Browning, Hsieh, Ashwell, 2010). A boundary value of WHtR=0.5 indicates increased risk for men and women and people in different ethnic groups. WHtR may also allow the same boundary values for children and adults. WHtR boundary values can be converted into a consumer-friendly chart.

Densitometry

Densitometry was developed in the early 1960s and uses the difference between body weight measured on dry land and during total water immersion to estimate total body density. This technique involves measuring a subject's weight in air and underwater. This is based on the principle that fat is less dense than water and that an individual with more body fat will have a lower body density. Percentage body fat is calculated with prediction equations based on the two-compartment model. Major limitations of densitometry, however, include cumbersome equipment (i.e. a water tank), participant performance and discomfort (i.e. water immersion) and a restriction to a two-component view of body composition (fat mass and FFM) (Chumlea and Guo, 2000).

Air Displacement Plethysmography

Air displacement plethysmography is a recently developed technique using air rather than water displacement for measuring body volume and density. The technique measures changes in gas pressure when a patient enters a closed chamber, resulting in the displacement of air (Demerath, Guo, Chumlea, Towne, Roche and Siervogel, 2002). The volume of air displaced is directly related to the total body volume of the patient, allowing for an estimation of total body density, via the measurement of body mass. This method requires adjustments for body temperature, body surface area and the volume of air exhaled during the test. The resulting total body density estimate can be used to calculate percentage body fat, TBF and FFM.

There is only one commercially available system for air-displacement plethysmography, which is known by the trade name BOD POD (Life Measurement, Inc, Concord, CA). Air-displacement plethysmography offers several advantages over established reference methods, including a quick, comfortable, automated, non-invasive, and safe measurement process, and accommodation of various subject types (e.g. children, obese, elderly, and disabled persons) (Fields, Goran, and McCrory, 2002). Another clear advantage of this technique compared with the densitometry measurement is that the subject does not have to be submerged in water; however, it has all of the technical limitations of the densitometry method. Multiple readings over a short period of time can be obtained, which will help to average out some of these concerns.

Dilution method (hydrometry)

This method measures total body water using isotopes based on the principle that water exists in a fairly stable proportion to fat free mass. Total body water is calculated with validated dilution equations. Total body water quantity and distribution is affected by many pathological and physiological conditions. Deuterium water, tritiated water and ^{18}O-labelled water ($H_2{}^{18}O$) can be used for measurement (Ayvaz and Çimen, 2011). The labeled water rapidly spreads within the body. The concentration of stable and labelled molecule is measured and total body water is calculated with the use of dilution principle. Dilution principle states that the volume of the compartment is equal to the amount of tracer added to the compartment divided by the concentration in the compartment (Mattsoon and Thomas, 2006).Total body water is measured with high accuracy rate with a 1 to 2% margin of error (Mattsoon and Thomas, 2006).

Bioelectric Impedance Analysis (BIA)

Bioelectric impedance analysis (BIA) is one of the many methods currently use to assess body composition. It is used for calculating total body water, FFM and fat tissue mass. This method is based on the principle that the conductivity of body water varies in different compartments (Ayvaz and Çimen, 2011). BIA measures the impedance to an applied small electric current as it passes through the body's water pool (Lee and Gallagher, 2008). From an established equation that uses the measured impedance value and height, total body water is estimated (Mattsoon and Thomas, 2006). Then fat-free mass is calculated assuming 73% of humans' fat-free mass is water (Lee and Gallagher, 2008). Fat mass is found by subtracting fat-free mass from body weight. Single frequency BIA is capable of assessing TBW and FFM but not intracellular and extracellular water (Lee and Gallagher, 2008). . Multi frequency BIA or bioimpedance spectroscopy can measure total body water as intracellular and extracellular water. Multi segmental BIA can analyse composition of extremities as well as trunk (Lee and Gallagher, 2008). It is probably the most frequently used method, due mainly to the relatively inexpensive cost of the basic instrument, its ease of operation, and its portability. Most body composition methods are costly and difficult to transport and require specialized teams for their maintenance and optimum performance. In contrast, BIA systems are usually inexpensive, easy to carry from one site to another, and simple to operate. BIA, therefore, is a useful supplement to anthropometry.

There is growing use of BIA in field studies of body composition (Mueller et al, 2004). An important limitation of BIA methods is that when measurements are made, a slight change in the place of electrodes can produce differences in results. The measurements can show 2% variability in different days (Ayvaz and Çimen, 2011).

Dual-Energy X-Ray Absorptiometry (DXA)

The use of Dual-energy X-Ray Absorptiometry (DXA) in the evaluation of body composition is becoming more widespread. The method is quick, has a relatively low cost and can be easily used in clinical studies and in various health care delivery locations (Ayvaz and Çimen, 2011). This technique is based on the principle that the two x-ray beams of very low but different energy passing through the body are attenuated differently by bone mineral tissue and soft tissue. It provides estimates of the three components of the whole body (fat-free mass, fat mass and bone density) for specific regions such as the arms, legs and trunk.
Radiation exposure from DXA is considered small and is equivalent to 1-10% of a chest radiograph (Lee and Gallagher, 2008). DXA can also be used in large community-based studies. Due to the emission of tissue specific energy by X-rays, it directly measures body fat in line with the triple compartment model (fat tissue, bone and lean tissue) (Andreoli, Scalzo, Masala, Tarantino and Guglielmi, 2009). DXA results of fat mass are influenced by trunk thickness. This issue is important in obese subjects. As trunk thickness increases, the measurement error increases (Lee and Gallagher, 2008). Although DXA measurements produce quite detailed and fairly accurate results for fat tissue mass, FFM and bone mineral content, its disadvantage is that it cannot be repeated frequently due to radiation exposure (Andreoli et al, 2009).

Computed tomography/magnetic resonance imaging

Computed tomography (CT) and Magnetic resonance imaging (MRI) are considered as the most accurate methods for quantification of skeletal muscle and adipose tissue and its distribution (Ayvaz and Çimen, 2011). These techniques are used for validation of other methods such as BIA (Mattsson and Thomas, 2006). Regional fat distribution is imaged reliably with MRI and CT. MRI and CT can also be used in the evaluation of the fat content of muscle and liver. Their utilization is increasing in body composition analysis. CT outlines the structure of internal organs. CT acquires images with computer analysis through the use of X-rays. CT differentiates tissues and organs based on their attenuation characteristics. MRI requires a closed magnetic area and a relatively longer time for measurement than CT. Although the two imaging modalities are completely different in technique, their results in subcutaneous and visceral fat tissue assessment are similar (Ayvaz and Çimen, 2011). MRI has been used in the determination of quantity and distribution of fat and muscular tissue. MRI can measure the volume of subcutaneous, intra-abdominal, visceral and intramuscular adipose tissue. There is no X-ray exposure, making this method conveniently applicable to children and adolescents (Mattsson and Thomas, 2006).

2.2.3 Perspective of people regarding body shape, size and obesity

Although body image is clearly multidimensional, it may be broadly defined as the mental picture of one's body- how it looks feels and moves (Croll, 2005). While most scholars agree that body image encompasses multiple physical and personal characteristics, in the context of Western societies, body image perceptions have been strongly associated with perceptions of body weight. In contrast, other scholars have provided a broader perspective on the study of the body and the importance of perceptions of the body to our understanding of experiences of health and illness (Willis, Miller and Wyn, 2001).

Generally, people hold varying views on the perfect body shape or size. Obesity and overweight of the various sexes and age groups are also viewed differently by various groups of people. Albert Stunkard (1963), the Chairman of the Psychiatry Department at the University of Pennsylvania, in a published question and answer period, addressed the stereotype of the "jolly" fat person: "In this day of emphasis on psychosomatic medicine, the usual stereotype of the obese person is that of the frustrated neurotic." In addition, Stunkard pointed out that fat people are considered "fair game for ridicule" and are "scapegoats," are associated with lower socioeconomic segments of society, fat men are considered "jolly" and fat women "motherly, nurturing." Some of these stereotypes still stand even almost 50 years later (Helb and Turchin, 2005; Teachman, Gapinski, Brownell, Rawlins and Jeyaram, 2003).

Psychological research conducted on obesity can be categorized into two areas: (a) that examining the heavy individual's perspective and (b) that examining the reactions that perceivers have toward heavy individuals (Turchin, 2005). From the heavy target's perspective, studies show that being heavy is not necessarily associated with general psychological dysfunction such as anxiety and depression, although it is moderately correlated with lowered self-esteem (Miller and Downey, 1999). Heavy targets tend to believe the obesity stigmatization they receive is warranted, but they are sometimes able to compensate for the discrimination they face (Miller, Rothblum, Felicio and Brand, 1995; Quinn and Crocker, 1999). From the perceiver's perspective, research has shown that there are stereotypes and negative attitudes toward obese individuals that characterize them as lazy, undisciplined, and unhappy (Hebl & Mannix, 2003). Heavy individuals are discriminated against in academic domains (Crandall, 1995), professional employment (Hebl and Kleck, 2002), health care settings (Hebl and Xu, 2001), and interpersonal domains (Hebl and Mannix, 2003). However, Christakis and Fowler (2007) present data which provides a contrasting point of view, that obesity is becoming more acceptable. Whether attitudes toward obesity are more acceptable or maintain the stigma suggested in most of the literature, these beliefs are strongly affected by cultural contingencies including race, ethnicity and gender.

Across racial and ethnic populations, perspectives differ: obese people have more or less latitude and stigma depending on the socio-cultural context. Perceptions differ between Africans and Caucasians, African-Americans and white Americans; for instance, white women (with the lowest obesity rate of any categorized group with the exception of Asian's who have lower overall obesity rates) stigmatize obesity the most and are stigmatized the most for being obese (Helb and Turchin, 2005). Studies show that while black women have a higher prevalence of overweight as compared to white women, they generally experience less body dissatisfaction, have a larger ideal body size, are more tolerant of a variety of body sizes and feel attractive at higher weights (Celio, et al., 2002). Previous studies have suggested that heavier body image ideals and a greater cultural tolerance for larger body sizes among black women may serve as a protective factor in the development of certain types of eating disorders, such as anorexia nervosa and bulimia nervosa (Striegel-Moore, Dohm, Kraemer, Taylor, Daniels, Crawford, et al., 2003).

In some African cultures, being fat is a symbol of good life and wealth. In a rite of passage, some Nigerian girls spend months gaining weight and learning customs in a special room.

“To be called a ‘slim princess’ is an abuse,” says a defender of the practice (Simmons, 1998). However in Nigeria, this practice which was common among the Calabar people is now less popular. In another study, the body size perception of African women in the Mangaung was determined by Venter and others (Venter, Walsh, Slabber and Bester, 2009). Body size perception was determined by having the subjects respond to a series of photographs representing five body mass index categories. Although almost one third of the respondents viewed the overweight body as healthiest and obese people were considered wealthier, obesity was not often seen as attractive.

Gender injects another dynamic into general attitudes toward obesity. In the United States there is a strong cultural anti-fat bias that has particular manifestations of obesity being a moral failure (Teachman, Gapinski, Brownell, Rawlins and Jeyaram, 2003; Helb and Turchin, 2005) but among individuals in different populations there is less or more bias attached to obesity. The idealized body of men, which conjures virility, strength and musculature, is increasingly prevalent in popular culture and is initiating more men into a “struggle with body image similar to what women have long experienced” with some gendered differences (Tager et al, 2007).

The main aspect of body size considered important by children, regardless of their own size, appears to be how being large can affect popularity and fitting in (Rees, Oliver, Woodman and Thomas, 2011). Body size was seen by children to affect both the way they interact with each other and how included they feel. Children thought that overweight children might not have people to play with, or be lonely (Girl Guiding, 2007), might be less popular than thin children (Dixey, Sahota, Atwal and Turner , 2001; Girl Guiding, 2007), might only have fat friends (Mulvihill, Rivers and Aggleton, 2000), might need to choose a boyfriend or girlfriend the same size as themselves (Girl Guiding, 2007), or might even need to get slim in order to make friends (Edmunds, 2000).

2.2.4 Obesity Prevention

From a population perspective, obesity prevention means lowering the mean body mass index (BMI) level and decreasing the rate at which people enter the upper end of the BMI distribution. Within the population, accomplishing this will require that adults at a healthy weight (i.e., not underweight, overweight, or obese) maintain that status and avoid the phenomenon of excess weight gain that commonly accompanies aging. For children, prevention means maintaining a healthy weight trajectory and preventing excess weight gain while growing, developing, and maturing. Prevention for individuals who are already overweight or obese can be defined as avoiding progression to a more severe level of obesity and/or preventing or delaying the onset of obesity-related medical conditions (IOM, 1995).

Studies have evaluated four major types of interventions that were expected to produce weight gain prevention effects. These include: (a) multi-focus cardiovascular disease prevention programmes that targeted obesity along with other risk factors for cardiovascular disease (e.g., hypertension and smoking), (b) prevention programmes that focused solely on the prevention of obesity or weight gain, (c) interventions designed to solely increase physical activity, and (d) eating disorder prevention programmes that promote use of healthy weight management skills (Stice, Shaw and Marti, 2006).

Researchers have hypothesized that obesity prevention programmes are more effective when they are delivered to middle school or high school students versus grade school students (Baranowski Cullen, Nicklas, Thompson, and Baranowski, 2002). This is due to the fact that younger children may find it difficult to grasp the concepts and skills taught in the interventions and may also be less likely to impact the food purchases made by adults.

Families and schools represent the most important foci for preventive efforts in children and adolescents. One productive approach is to proceed from an examination of factors that affect energy balance to the identification of more proximal influences on those factors. This approach may help to narrow the strategies necessary to prevent or treat childhood obesity (Dietz and Gortmaker, 2001).

Results from prior trials suggest that obesity prevention programmes that promote a healthier lower-calorie diet (Perry et al., 1998) and those that also attempted to increase physical activity and/or decrease sedentary behavior (Gortmaker et al., 1999) produced larger effects for females than for males. However, another obesity prevention programme that promoted healthy lower-calorie diets and increased physical activity found significantly stronger effects for males than for females (Kain, Uauy, Vio, Cerda and Leyton, 2004) and one obesity treatment trial found that an intervention solely aimed at increasing activity and decreasing sedentary behaviours was more effective for boys than girls, though an intervention solely focusing on increasing activity level was equally effective for boys and girls (Epstein, Paluch and Raynor, 2001).

2.3 Epidemiology of excess body fat mass

Worldwide epidemiology of obesity

Obesity has reached epidemic proportions globally, with at least 2.8 million people dying each year as a result of being overweight or obese. Once reported as the problem of high-income countries, obesity is now also prevalent in low- and middle-income countries (WHO, 2012).
The prevalence of obesity has increased sharply over the last three decades; currently 65% of adults are classified as overweight or obese (Hedley et al., 2004). The prevalence of obesity has risen even more sharply among adolescents and young adults (Hedley et al., 2004), which is alarming because obesity persists into adulthood for 70% of obese adolescents (Magarey, Daniels, Boulton and Cockington, 2003). Obesity also carries a high fiscal cost; roughly $100 billion per year is spent on obesity-related health care (Wolf, 1998).

Prevalence estimates of obesity usually are derived from surveys or population studies because systematic data on obesity generally cannot be gathered from medical records or vital statistics. Virtually all data on prevalence and trends are based on measurements of weight and height using various cut-offs such as BMI categories and BMI-for-age classifications rather than on body fat because of the logistical difficulties involved in measuring body fat in population studies (Ogden, Yanovski, Carroll and Flegal, 2007).

The National Health and Nutrition Examination Survey (NHANES) program provides national estimates of overweight for adults, adolescents, and children in the United States. A series of cross-sectional, nationally representative examination surveys conducted by the National Center for Health Statistics of the CDC, the NHANES surveys were designed using stratified multistage probability samples. Currently, NHANES includes oversampling of adolescents, Mexican Americans, and African Americans, among other groups, to improve estimates for these groups. All of the surveys included a standardized physical examination in a mobile examination center with measurement of recumbent length, stature, and weight. Stature was measured in children 2 years and older and recumbent length in children younger than 4 years (NHANES, 2006).

In 2003–2004, 32.9% of adults 20 –74 years old were obese. In the early 1960s, the prevalence of obesity was 11% among men and 16% among women. The prevalence changed relatively little over the time period from 1960 to 1980. However, between 1976 and 1980

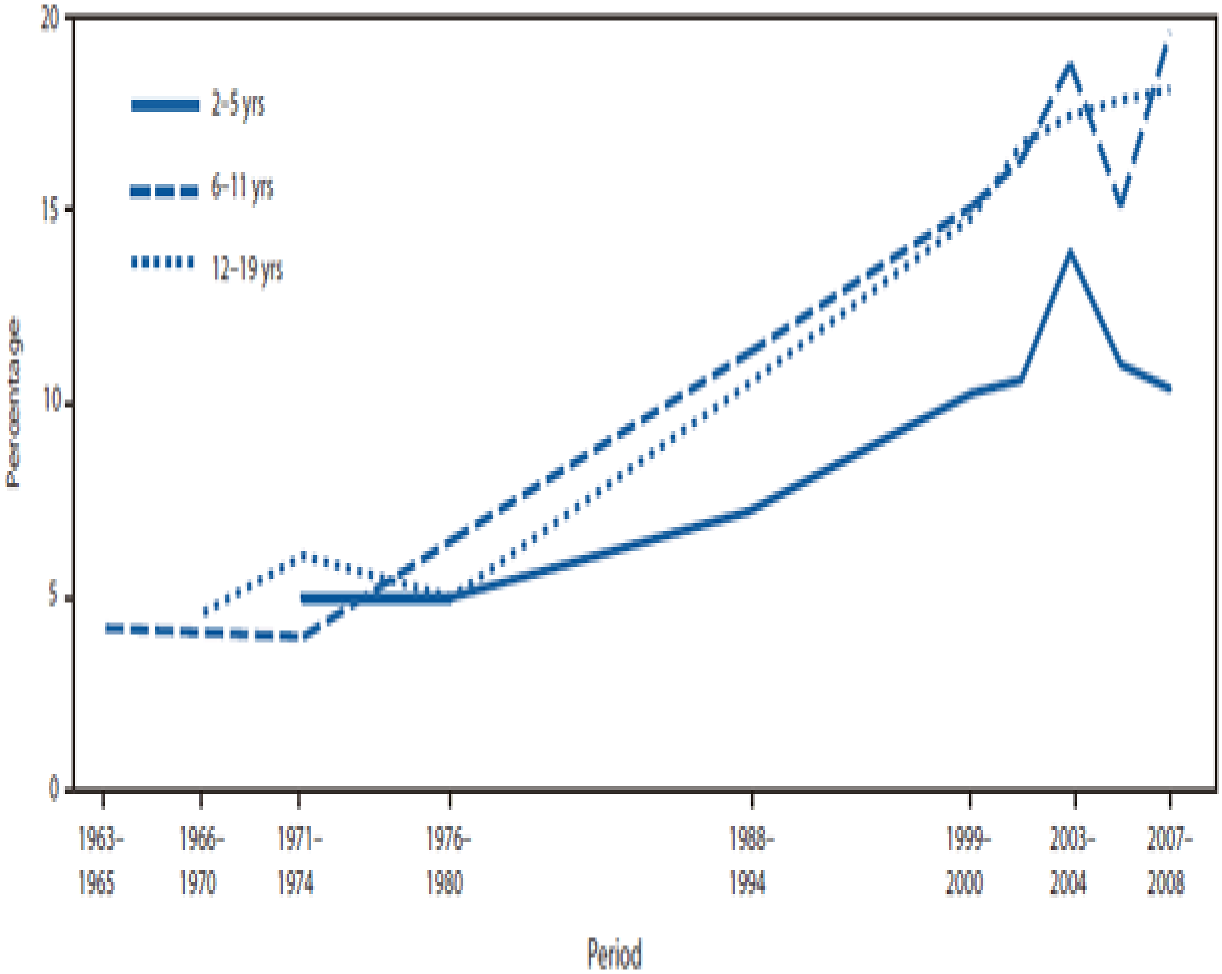
(NHANES II) and 1988 and 1994 (NHANES III), the prevalence of obesity increased considerably, to about 21% in men and to about 26% in women. By 2003–2004 the prevalence had increased to almost 32% in men and 34% in women. Even during the short time period between 1999 and 2004 there was a significant increase in the prevalence of obesity among men, but not among women (Ogden, Carroll, Curtin, McDowell, Tabak and Flegal, 2006). Trends among children and adolescents were similar to those among adults. After little change was seen in the prevalence of overweight among children and adolescents in the 1960s and 1970s there was an increase between NHANES II and NHANES III and a further increase between NHANES III and NHANES 2003–2004. By 2003–2004, more than 17% of teenagers (12–19 years of age) were overweight (Figure 2.1). The prevalence of overweight among boys and girls increased significantly during the 6-year time period from 1999 to 2004.

In England, the prevalence of obesity (BMI ≥ 30) among women 25–34 years of age increased from 12% to 24% in only 9 years between 1993 and 2002 (Rennie and Jebb, 2006). In Portugal, increases in overweight among school-age children also have been found (Padez, Fernandes, Mourao, Moreira, and Rosado, 2004). Less-developed countries also have seen increases in obesity. Among preschool-age children in urban areas of China, the prevalence of obesity increased from 1.5% in 1989 to 12.6% in 1997(Luo and Hu, 2002).

Differences in the prevalence of obesity between countries in Europe or between race-ethnic groups in the United States tend to be more pronounced for women than for men (Seidell and Flegal, 1997).

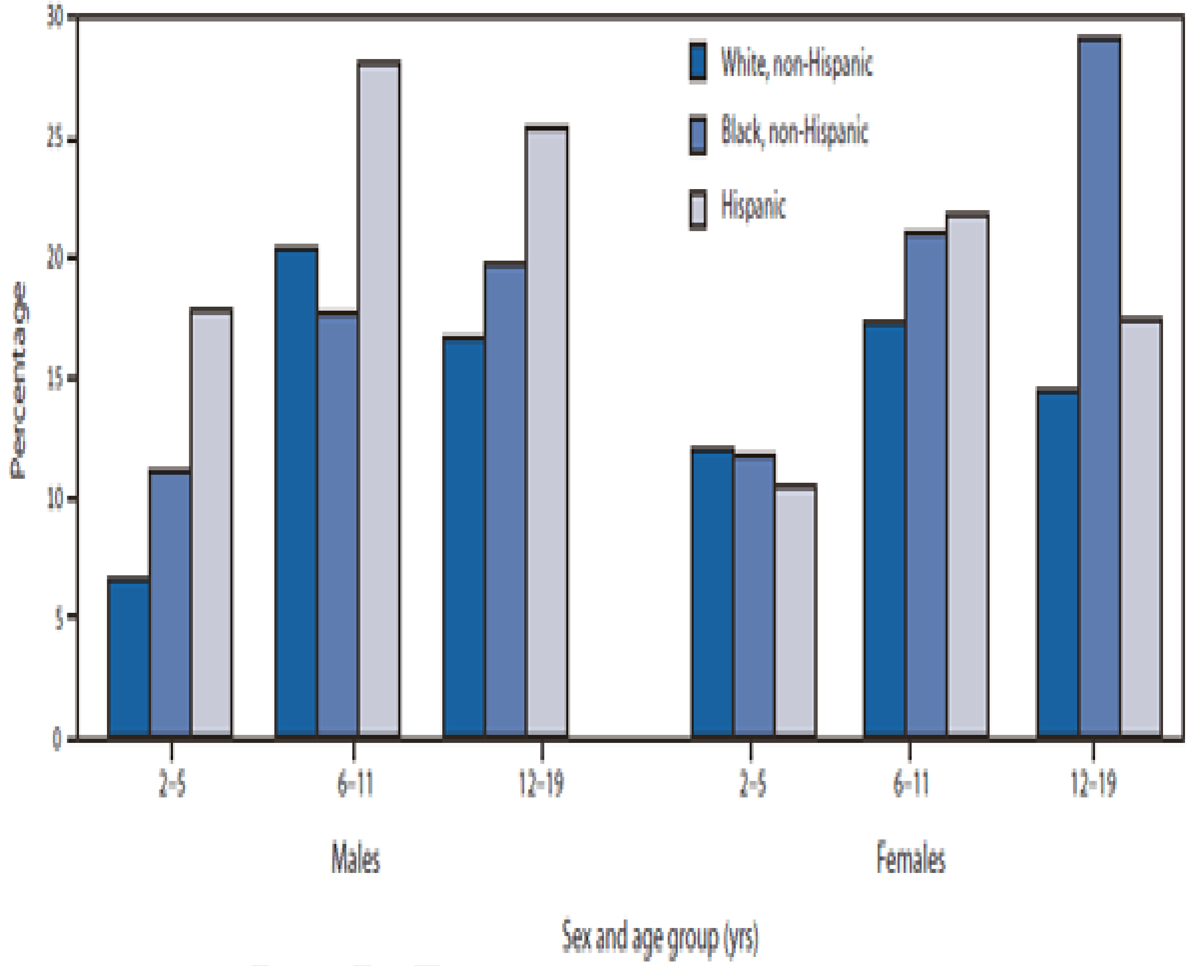
For example, in Europe, the WHO Multinational Monitoring of trends and determinants in cardiovascular disease study, which gathered data from 39 sites in 18 countries, found the prevalence of obesity was similar for men across all sites. For women, however, there were marked differences in prevalence between sites, with higher values for women from Eastern Europe. Similarly, in the United States, there are marked differences in the prevalence of obesity by race-ethnic group for women but not for men. Among teenagers in 1999 –2004 in the United States, differences by race/ethnicity exist for both boys and girls.

Figure 2.2: Trends in obesity among children and adolescents: United States, 1963-2008



Source: CDC, 2011

Figure 2.3: Prevalence of obesity among children and adolescents, by sex, age group, and race/ethnicity in United States, 2007--2008



Source: CDC, 2011

Epidemiology of obesity in Africa

There has been a growing epidemiological trend of obesity from developed countries to the developing world, including Africa. Obesity is a growing problem in these countries, especially since female fatness is viewed as a sign of social status and is a cultural symbol of beauty, fertility and prosperity. In Morocco results from the 1984 national household consumption and expenditure survey (Government of Morocco Ministry of Socio-Economic Affairs, 1984/1985) already showed high levels of overweight and obesity among women in urban areas (20% of women with body mass index BMI> 28). In 1998, the pharmaceutical company ROCHE funded a national level survey in Morocco on 1500 men and women 15 to 60 years of age. Preliminary results indicate that the prevalence of obesity among women is 17.8% (ROCHE 1999). In Tunisia, the National Nutrition Institute completed a national survey in 1997, revealing female obesity to be a serious public health problem in that country. The prevalence of overweight and obesity (BMI ≥ 25) increased from 28.3% in 1980 to 51% in 1997. Obesity tripled in 17 years. At present, one out of every two women becomes overweight or obese. There is reason to be concerned about the level of obesity in North Africa. In Morocco and Tunisia, the prevalence of mortality from CVD (25–30%) and diabetes (10%) is high. In South Africa, some studies indicate a high prevalence of obesity both in low and high class subjects (Voster et al, 2000; Puoane et al, 2002). According to Uwaifo and Arioglu (2004), a clear and distinct secular trend of profoundly increasing BMI clearly exists when people from Africa migrate to countries in the Northern Hemisphere.

In Nigeria, initial data in the middle and later part of the 20th century suggested a low prevalence of overweight and obesity (Johnson, 1970); however recent reports from various studies indicate an increasing prevalence (Cooper et al, 1997; Lawoyin et al, 2002; Akpa, Agomuoh and Alasia, 2006). Some studies have documented alarming prevalence rates of 71.6% in females and 50.55 in males in a population of hypertensive patients, figures similar to that from developed countries (Amodu, Mba and Lawson, 2005).

Another study by Kadiri and Salako (1997) revealed that obesity was present in 21% males and 28% females while in a group of Type 2 diabetics 83% were overweight or obese (Fadupin, Joseph and Keshinro, 2004), all suggesting marked increase in prevalence comparable to what is obtained in the developed countries.
The reasons for these phenomenal increases in obesity rates in Nigeria can easily be attributed to rapid and unplanned urbanization, change from local dietary pattern to Western

style diet which is driven by proliferation of fast food outlets in major cities across the country (Akpa and Mato, 2008).

2.3.1 Factors that may influence body fat mass

Increased Percentage Body Fat (PBF), which causes overweight and obesity, usually results from a heterogeneous group of conditions. Body weight, size and shape is determined by an interaction between genetic, environmental and psychosocial factors acting through the physiological mediators of energy intake and expenditure. The major potential determinants of obesity as found from the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) included low socioeconomic status and parental overweight.

Socioeconomic status: Previous investigators have reported the relationship between socioeconomic status and obesity in developing countries to be positive and strong; implying that the higher the socioeconomic status, the more likely individuals will develop obesity (Rissanen, 1997; Bovet, Chiolero, Madeleine, Gabriel, and Stettler, 2003). On the other hand, a consistent and strong inverse relationship has been established between socioeconomic status and obesity in the developed Western societies (Stunkard, 1997; Rissanen, 1997). However, Fezeu et al (2006) submitted that the reported positive relationship between socioeconomic status and obesity may not be true for all developing countries. It is believed to be highly dependent upon the stage of industrial development of a country or region (Sorensen, 1995).

Studies from some developed countries show that adults in the low socioeconomic stratum have higher BMI than their better educated and wealthier counterparts (Flegal et al, 2000; Kuczmarski et al, 2000; Reilly et al, 1999). However, a finding from a developing country in West Africa, Ghana, showed that higher/middle class subjects exhibited higher BMI values compared to subjects from the lower class (Amoah, 2003). Recent studies have shown that the increasing economic and social development of each country, particularly in the developing countries, seems to rapidly shift the burden of obesity towards the poor, thus, increasing the rate of obesity among poor people (Popkin, 2002; Monteiro et al, 2004; Song 2006; Mbada, Adedoyin and Odejide, 2009).

A recent study shows that overweight and obesity are not related to affluence among Mauritian adolescents and having a low socioeconomic status could be a risk factor for pediatric obesity especially in girls in Mauritius (Fokeena and Jeewon, 2012). This corroborates the findings of studies conducted among adolescents in developed countries like Australia, USA, and Germany (McMurray, Harrell, Deng, Bradley, Cox, and Bangdiwala, 2000; Aranceta, Perez-Rodrigo, Serra-Majem et al, 2001; Morgenstern, Sargent, and Hanewinke, 2004; Hanson and E. Chen, 2007), and studies in Nigeria and Serbia, two developing countries (Mbada, Adedoyin, and Odejide, 2009; Grujic, Cvejin, Nikolic et al., 2009).

Age: A large study was conducted to characterize the relation between age and body fat in 4 ethnic groups- Asians, Blacks, Puerto Ricans and Whites (Mott, Wang, Thornton, Allison, Heymsfield, and Pierson Jr, 1999). The study showed a highly significant curvilinear relation between age and body fat was found, indicating a peak amount of body fat in late middle age and lower amounts of body fat at younger and older ages ($P < 0.001$). The age at which maximum body fat was predicted in the various groups ranged from 53 to 61 years for fat mass and from 55 to 71 years for fat percentage. In Puerto Rican men there was no significant relation between age and fat mass, and the relation between age and fat percentage was linear and positively correlated.

Sex: Studies have shown that women generally have a higher percentage of body fat (PBF) than men. A healthy body fat range for women 35 to 55 years of age is 25% to 32%, whereas a healthy range for men the same age is 10% to 18% (Heyward and Wagner, 2004). For this age group, a PBF of over 25% for men or over 38% for women is considered an indication of obesity.

A study was conducted by Taylor and others (Taylor, Gold, Manning and Goulding, 1997) among pre-pubertal children aged 3 to 8 years to determine if gender difference in body fat could be determined. Findings from this study revealed that boys had lower percentage body fat, lower fat mass and higher bone-free lean tissue mass than girls. This study helped to demonstrate that significant gender differences in body composition are evident well before puberty.

Percentage body fat of a cross-section of 1251 British school children and adolescents aged 5-18 years from white, South Asian and African-Caribbean ethnic groups was determined to evaluate gender and ethnic differences (Shaw, Crabtree, Kibirige, and Fordham, 2007). Findings from this study also revealed that significant gender differences in percentage body fat were seen, with girls having higher values from the age of 5 years. This difference in PBF increased from 3.8% at 5 years of age to 12.9% at 18 years of age.

Genetic susceptibility: Apart from rare obesity-associated syndromes, the genetic influences seem to operate through susceptibility genes. Such genes increase the risk of developing a characteristic but are not essential for its expression or, by themselves, sufficient to explain the development of a disease (Kopelman, 2000). The susceptible-gene hypothesis is supported by findings from twin studies in which pairs of twins were exposed to periods of positive and negative energy balance (Bouchard et al, 1990). The differences in the rate of weight gain, the proportion of weight gained and the site of fat deposition showed greater similarity within pairs than between pairs. This suggests differences in genetic susceptibility within a population determine those who are most likely to become obese in any given set of environmental circumstances (Kopelman, 2000).

Food/energy intake: A study conducted by the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) showed a statistically significant positive association between overweight as well as obesity and the total beverage intake, the consumption of water (including tea), of meat and sausages, the total food and beverage intake, and the intake of energy-providing food and beverages (Kleiser, Rosario, Mensink, Prinz-Langenohl and Bärbel-Maria Kurth, 2009). Furthermore, overweight was found to be positively associated with the consumption of soft drinks and fast food. There was a statistically significant negative association between both overweight and obesity and the consumption of juice, as well as between overweight and salty snacks and butter/margarine. No association, however, appeared between weight status and the consumption of vegetables and fresh fruit as well as for pasta/rice/potatoes, bread/cereals, milk/dairy products, fish, eggs, and sweets.

Several mechanisms have been proposed to explain why high fat intake should lead to greater body fat (Pi-Sunyer, 1990; Gershoff, 1995).Dietary fat is the most energy-dense macronutrient and lend greater flavor to foods, which could lead to over consumption (Willett, 1998). Also, dietary fat may be utilized more efficiently than carbohydrates and accumulate as body fat more readily (Astrup, 1993). However, Willett (1998) concluded that diets high in fat are not the primary cause of the high prevalence on excess body fat, nor are reductions in dietary fat a solution.

It is critical therefore, for policy makers to understand the links between nutrition and obesity development, as well as related dietary patterns.

Physical activity: The most variable component of energy expenditure is physical activity, representing 20–50% of total energy expenditure. Cross-cultural studies of physical activity and BMI demonstrate a sevenfold increased risk of overweight (BMI > 25) in those with a physical activity level ratio (total energy expenditure/RMR) of <1.8(Ferro-Luzzi and Martino, 1996). In developed countries there is a relationship between low levels of physical activity and obesity. A longitudinal Finnish study found that those reporting physical exercise three or more times each week had on average lost weight since a preceding survey. By contrast, those who undertook little physical activity gained weight and had twice the risk of gaining 5 kg or more (Rissanen, 1991). In Finland, a decline in physical activity at work and in transport during the past 10 years has been accompanied by a significant increase in leisure time. Among children in the United States, the relative risk of obesity is 5.3 times greater for children who watch television for 5 hours or more each day compared with those children who watch for less than 2 hours, even after correcting for a wide range of socioeconomic variables (Gormaker, 1996). In the United Kingdom, a study combining data on energy intake and physical activity in relation to the secular increase in adult obesity shows no relationship between total energy intake or fat consumption and the prevalence of obesity, but a close relationship between proxy measures of physical activity such as television viewing and car ownership (Prentice and Jebb, 1995).

Culture: Cultural practices also contribute to percentage body fat. In some cultures, especially in Africa, it is a sign of affluence for one to be overweight. A slim individual is seen as poor and lowly. However, an opposite trend is seen in developed countries where being slim especially for ladies is considered fashionable. In spite of this, however, a marked change in BMI is frequently witnessed in migrant studies, where populations with a common genetic heritage live under new and different environmental circumstances. Pima Indians, living in the United States for example, are on average 25 kg heavier than Pima Indians living in Mexico (Ravussin, 1995). A similar trend is seen for Africans living in the United States. In Nigeria the mean BMI for men and women is 21.7 and 22.6, respectively; in the United

States the average BMI for Nigerian men and women is 27.1 and 30.8, respectively (Wilks et al, 1996). This increasing prevalence of obesity is associated with adverse health consequences.

2.3.2 The Adolescent Body Composition

According to the World Health Organization (WHO), an adolescent is an individual aged 10 to 19 years of age (WHO, 2010). Adolescence is a transitional period of human life in which there are remarkable changes including physical appearance. They therefore have special nutritional requirements that must be met in order to help them through this developmental stage.

Three distinct growth phases have been recognized in childhood which is critical in the development of obesity (Raman, 2002). These are the fetal/infant phase, which is limited by nutrient availability to the mother, placenta or the infant, the childhood growth phase which is regulated by growth hormone and insulin-like growth factors and may also be limited by nutrient availability, and the pubertal or adolescent growth phase which is regulated primarily by the sex steroids. About a third of adult obesity in women has its onset in adolescence (Bradon et al, 1986), and the central fat accumulation in adolescent males poses increased morbidity and mortality risks.

The amount of fat mass in adolescent girls is usually higher than in boys (Rodriguez et al, 2004). Among adolescent girls, independently of the chronological age, pubertal development is associated with an increase of body fat, while adolescent boys show a decrease of body fat, higher pecks of height velocity and an increase of both shoulder span and leg-to-trunk length ratio. Sex differences in fat mass are apparent even long before puberty tends to start (Taylor et al, 1997; Attie and Brooks-Gunn, 1989).

In order to define overweight and obesity in adolescents, it is important that body fat cut-off values determined by reference methods (Rodriguez et al, 2004). The definition of excess body fat is somewhat arbitrary even if total percentage body fat (PBF) is known. This is because the level of adiposity may vary widely in relation with age, gender and pubertal development. In the absence of clear cut-off points, the most consistent %FM values for the definition of excess body fat in female adolescents range between 30 and 35% (Weststrate et al, 1989; Taylor et al, 2003; Taylor et al, 2002; Sardinha et al, 1999). Since adiposity in male adolescents decreases with age and sexual development (Taylor et al, 2002), PBF cut-offs selected for excess body fat in males are 25–30% for adolescents aged 10 to15 years, and 20–25% when subjects up to the age of 18 years are considered (Moreno et al, 2002; WHO, 1998).

2.4 Reviews of previous research as related to the study

Bioelectrical impedance analysis (BIA) is one of many methods currently used to assess human body composition. BIA is based on the principle that fat mass (FM) and fat-free mass (FFM) have different conductive and dielectric properties due to the fact that the FFM contains water and therefore has lower resistance than FM (Deurenberg et al, 1988). An electrical current is sent through the human body and the bioelectrical impedance (BI) is measured. Relating the BI to the conductors (the human body) height gives an assessment of total body water (TBW), and hence FM and FFM, can be calculated (Segal et al, 1985).

Bioelectric impedance was used to estimate equations for assessment of body composition in Sri Lankan children (Wickramasinghe, Lamabadusuriya, Cleghorn and Davies, 2008). These equations were derived to predict total body water and fat-free mass of 5- to- 15 year old healthy children. This helped to form a basis for predicting equations for South Asian Populations. However, this study was limited in the sense that other studies on other closely related populations by using multi-component body composition assessment need to be carried out.

Mok and others (Mok et al, 2006) compared the use of bioelectric impedance and skinfold-thickness measurements with the water dilution in estimating the body composition of children with Duchenne muscular dystrophy (Mok, Beghin, Gachon, Daubrosse, Fontan, Cuisset, Gottrand and Hankard, 2006). However, it was found out that bioelectric impedance analysis (BIA) method was closer to the water dilution method in predicting fat-free mass and fat percentage than the skinfold thickness method.

The Saarland Growth Study was used to analyse body composition of children, aged 3 to 11 years (Weinand, Muller, Zabransky, Danker-Hopfe, 2000). Measurement of height, weight, girth (abdomen, upper arm, calf) and skinfolds and bioelectric impedance (BIA) were taken. This study aimed to set up current reference charts of anthropometric data in the Saarland. However body fat estimated by a formula based on BIA test parameters yielded negative values so it was proposed that sex- and age-specific raw charts of BIA test parameters be used in future.

Body fat was measured by bioelectrical impedance in 14,842 Hong Kong Chinese children by Sung and others (Sung, So, Choi, Li, Yin and Nelson, 2009). This cross sectional study was conducted in order to establish reference standards for percentage body fat measured in Hong Kong Chinese children by various methods involving bioelectrical impedance analysis. Percentage body fat was measured with the Tanita Body Composition Analyzer (Model no. BF-522) and percentile curves were constructed using the least mean square (LMS) method. The repeatability of the percentage body fat measurement was assessed at different times of the day by BF-522 bioelectrical impedance analysis in a small sample of children. In another sample, assessment was by the BF-522 and two other models (Tanita BC-418 and BF-401) consecutively to test the agreement of percentage body fat values obtained by the three different models. An important point to note from this study is that readings obtained at different times of the day vary and data obtained by different makes and models of bioelectrical impedance analysis machines may not be interchangeable.

Bioelectric Impedance Analysis (BIA) is however not the Gold Standard for measuring the percentage of fat mass. The Gold Standard, Dual X-Ray Absorbitometry (DXA) is more expensive and invasive. Hence, prediction equations need to be derived using BIA and DXA. Lazzer et al (2008) attempted this and found out that DXA, air-displacement plethysmography (ADP) and the BIA were not interchangeable for the assessment of percentage fat mass in severely obese children and adolescents (Lazzer, Bedogni, Agosti, De Col, Mornarti and Sartorio, 2008). They were however able to derive a new prediction equation which offers an alternative approach to DXA for the estimation of body composition in severely obese children and adolescents.

Owa and Adejuyigbe determined body fat mass, body mass index, and mid-upper arm circumference, in 954 5–15-year-old Nigerian children (Owa and Adejuyigbe, 1997). They derived regression equations between body fat mass and age, body mass index, and mid-upper arm circumference for each sex. The mean fat mass, percentage fat mass, body mass index, and mid-upper arm circumference were significantly higher in the female than male. Percentage fat mass varied between 3.02 and 32.16, and 1.88 and 53.84 in males and females, respectively (P=0.0000). The percentage fat mass was found to increase slightly with age significantly in the female and decreased slightly with age in the male. The authors concluded based on the US standards that 18 per cent of the children were obese and that childhood obesity may soon become a medical problem in Nigeria. This study provides a good reference for the nutritional status of Nigerian children in a particular location; however, there is need for further studies to increase the validity of this study.

In a related study by Owa and Adejuyigbe (1996), total and percentage body were determined in 904 healthy Nigerian children aged 5 to 15 years using bioelectric impedance. This study was conducted to assess the practical application of bioelectric impedance analysis in determining total and percentage body water in a clinical setting. Total body water (TBW) was calculated using the equation ($0.60*[Ht^2/I] – 0.5$) as reported by Davies et al (1988). It was also measured directly using Holtain Body Composition Analyser (HBCA). The HBCA gave higher values than the calculated values but these were consistent and significant. Total body water (TBW) was reported as higher in boys than girls. Percentage body water was reported to increase with age but not significantly so in boys ($p > 0.076$) and decreased significantly with age in the girls ($p = 0.008$). This showed an inverse relationship with regards to the differences between sexes in how the proportion of body fat mass increased with age, that is body fat mass tended to decrease with age in boys and increase with age in girls.

Bioelectrical impedance was used to investigate the body composition of children with sickle cell disease (SCD) in northern Nigeria by VanderJagt et al (VanderJagt, Okolo, Rabasa and Glew, 2000). In addition to documenting differences in the body composition of adolescent boys with sickle cell disease in Nigeria, this study also demonstrated the feasibility of using bioelectrical impedance to analyse the body composition of individuals under the hot, arid conditions which prevail in sub-Saharan Africa. However, the findings of this study were limited owing to the sample size used (n=48). Another study was conducted on children with calcium-deficiency rickets (VanderJagt, Morales, Thacher, Diaz and Glew, 2001). Because of the calcium-deficiency rickets, a corrected height was used for the children. Also, the sample size for the study (n=28) cannot be used as reference for a large population.

The above two studies did not emphasize a healthy population of children. Leman and others estimated the body composition of children in south-western Nigeria to validate bio-electrical impedance analysis (Leman, Adeyemo, Schoeller, Cooper and Luke, 2003). Total body water (TBW) was measured in 92 individuals (53 adults and 39 children) using deuterium dilution; height, weight and resistance were measured by BIA. It was concluded that BIA is for use among Nigerian children and adults and provides a potentially important tool for research.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

This study was conducted in Ibadan North Local Government Area of Oyo State, Nigeria. Ibadan is the third largest city in Nigeria by population (after Lagos and Kano) and the largest by geographical area. It is located in south-western Nigeria, 128 km inland northeast of Lagos and 530 km southwest of Abuja, the Federal Capital territory (FCT) and is a prominent transit point between the coastal region and the areas to the north. Ibadan had been the centre of administration of the old Western Region, Nigeria since the days of the British colonial rule. The principal inhabitants of the city are the Yoruba-speaking people.

The Ibadan North Local Government Area was founded by the Federal Military Government of Nigeria on the 27th September, 1991. It was carved out of the defunct Ibadan Municipal Local Government along with others. Its administrative headquarters is situated at Bodija. The Local Government Area covers a landmass of 132.500 square kilometers with a population density of 2,626 persons per square kilometer. Using a growth rate of 3.2% from 2006 census, the 2010 estimated population for the Local Government area is put at 347,998 (Oyo State Government, 2010).

Majority of the population of Ibadan North Local Government are in the private sector. They are mainly traders and artisans. A good number of their workers are Civil Servants who live predominantly around Bodija Estate, Agbowo, Sango, Mokola, the University of Ibadan and the Polytechnic Ibadan.

3.2 Study Site

The study was carried out in 8 public and private secondary schools in Ibadan North Local Government Area of Oyo State through a simple random sampling.

3.3 Study Population

The study population included secondary school students aged 10 to 19 years in public and private schools in Ibadan North Local Government Area of Oyo State.

3.4 Study Design

This was a cross-sectional and analytical study utilizing quantitative methods of data collection.

3.5 Sample Size and Statistical Power

Owa and Adejuyigbe (1997) reported that man body fat mass varied between 3.02 and 32.16, and 1.88 and 53.84 in male and female children aged 5-15 years respectively.

Using the sample size formula for single estimate of mean:

Minimum sample, S $= \frac{(u+v)^2\sigma^2}{(\mu-\mu_0)^2}$

Where

u = One-sided percentage point of the normal distribution corresponding to 100% - power, if power = 80% then u = 0.84

v = Percentage point of the no normal distribution corresponding to the (two-sided) significance level, at 5%, v = 1.96

$\mu - \mu_0$ = difference between known mean and hypothesized mean

Therefore sample size, s using all the mean values obtained by Owa and Adejuyigbe (1997) are as in the table below:

Table 3.1: Sample size computation

Known mean, μ	$\mu - \mu_0$	Standard deviation, σ	Sample size, S
Male			
3.02	0.302	0.5	21
32.16	2.16	10.0	168
Female			
1.88	0.38	0.5	13
53.84	3.0	15.0	195

Therefore a minimum of 168 male and 195 female secondary school students was calculated to be recruited for this study giving a total of 363.

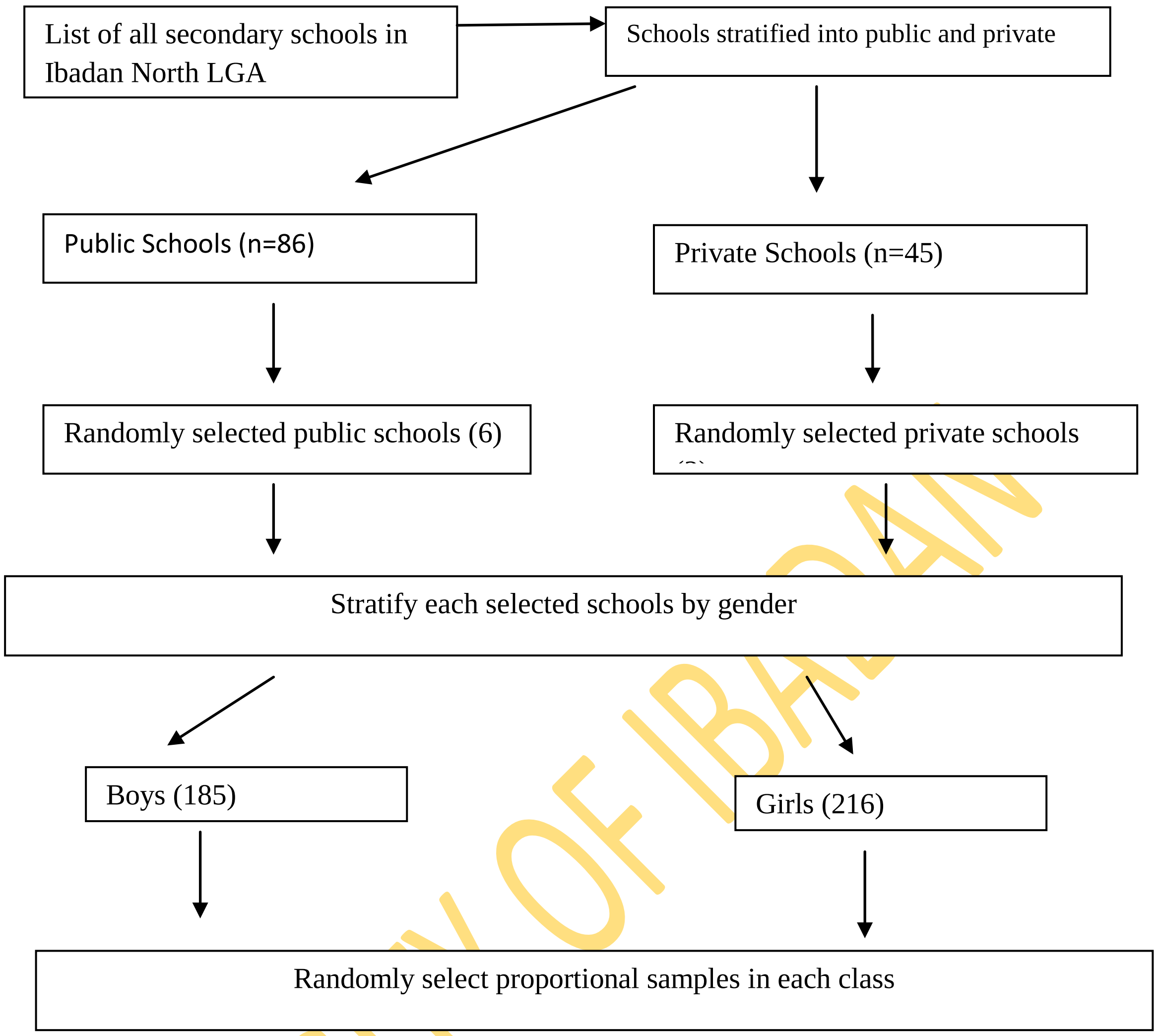
In order to adjust for non-response rate of 10%, the total minimum sample size to be studied was 401(185 male and 216 female).

To adjust for the design effect of using a multistage sampling as opposed to total sample, the sample size was multiplied by a factor of 1.5.

Therefore the final sample size (n) = 401 x 1.5 ≈ 602

3.6 Sampling Technique

A three-stage random sampling method was used. First, a list of private and public secondary schools in Ibadan North Local Government was made. The registered schools constitute 86 public and 45 private schools. A ratio of 2 public schools to 1 private school was used. The first stage of sampling involved stratification of secondary schools into two groups of public and private schools. The second stage of sampling involved selection of 6 public and 2 private secondary schools using simple random technique. The third stage involved selection of students at schools after stratification by gender. At school level the number of pupils to be selected was determined by the proportion contribution to the estimated sample size. For example, school A contributed = (school A population/All selected school population) X Sample size.



However a total of 623 students (249 male and 374 female) were eventually recruited into the study.

3.7 Data Collection Techniques

All research assistants used for this study were trained for two days prior to the commencement of the data collection on how to use the bioelectric impedance analyzer (BIA), the weighing scale, tape, and the wall-mounted stadiometer. They were also trained on how to administer the Physical Activity Questionnaire for Adolescents (PAQ-A) and the Food Frequency Questionnaire (FFQ). A pretested, structured interviewer-administered questionnaire was used to collect data on socio-demographic characteristics.

Anthropometric Measurements

Measurements were made with the students putting on only their school uniforms and without any shoes or socks on. Height was measured in centimetres (cm) using a wall-mounted stadiometer. Weight was measured in kilograms (kg) using an electronic scale. All measurements were taken twice. A third measurement was taken if the first two differed by more than 0.5 cm (height) or 0.3 kg (weight).

Waist and hip circumferences were measured using a tape to the nearest 0.1 cm. Waist circumference was measured at the level of the umbilicus and the superior iliac crest. The measurement was made at the end of a normal expiration while the subject stood upright, with feet together and arms hanging freely at the sides. Hip circumference was measured at the maximum point below the waist, without compressing the skin.

Percentage Body Fat Measurement

Percentage Body Fat (PBF) was measured using Maltron BF-906 (Body fat analyzer, Maltron Ltd, Essex, UK). This machine which uses hand –to-foot electrodes is non-invasive, inexpensive and portable and requires minimal subject compliance. The method depends on measuring the resistance (impedance) to an electrical current travelling through body tissues. Fat-free mass (FFM) contains high levels of water and electrolytes, and acts as a conductor of electrical currents, whereas fat mass is comparatively anhydrous and acts as a resistor to the flow of electrical current. It has also been previously used by others (Wardle et al, 2001; Papandreou, Malindretos and Rousso, 2010).

Figure 3.1: Maltron Body Fat Analyser (BF-906)

Physical Activity

Data on physical activity was assessed by adapting the Physical Activity Questionnaire for Adolescents (PAQ-A) developed by Kowalski and others (Kowalski, Crocker, & Kowalski, 1997). The PAQ-A is a nine-item, seven-day self-report recall questionnaire, designed and extensively used for surveillance and monitoring. It measures habitual moderate-to-vigorous activity levels during the school year, providing an estimate of total activity. There is consistently high validity against a variety of direct measures. Reliability is considered to be moderate. The estimated completion time is 20 minutes. It is considered easy to administer, complete and code, and is a low burden to both the deliverer and the respondent. Analysis involves calculating a mean composite score based on responses to each item.

The PAQ-A was administered in the classroom and the summary score from eight items on a 5-point scale was computed. Mean score was calculated, with 1 meaning low physical activity and 5 indicating high physical activity. Physical activity score (PAS) was assessed as low (1.00-1.99), moderate (2.00-3.50) and high (3.51-5.00).

Dietary Intake

Dietary intake was assessed using a Food Frequency Questionnaire (FFQ). Food frequency questionnaires (FFQ) are designed to assess habitual diet by asking about the frequency with which food items or specific food groups are consumed over a reference period (e.g. 6 months or a year). FFQs may be based on an extensive list of food items or a relatively short list of specific foods. The foods listed should be a) major sources of a group of nutrients of particular interest or b) foods which contribute to the variability in intake between individuals in the population, and c) commonly consumed in the study population (Cade, Burley, Warm, Thompson and Margetts, 2004). The FFQ was modified to include foods commonly consumed in the local population.

3.8 Data Management and Statistical Analysis

The data were entered in spreadsheet and analysed using Statistical package for Social Sciences (SPSS) software version 16.0 (SPSS Inc. USA). Descriptive statistics, Chi-square tests, Student *t* test, ANOVA and Pearson correlation were used to obtain the results. The main outcome variables measured were height, weight and percentage body fat (PBF). Independent variables included socio-demographic variables such as age, gender parents' socioeconomic status, physical activity and dietary intake.

Participants' ages were grouped into five: 10-11, 12-13. 14-15, 16-17 and 18-19 years. Socioeconomic status was also grouped as high, middle and low for the purpose of comparison using the method recommended by Oyedeji (Oyedeji, 1987). This was based on computation of their father's and mother's level of education and current employment status. By this stratification, those in classes I and II were grouped as high, III was middle and IV and V were grouped as low socioeconomic classes respectively. Percentage Body Fat (PBF), measured by the body fat analyzer, was segregated by age and sex. Also, the PBF category for each age and sex was grouped using the Gaussian distribution as low ($<5^{th}$ percentile), normal (5^{th}-95^{th} percentile) and high ($>95^{th}$ percentile) of the study population.

Means of the outcome variables were compared using the Independent samples t-test. Percentiles were obtained for PBF in males and females separately. Partial correlation was used to show the relationship between anthropometric indices and PBF. Chi-square test was utilised for cross-tabulations between the dependent and independent categorical variables. Level of statistical significance was set at $p<0.05$ for all the analyses.

3.9 Ethical Consideration

The study protocol was reviewed and ethical approval was obtained from the Oyo State Ethical Review Committee. Permission to conduct the study was obtained from the authorities of each school. Participation in the study was completely voluntary as the researcher explained the study, answered questions and gave the students the option not to participate. Privacy of participants was ensured by using a serial number on the information collected, rather than a name.

Access to respondents' information was restricted to researchers only. There was no direct benefit to respondents, but findings from the study would inform stakeholders on how to plan interventions to check excess or too little fat mass among school adolescents. There was no harm done to the respondents in the course of the research.

3.10 Limitation of the study

Unlike what is known about BMI and WHtR, the health range of PBF has not been directly explored, which means there are no meaningful cut-offs to indicate cardiovascular and metabolic risks.

CHAPTER FOUR

RESULTS

4.1 Socio-demographic Characteristics

Out of the 623 participants that participated in this study, 374 (60%) were female while the rest (249) were male. Participants were adolescents aged 10 to 19 years. Overall mean age was 14.5±2.1 years. There was no significant difference in mean age of male (14.7±2.1 years) and female (14.4±2.0 years) participants. The age group 14-15 years had the highest representation among male (37.8%) and female (40.9%) adolescents (Figure 4.1.1). The least represented age group was 18-19 years which comprised 7.2% of male and 4.0% of female participants.

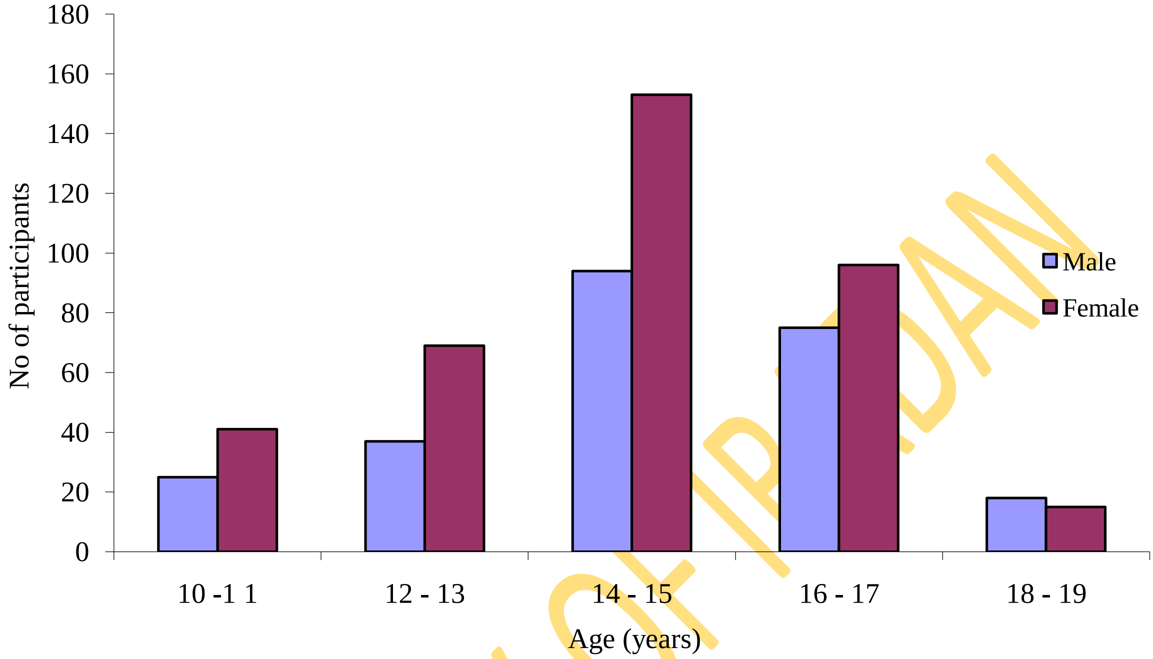
Majority of the adolescents (78%) were from monogamous families, 17% were from polygamous families and 5% came from homes with single parents. Of all male, 82.3% were from monogamous families, 13.3% were from polygamous families and 4.4% were from homes with single parents. Of all the female, 75.1% were from monogamous families, 19.5% were from polygamous families while the rest (5.3%) were from homes with single parents (Table 4.1.1).

Majority of the adolescents were Yoruba (84.6%). In all, 45(7.2%) were Igbo, 17 (2.7%) were Edo while other tribes made up the remaining 5.5% of all tribes. Among both sexes, Yoruba (84.3% of male and 84.6% of female) represented the most frequent tribe (Table 4.1.1).

More males were recruited from public schools (77.1%) than private schools (22.9%). Overall, 482 adolescents (77.4%) were from public schools while 141 (22.6%) were from private schools (Table 4.1.1).

Overall, majority of parents were of the middle socioeconomic class (51.7%) for both male (56.2%) and female (48.7%). Overall, 122 (19.6%) adolescents were from the low socioeconomic class while 179 (28.7%) were from high socioeconomic class (Table 4.1.1). Among male adolescents, 42 (16.9%) were from low socioeconomic class while 67(26.9%) were from high socioeconomic class. Among the female adolescents, 122 (19.6%) were from low socioeconomic class while 179 (28.7%) were from high socioeconomic class (Figure 4.1.2).

Figure 4.1.1: Age Distribution of secondary school adolescents in Ibadan North Local Government Area, Nigeria



Distribution is normal as shown above

Table 4.1.1: Socio-demographic characteristics of secondary school adolescents in Ibadan North Local Government Area, Nigeria

Characteristics	Male (%)	Female (%)	Total (%)
Family Type			
Monogamous	205 (82.3)	281 (75.1)	486 (78)
Polygamous	33 (13.3)	73 (19.5)	106 (17)
Single Parent	11 (4.4)	20 (5.3)	31 (5)
Total	**249 (100)**	**374(100)**	**623 (100)**
Tribe			
Yoruba	210 (84.3)	317 (84.8)	527 (84.6)
Igbo	16 (6.4)	29 (7.8)	45 (7.2)
Edo	9 (3.6)	8 (2.1)	17(2.7)
Others	14 (5.6)	20 (5.3)	34 (5.5)
Total	**249 (100)**	**374 (100)**	**623 (100)**
School Type			
Public	192 (77.1)	290 (77.5)	482 (77.4)
Private	57 (22.9)	84 (22.5)	141 (22.6)
Total	**249 (100)**	**374 (100)**	**623 (100)**
Parents' socioeconomic class			
Low	42 (16.9)	80 (21.4)	122 (19.6)
Middle	140 (56.2)	182 (48.7)	322 (51.7)
High	67 (26.9)	112 (29.9)	179 (28.7)
Total	**249(100)**	**374(100)**	**623(100)**

4.2 Anthropometric Indices

Weight and Height

Overall mean weight was 47.0±9.7kg. Overall, the female adolescents had a significantly higher mean weight (48.0±8.9 kg) than the male adolescents (45.3±10.6 kg; p = 0.001). Female adolescents had significantly higher weight across all age groups except 18-19 years, though this difference was only significant among ages 12-13 and 14-15 (p = 0.000). At age group 18-19 years, males had significantly higher weight 18-19 (p = 0.000). This is shown in Table 4.2.1. Figures 4.2.1 and 4.2.2 are graphical representations of weight against age for male and female adolescents respectively.

Overall mean height was 157.2±9.8cm. The height distribution of the various age groups is shown in table 4.2.1 below. There was no significant difference between the height of male (157.9±12.4 cm) and female (156.7±7.6 cm) adolescents (p = 0.131). Females were significantly taller than males among age groups 10-11 (p = 0.049) and 12-13 (p = 0.027). Males were taller than females at age groups 16-17 (p = 0.000) and 18-19 (p = 0.001). Though females were slightly taller than males at age group 15-16, this difference was not statistically significant (p = 0.164). Figures 4.2.3 and 4.2.4 are graphical representations of height against age for male and female adolescents

Waist and Hip Circumferences

Generally, the waist circumference of females was higher than that of males in almost all age groups, significantly so at age groups 12-13 (p = 0.001), 14-15 (p = 0.001) and 16-17 (p = 0.018). However for age group 18-19, males had slightly higher waist circumference (p = 0.420). (Table 4.2.2).

The distribution of hip circumferences as seen in Table 4.2.2 below shows that females had significantly wider hips at age groups 12-13 (p = 0.000), 14-15 (p = 0.000) and 18-19 (p = 0.002). Males had wider hip circumferences at age groups 10-11 and 18-19, though not significant. (p = 0.408 and p = 0.476 respectively).

Body Mass Index (BMI)

The BMI of the participants are as shown in Table 4.2.3 below. Female adolescents had significantly higher BMI than male through the age groups, though this difference was found to be significant at age groups 12-13 (p= 0.000), 14-15 (p = 0.000) and 16-17 (p = 0.000).

Waist to height ratio (WHtR) and Wasit-Hip ratio (WHR)

The overall mean waist to height ratio (WHtR) was 0.4±0.04, with a mean WHtR of 0.4±0.04 for male and 0.4±0.05 for female ($p = 0.000$). The WHtR of the different age groups of male and female adolescents are as shown in Table 4.2.4 below.

The overall mean waist hip ratio (WHR) was 0.8±0.05 with a mean WHR of 0.8±0.05 for male and 0.8±0.06 for female ($p = 0.092$). The WHR of the different age groups of male and female adolescents are as shown in Table 4.2.4 below.

Table 4.2.1: Weight and Height of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	Weight (kg)			Height (kg)		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	37.0±9.3	39.2±8.8	.341	143.8±6.5	147.3±7.1	.049
12-13	39.1±10.2	45.6±7.8	.000	151.8±11.8	156.0±7.3	.027
14-15	43.0±8.2	48.3±8.4	.000	156.0±10.7	157.6±6.6	.164
16-17	51.5±8.7	52.8±7.2	.295	165.6±9.0	159.5±6.8	.000
18-19	57.6±6.4	50.7±5.9	.004	169.8±10.2	158.7±6.2	.001
Total	**45.3±10.6**	**48.0±8.9**	**.001**	**157.9±12.4**	**156.7±7.6**	**.131**

Figure 4.2.1: Graph of weight against age for male secondary school adolescents in Ibadan North Local Government area, Nigeria

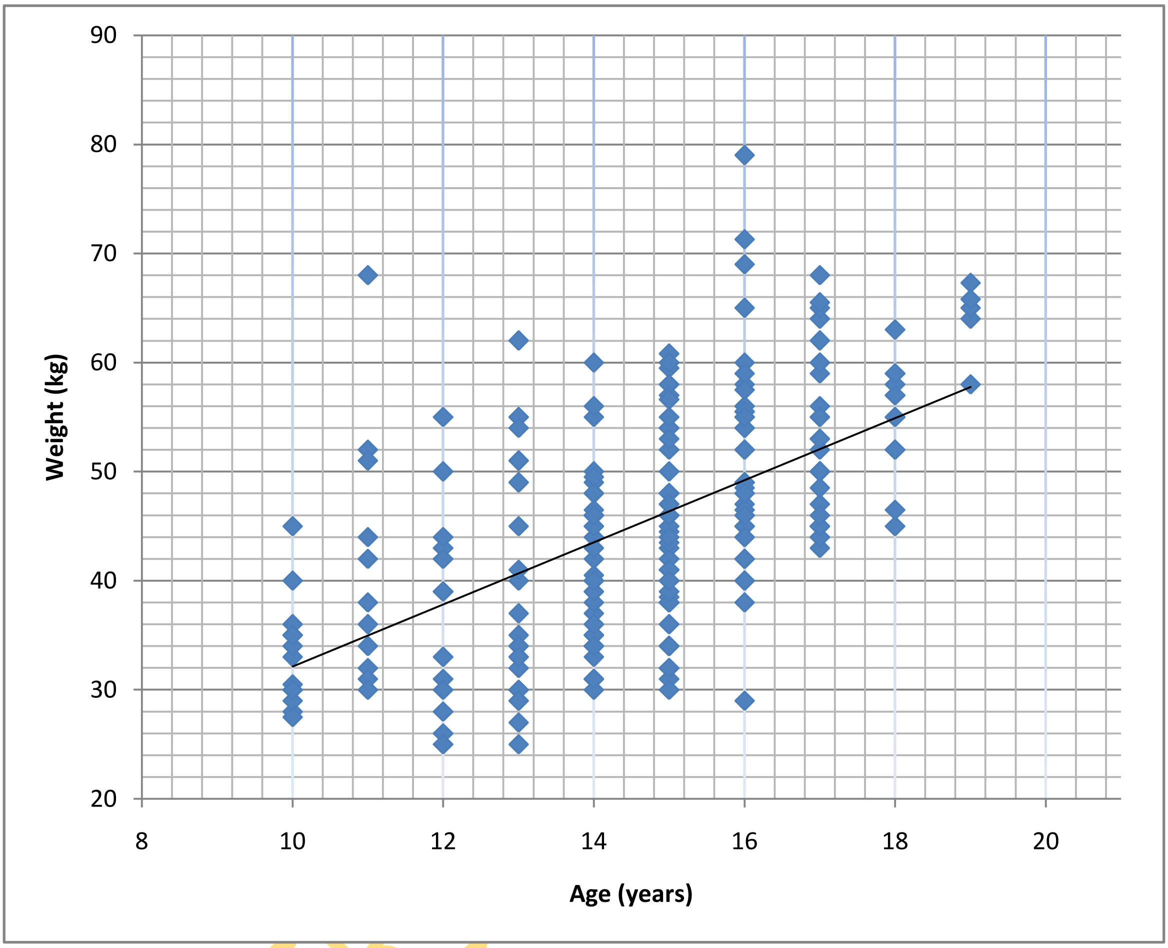


Figure 4.2.2: Graph of weight against age for female secondary school adolescents in Ibadan North Local Government area, Nigeria

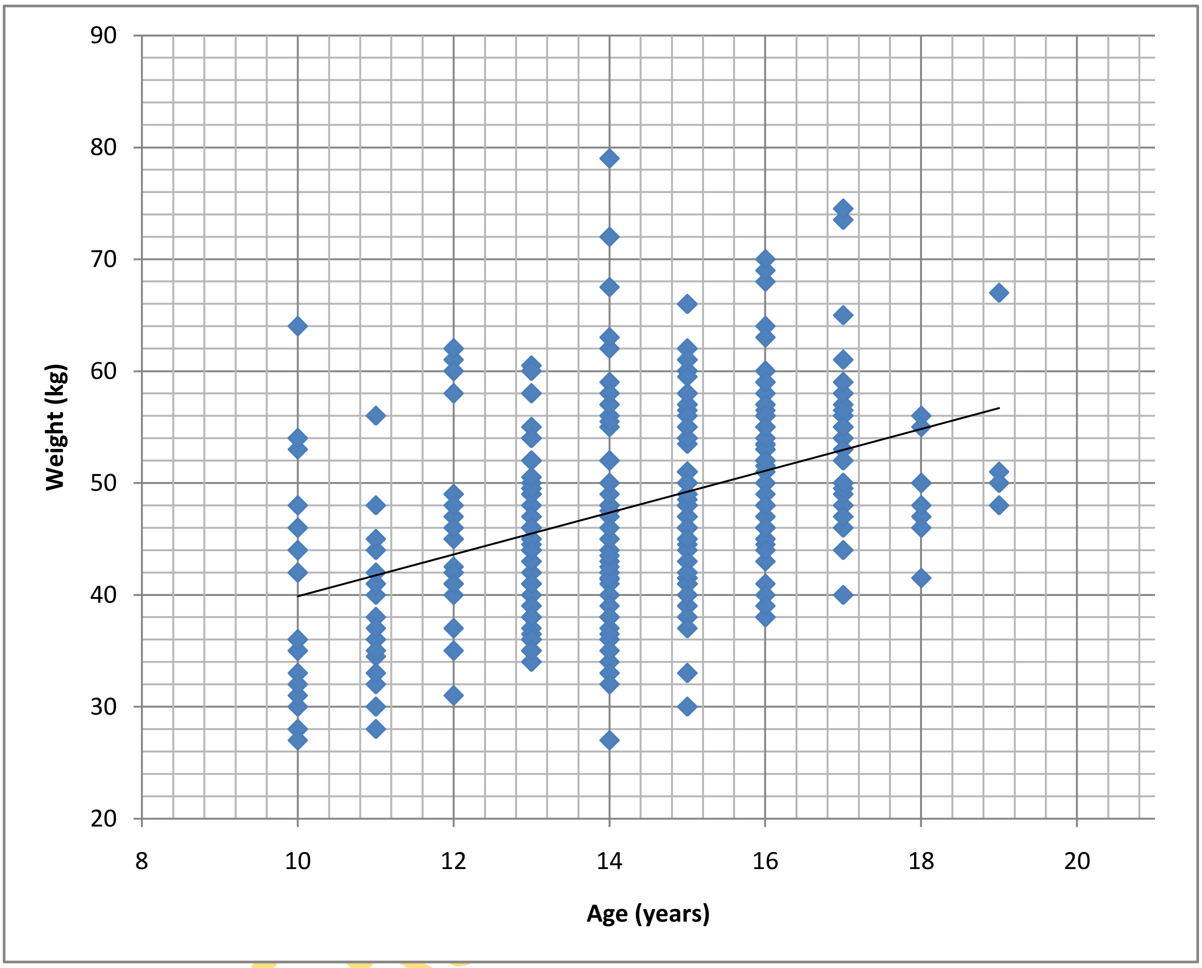


Figure 4.2.3: Graph of height against age for male secondary school adolescents in Ibadan North Local Government area, Nigeria

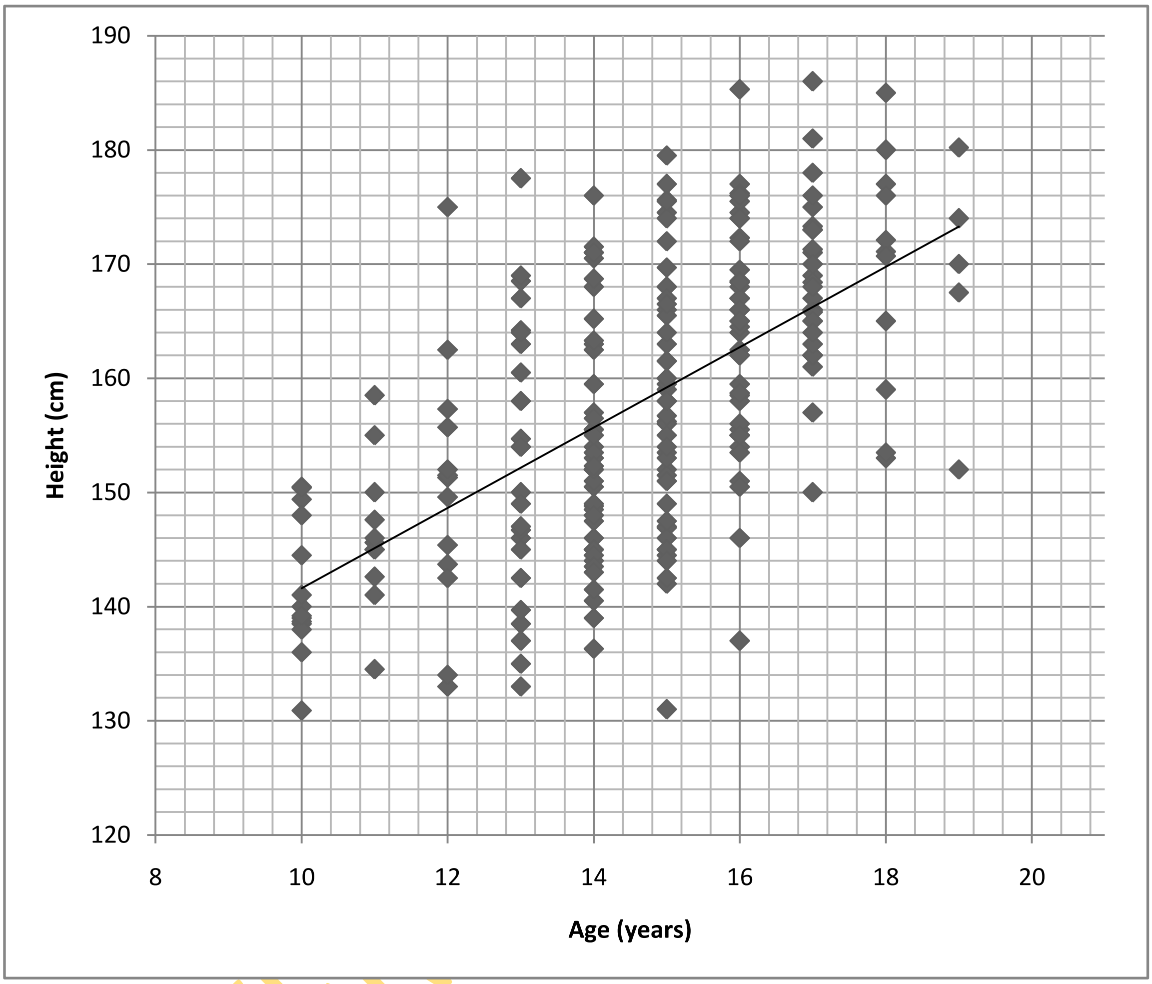


Figure 4.2.4: Graph of height against age for female secondary school adolescents in Ibadan North Local Government area, Nigeria

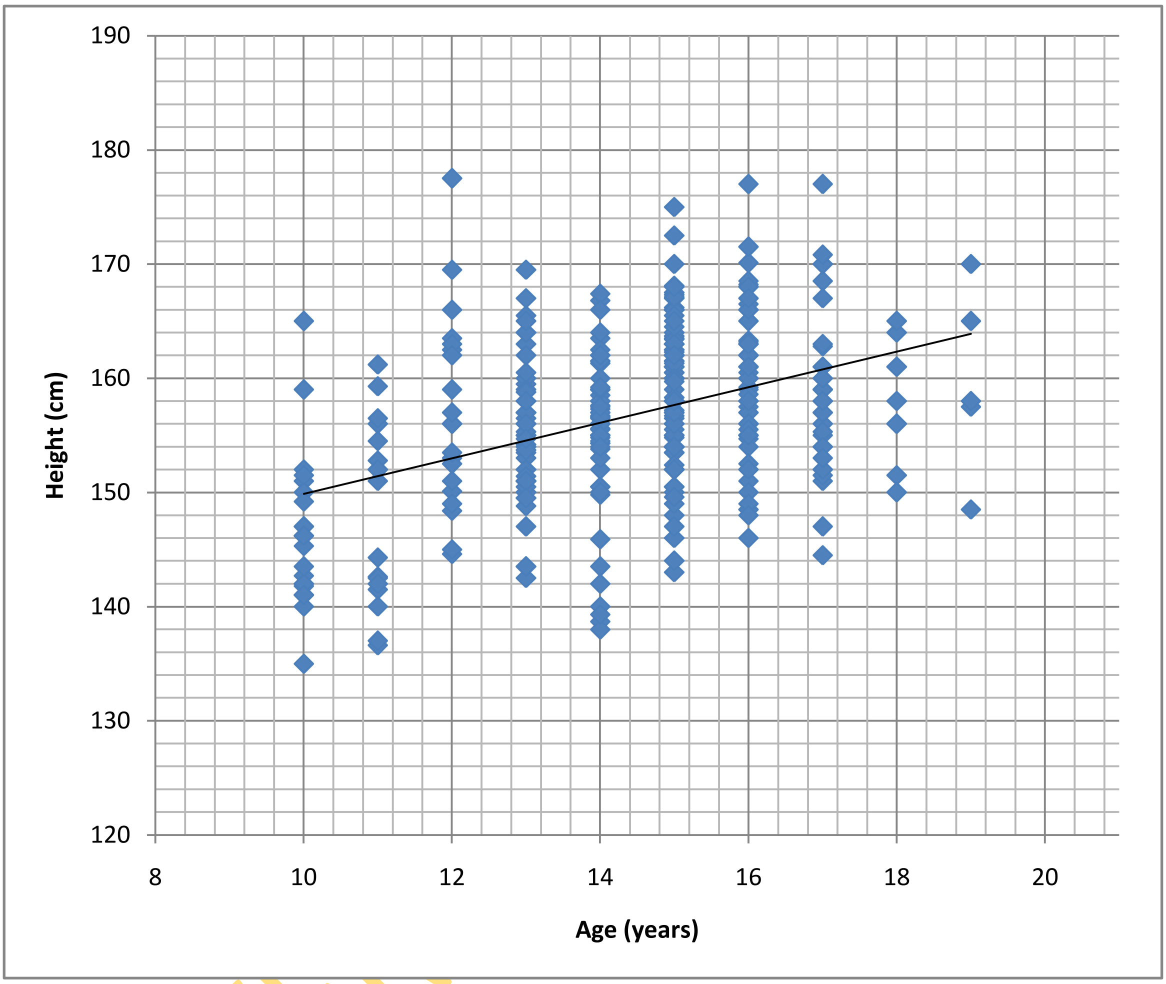


Table 4.2.2: Waist and Hip circumferences of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	WC (cm)			HC (cm)		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	63.1±8.4	64.4±9.7	.608	73.7±8.6	71.9±7.9	.408
12-13	61.3±7.2	65.8±6.3	.001	72.8±8.4	79.2±8.0	.000
14-15	65.0±5.9	68.0±7.6	.001	76.7±6.7	82.4±8.7	.000
16-17	69.0±6.5	71.6±7.0	.018	82.4±7.0	86.3±8.3	.002
18-19	71.3±5.8	70.0±2.8	.420	87.7±6.8	86.2±4.6	.476
Total	**65.8±7.2**	**68.2±7.7**	**.000**	**78.2±8.4**	**81.8±9.3**	**.000**

Table 4.2.3: BMI of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	BMI		
Age	**Male**	**Female**	**P**
10-11	17.8±3.4	18.1±3.5	.725
12-13	16.6±2.1	18.7±2.3	.000
14-15	17.5±1.8	19.4±3.2	.000
16-17	18.7±1.9	20.8±2.6	.000
18-19	20.0±2.2	20.1±1.8	.921
Total	**17.9±2.3**	**19.5±3.0**	**.000**

Table 4.2.4: Waist-Height ratio (WHtR) and Waist-hip ratio (WHR) of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	WHtR			WHR		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	0.4±0.5	0.4±0.06	.889	0.9±0.04	0.9±0.08	.032
12-13	0.4±0.03	0.4±0.04	.006	0.8±0.06	0.8±0.06	.355
14-15	0.4±0.04	0.4±0.05	.012	0.8±0.05	0.8±0.05	.001
16-17	0.4±0.03	0.4±0.04	.000	0.8±0.05	0.8±0.04	.247
18-19	0.4±0.03	0.4±0.02	.036	0.8±0.04	0.8±0.03	.923
Total	**0.4±0.04**	**0.4±0.05**	**.000**	**0.8±0.05**	**0.8±0.06**	**.092**

4.3 Percentage Body Fat (PBF), Percentage Fat Free Mass (PFFM) and Percentage Body Water (PBW)

4.3.1 Percentage Body Fat (PBF)

The PBF (%) and FM (kg), as measured by the Bioelectric Impedance Analyser (BIA) are represented by table 4.3.1 below. Overall mean PBF was 12.6±7.1% while overall mean FM was 6.3±4.2kg. Overall, the PBF was found to be significantly higher among female (14.9±6.7%) than male (8.5±5.6%) adolescents ($p = 0.000$). Across age groups, the PBF was significantly higher in female among age groups 12-13, 14-15 and 16-17 ($p = 0.000$). Body Fat mass (FM) was also higher among female (7.5±4.2kg) than male (4.0±2.9kg) adolescents ($p = 0.000$). Again, across age groups, this was significantly higher among age groups 12-13, 14-15 and 16-17 ($p = 0.000$) (Table 4.3.1).

The figures below show the plotted graphs for Percentage Body Fat (PBF) against age for male (4.3.1) and female (4.3.2) adolescents. The graphs show a negative correlation between PBF and age for male adolescents ($r = -0.0224$; $p=0.002$). However, there was no significant correlation between PBF and age among female adolescents ($r = 0.064$; $p=0.064$).

Table 4.3.1: Percentage Body Fat (PBF) and Fat Mass (FM) of secondary school adolescents in Ibadan North local Government Area, Nigeria by age group and sex

	PBF (%)			FM (kg)		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	11.5±7.0	13.5±7.2	.294	4.7±3.8	5.7±4.0	.309
12-13	8.1±5.9	14.4±6.2	.000	3.4±2.6	6.8±3.6	.000
14-15	9.7±5.0	15.8±6.7	.000	4.3±2.4	8.0±2.3	.000
16-17	5.8±4.0	14.6±7.1	.000	3.4±2.7	8.0±4.4	.000
18-19	7.6±6.6	14.3±7.0	.012	4.5±4.0	7.5±4.3	.055
Total	**8.5±5.6**	**14.9±6.7**	**.000**	**4.0±2.9**	**7.5±4.2**	**.000**

Figure 4.3.1: Graph of PBF against age for male secondary school adolescents aged 10-19 years in Ibadan North Local Government Area, Nigeria

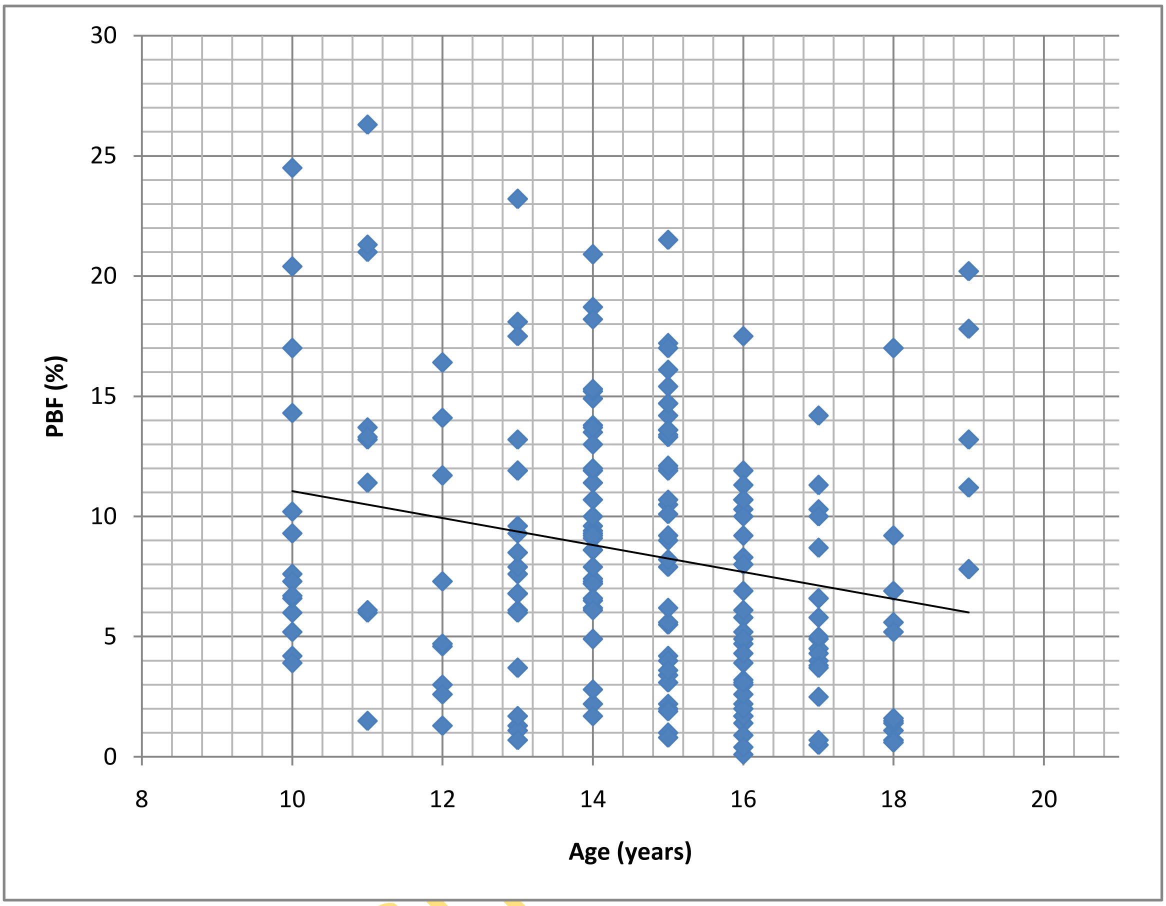
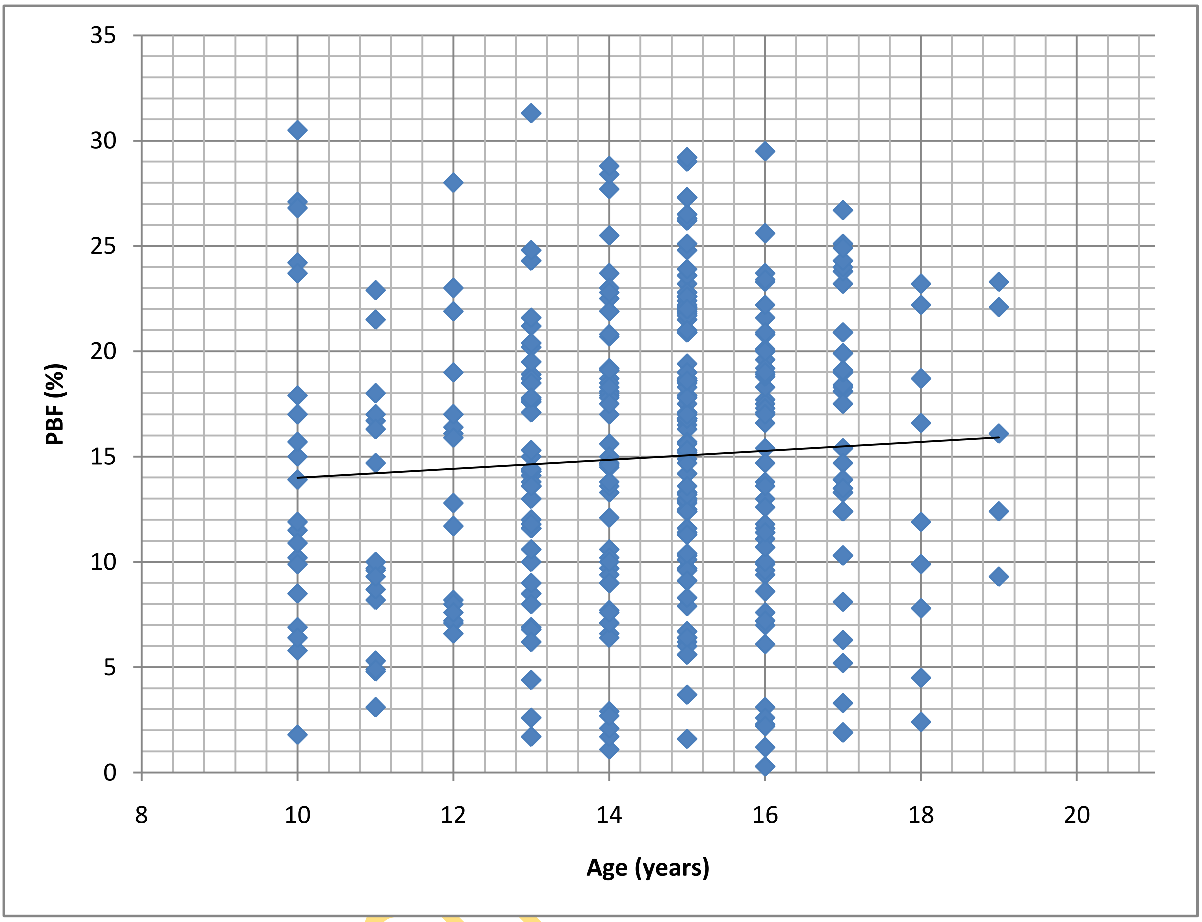


Figure 4.3.2: Graph of PBF (%) against age for female secondary school adolescents aged 10-19 years in Ibadan North Local Government Area, Nigeria



4.3.2 Percentage Fat Free Mass (PFFM)

The Percentage Fat Free Mass (PFFM) of male and female adolescents as estimated by BIA is shown in table 4.3.2. Overall mean PFFM was 87.1±7.7%. The overall mean Fat Free Mass (FFM) was 41.4±8.1kg. Generally, males had a higher PFFM (91.1±7.6%) than females (85.0±6.8%; p = 0.000). Similarly, the FFM of males (42.5±10.1kg) was higher than that of females (40.8±6.7kg; p =0.026). The PFFM was significantly higher for males than females among age groups 14-15 (p = 0.000), 16-17 (p = 0.000) and 18-19 (p = 0.011) while the FFM was significantly higher for males than females among age groups 16-17 (0.000) and 18-19 (p = 0.000).

Table 4.3.2: Percentage Fat Free Mass (PFFM) and Fat Free Mass (FM) of secondary school adolescents in Ibadan North Local Government Area, Nigeria by age group and sex

	PFFM (%)			FFM (kg)		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	88.4±7.0	86.5±7.2	.294	32.7±6.5	33.9±6.2	.469
12-13	89.4±14.3	85.6±6.8	.088	38.2±9.4	39.1±5.7	.582
14-15	90.3±5.0	84.0±6.8	.000	39.6±7.9	40.6±6.2	.287
16-17	94.2±4.0	85.4±7.0	.000	50.5±7.0	45.2±5.5	.000
18-19	92.4±6.6	85.6±7.0	.011	53.4±6.2	43.2±3.6	.000
Total	**91.1±7.6**	**85.0±6.8**	**.000**	**42.5±10.1**	**40.8±6.7**	**.026**

4.3.2 Percentage Body Water (PBW)

The body water of male and female adolescents in percentage (PBW) and litres (BW) as estimated by BIA is shown in table 4.3.2. Overall mean PBW was 63.9±5.2%. The overall mean Body Water (BW) was 30.3±6.0 litres. Generally, males had a higher PFFM (66.9±4.1%) than females (62.9±5.0%; p = 0.000). Similarly, the BW of males (31.1±7.4 litres) was higher than that of females (29.9±5.1 litres; p =0.033). The PBW was significantly higher for males than females among age groups 12-13 (P = 0.000),14-15 (p = 0.000), 16-17 (p = 0.000) and 18-19 (p = 0.012), while the BW was significantly higher for males than females among age groups 16-17 (0.000) and 18-19 (p = 0.000).

Table 4.3.3: Percentage Body Water (PBW) and Body Water (BW) of secondary school adolescents in Ibadan North Local Government Area, Nigeria by age group and sex

	PBW (%)			BW (litres)		
Age	**Male**	**Female**	**P**	**Male**	**Female**	**P**
10-11	64.7±5.1	62.7±4.6	.327	23.9±4.8	28.6±4.2	.464
12-13	67.2±4.3	61.6±4.9	.000	27.9±6.9	29.8±4.5	.576
14-15	66.1±3.7	61.6±4.9	.000	29.0±5.8	29.8±4.5	.285
16-17	68.9±2.9	62.5±5.2	.000	37.0±5.1	33.3±4.6	.000
18-19	67.6±4.9	62.7±5.2	.012	39.1±4.6	30.9±3.7	.000
Total	**66.9±4.1**	**62.2±5.0**	**.000**	**31.1±7.4**	**29.9±5.1**	**.033**

4.4 PBF Percentiles

Summary Statistics of PBF Percentiles

Tables 4.4.1 and 4.4.2 below represent summary statistics of PBF in male and female adolescents respectively. For each age group, the PBF percentiles were calculated for 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles. Among male participants, the least PBF for 5^{th} percentile was 0.4% at age group 16- 17, while the highest percentage body fat at 95^{th} percentile was 25.9% at age group 10- 11. Among the female participants, the least percentage body fat for 5^{th} percentile was 2.0% at age group 16- 17, while the highest percentage body fat at 95^{th} percentile was 27.3% at age group 10- 11.

Table 4.4.1: Summary Statistics of Percentage Body Fat among Male secondary school adolescents aged 10-19 years in Ibadan North Local Government Area, Nigeria by age

Age (years)	Mean±SD	Percentile				
		5th	25th	50th	75th	95th
10 – 11	11.5±7.0	2.1	6.0	9.8	16.3	25.9
12 – 13	8.1±5.9	0.9	3.2	7.1	11.9	20.9
14 – 15	9.7±5.0	1.8	6.2	9.4	13.6	18.4
16 – 17	5.8±4.0	0.4	2.7	4.9	9.1	13.2
18 – 19	7.6±6.6	0.6	1.4	6.3	12.7	20.2

Table 4.4.2: Summary Statistics of Percentage Body Fat among Female secondary school adolescents in Ibadan North Local Government Area, Nigeria by age

Age (years)	Mean±SD	Percentile				
		5th	25th	50th	75th	95th
10 – 11	13.5±7.2	3.0	8.4	11.7	17.2	27.3
12 – 13	14.4±6.2	4.4	9.0	14.3	18.7	24.8
14 – 15	15.8±6.7	3.7	10.3	16.7	21.5	27.3
16 – 17	14.6±7.1	2.0	9.9	14.7	19.9	25.1
18 – 19	14.3±7.0	2.4	8.9	14.3	22.1	23.3

Smoothed Percentile Curves for PBF of male and female adolescents

Figures 4.4.1 and 4.4.2 below show the smoothed percentile curves for male and female adolescents. For each age group, the PBF percentiles were calculated for 5th, 25th, 50th, 75th and 95th percentiles. The smoothed percentile curves were then plotted and shown in the figures below.

Figure 4.4.1: Smoothed percentile curves for PBF of male secondary school adolescents in Ibadan North Local Government Area, Nigeria

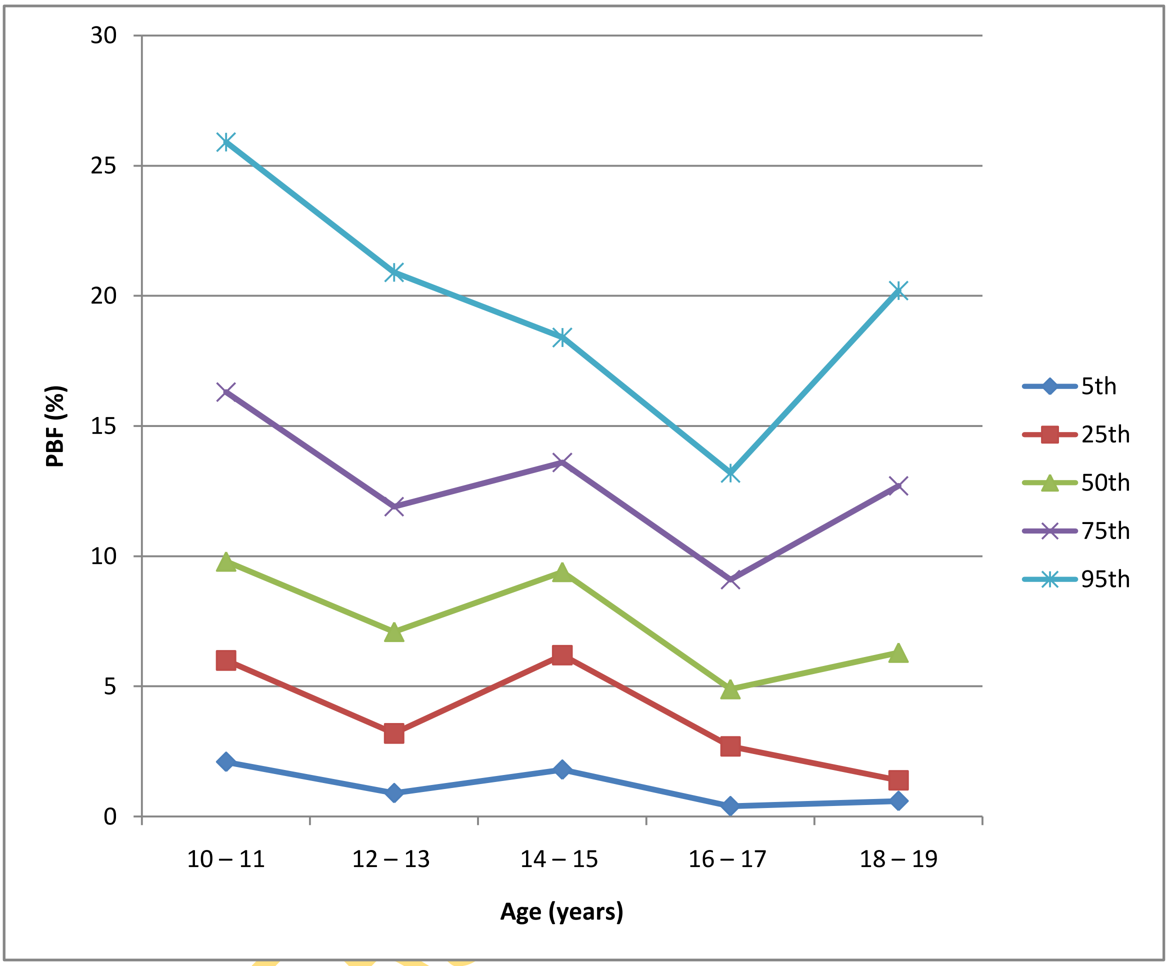
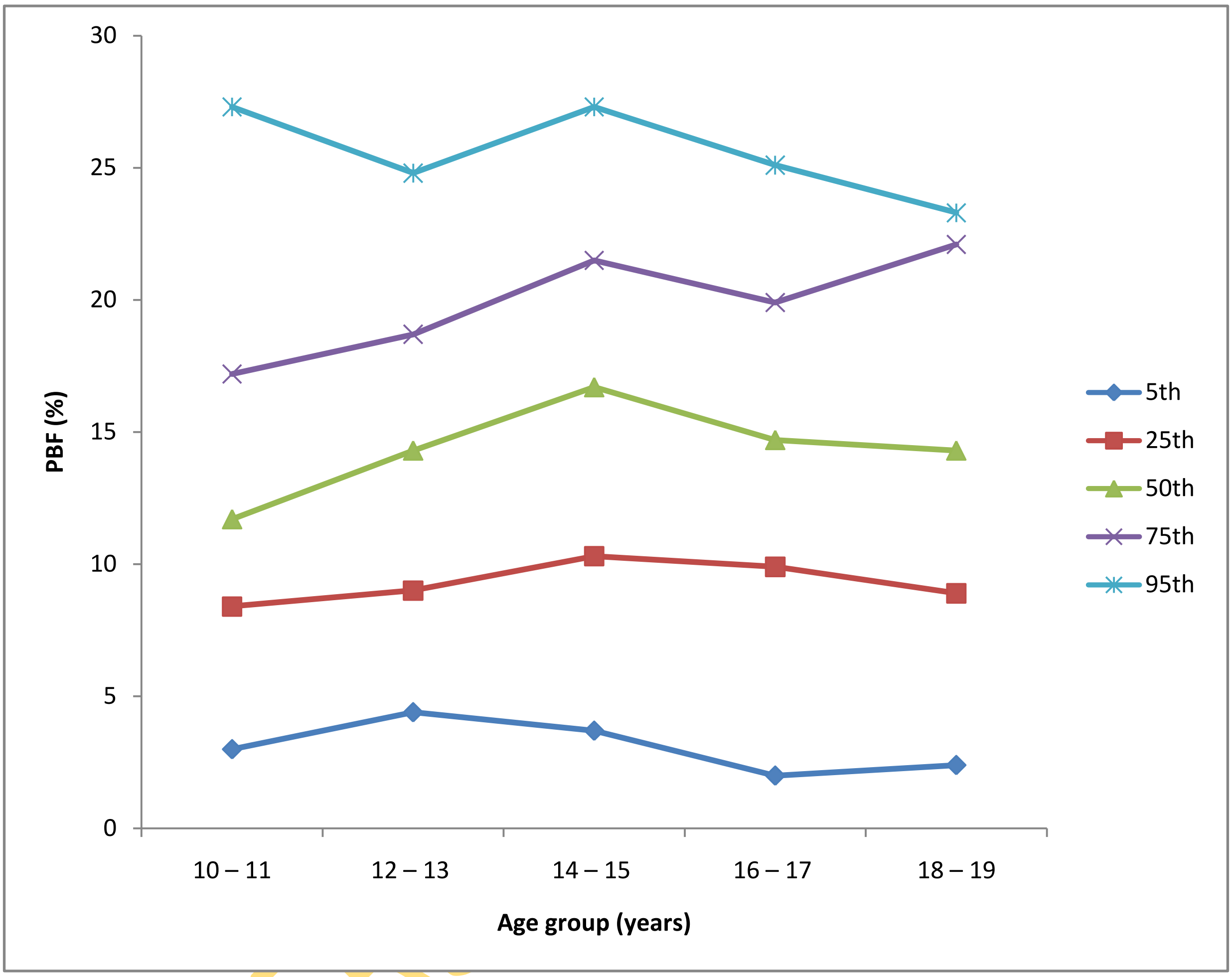


Figure 4.4.2: Smoothed percentile curves for PBF of female secondary school adolescents aged 10-19 years in Ibadan North Local Government Area, Nigeria



4.5 Relationship between PBF and Anthropometric indices

Table 4.6.1 below shows the relationship between PBF and anthropometric indices among male and female secondary school adolescents in Ibadan North Local Government Area, Nigeria.

Correlation between PBF and weight

There was no significant correlation between PBF and weight among male adolescents (r=0.061, p=0.411) but there was a significant correlation between PBF and weight among female participants (r=0.462, p=0.000).

Correlation between PBF and height

There was a significant negative correlation between PBF and height for male adolescents (r=-0.192, p=0.009) but there was no significant correlation between PBF and height among female adolescents (r=0.026, p=0.643).

Relationship between PBF and WC

There was a positive relationship between PBF and WC among male (r= 0.146, p=0.0440) and female adolescents (r=0.413, p=0.000).

Relationship between PBF and HC

Findings from this study reveal no correlation between hip circumference and PBF among male adolescents (r=0.091, p=0.217) but a positive correlation between hip circumference and PBF among female adolescents (r = 0.427, p=0.000).

Relationship between PBF and BMI

There was a positive correlation between the PBF and BMI values for all adolescents (r = 0.537, p = 0.000). The correlation in males (r = 0.368, p =0.000) was less than that in females (r = 0.549, p = 0.000).

Relationship between PBF and WHtR

There was a significant correlation between PBF and WHtR (r = 0.519, p = 0.000). The correlation between PBF and WHtR was positive for both male (r = 0.347, p = 0.000) and female (r = 0.430, p = 0.000) adolescents.

Relationship between PBF and WHR

There was no significant correlation between PBF and WHR across all adolescents ($r = -0.17$, $p = 0.699$). Similarly, there was no significant correlation between PBF and WHR among male ($r = 0.108$, $p = 0.143$) and female ($r = -0.030$, $p = 0.590$) adolescents

Table 4.5.1 Relationship between PBF and anthropometric indices of secondary school adolescents in Ibadan North Local Government Area, Nigeria

Anthropometric indices	PBF					
	Male		Female		Total	
	r	P	R	P	r	P
Weight	0.061	0.411	0.462	0.000	0.318	0.000
Height	-0.192	0.009	0.026	0.643	-0.093	0.034
WC	0.146	0.0440	0.413	0.000	0.355	0.000
HC	0.091	0.217	0.427	0.000	0.366	0.000
BMI	0.368	0.000	0.549	0.000	0.537	0.000
WHtR	0.347	0.000	0.430	0.000	0.519	0.000
WHR	0.108	0.143	-0.030	0.590	0.17	0.699

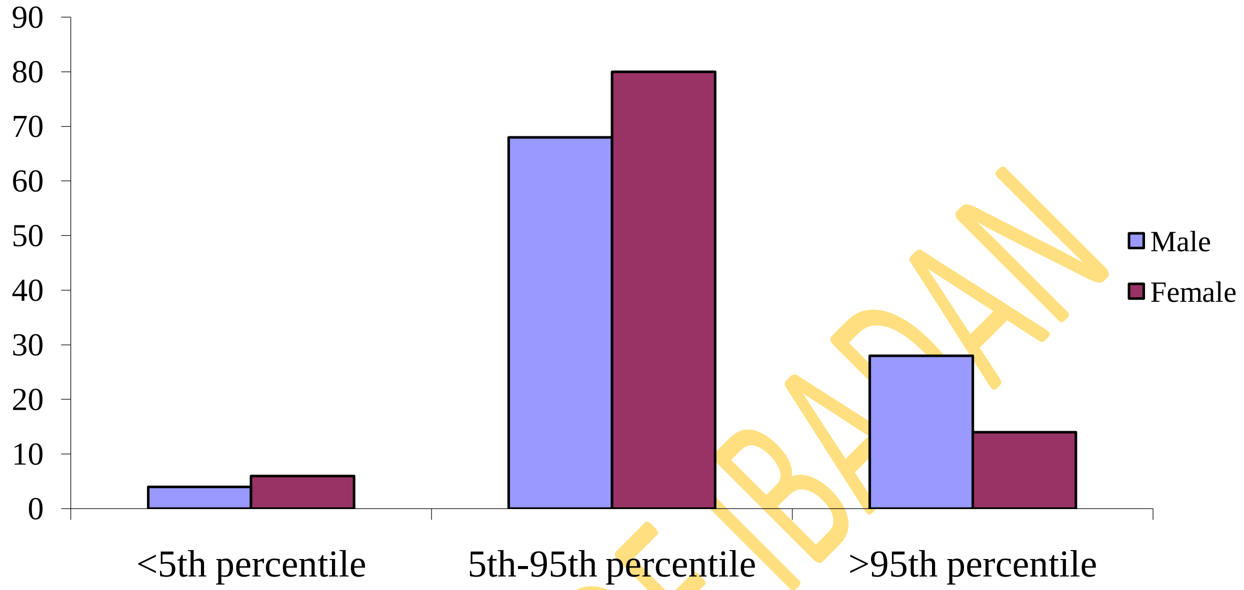
4.6 Relationship between PBF and socio-demographic characteristics

4.6.1 PBF Percentiles and Sex

Figure 4.6.1 shows the overall PBF percentiles of participants by sex. Overall, majority of PBF falls within 5^{th}-95^{th} percentile for both male (68.7%) and female (81.3%). More female than male adolescents fell below the 5^{th} percentile of PBF for their age (X^2 = 17.599, p = 0.000). Similarly, more female than male adolescents fell within the 5^{th} and 95^{th} percentiles of PBF for their age (X^2 = 17.599, p = 0.000).

However, the graphs show that more male than female adolescents are likely to fall above 95^{th} percentile of PBF estimates for age and sex (X^2 = 17.599, p = 0.000) (Figure 4.6.1).

Figure 4.6.1: PBF categories of secondary school adolescents in Ibadan North Local Government Area, Nigeria by sex



Distribution is normal as shown above

4.6.2 PBF Percentiles and School Type

Table 4.6.1 shows the mean PBF of participants by school type. Generally males in private schools had a higher PBF than those in public school ($p = 0.037$), while there was no significant difference in mean PBF of females in private and public schools ($p = 0.991$).

Table 4.6.2 shows the PBF categories of male and female adolescents in public and private schools. In the public school, more females fell in the <5th and 5th-95th percentile categories while more males were found to fall within >95th percentile category ($X^2 = 17.810$, $p = 0.000$). Similarly, among those in private school, more females fell in the <5th and 5th-95th percentile categories while more males were found to fall within >95th percentile category ($X^2 = 0.827$, $p = 0.661$).

Table 4.6.1: Mean PBF of secondary school adolescents in Ibadan North Local Government Area, Nigeria by school type

	Male	**P**	**Female**	**p**
Private	10.0±5.8	0.037	14.9±7.0	0.991
Public	8.0±5.5		14.9±6.7	

Table 4.6.2: PBF categories of male and female adolescents in public and private secondary schools in Ibadan North Local Government Area, Nigeria

	Public School				Private school			
PBF category	**Male n(%)**	**Female n(%)**	**X^2**	**P-value**	**Male n(%)**	**Female n(%)**	**X^2**	**P-value**
<5th	7 (3.6)	14 (4.8)	17.810	0.000	1(1.8)	2 (2.4)	0.827	0.661
5th -95th	124(64.6)	124(79.7)			47(82.5)	73(86.9)		
>95th	61(31.8)	45(15.5)			9 (15.8)	9 (10.7)		

4.6.3 PBF and Socioeconomic Class

Table 4.6.3 shows the mean PBF of participants by socioeconomic classes- low, middle and high. The mean PBF for female participants was generally higher across socioeconomic groups than male participants (p=0.000). However, the mean PBF of low, middle and high socioeconomic groups were not significantly different within male participants and female participants (p=0.000).

Table 4.6.4 shows the PBF percentiles of male and female adolescents by socioeconomic status. The greatest percentages of participants fell in 5^{th}-95^{th} percentile for all socioeconomic classes in both sexes, while more participants were >95^{th} percentile for both sexes.

Among male participants in high socioeconomic class, 2 (3.0%) were <5^{th} percentile, 51 (76.1%) were in 5^{th}-95^{th} percentile and 14 (20.9%) were >95^{th} percentile. Among male participants in middle socioeconomic class, 5 (3.6%) were <5^{th} percentile, 93 (66.4%) were in 5^{th}-95^{th} percentile while 14 (33.3%) were >95^{th} percentile. For male participants in the low socioeconomic class, 1 (2.4%) were <5^{th} percentile, 27 (64.3%) were in 5^{th}-95^{th} percentile, while the remaining 14 (33.3%) were >95^{th} percentile.

For the female participants in the high socioeconomic class, 4 (3.6%) were <5^{th} percentile, 95 (84.8%) were in 5^{th}-95^{th} percentile while 13 (11.6%) were >95^{th} percentile. For the female participants in the middle socioeconomic class, 9 (4.9%) were <5th percentile, 143 (78.6%) were in 5^{th}-95^{th} percentile while 30 (16.5%) were >95^{th} percentile. Finally, for female participants in low socioeconomic class, 16 (4.3%) were <5^{th} percentile, 66 (82.5%) were in 5^{th}-95^{th} percentile while 11 (13.8%) were >95^{th} percentile.

Table 4.6.3: Mean PBF of participants by socioeconomic class

Socioeconomic Class	Sex Male	 Female	 P-value
Low	7.8±5.2	15.2±6.9	0.000
Middle	8.3±5.5	14.8±6.9	0.000
High	9.2±6.1	14.9±6.7	0.000
Total	**8.5±5.6**	**14.9±6.8**	**0.000**

Table 4.6.4: PBF category of participants by socioeconomic class

		Male	Female	X^2	P-value
High	**$<95^{th}$ percentile**	2 (3.0%)	4 (3.6%)	2.830	0.243
	5^{th}-95^{th} percentile	51 (76.1%)	95 (84.8%)		
	$>95^{th}$ percentile	14 (20.9%)	13 (11.6%)		
Middle	**$<95^{th}$ percentile**	5 (3.6%)	9 (4.9%)	8.401	0.015
	5^{th}-95^{th} percentile	93 (66.4%)	143 (78.6%)		
	$>95^{th}$ percentile	42 (30.0%)	30 (16.5%)		
Low	**$<95^{th}$ percentile**	1 (2.4%)	3 (3.8%)	6.510	0.039
	5^{th}-95^{th} percentile	27 (64.3%)	66 (82.5%)		
	$>95^{th}$ percentile	14 (33.3%)	11 (13.8%)		

Figures 4.6.2 and 4.6.3 are graphical representations of PBF categories for low, middle and high socio-economic classes for male and female adolescents. The figures show that the greatest percentages of the participants in all socioeconomic classes fall within the 5^{th}-95^{th} percentile, with a greater percentage of participants across all socioeconomic classes $>95^{th}$ percentile than $<5^{th}$ percentile.

Figure 4.6.2 PBF categories for high, middle and low socio-economic classes among male adolescents in Ibadan North Local Government Area, Nigeria

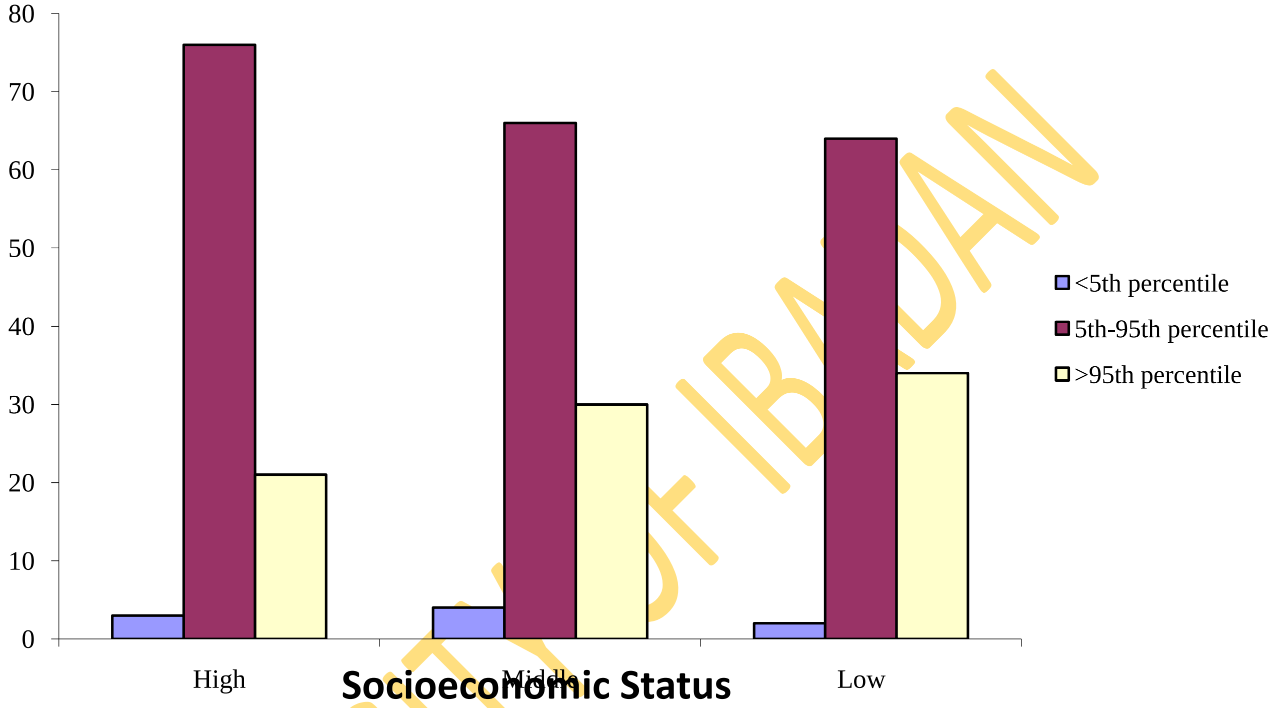
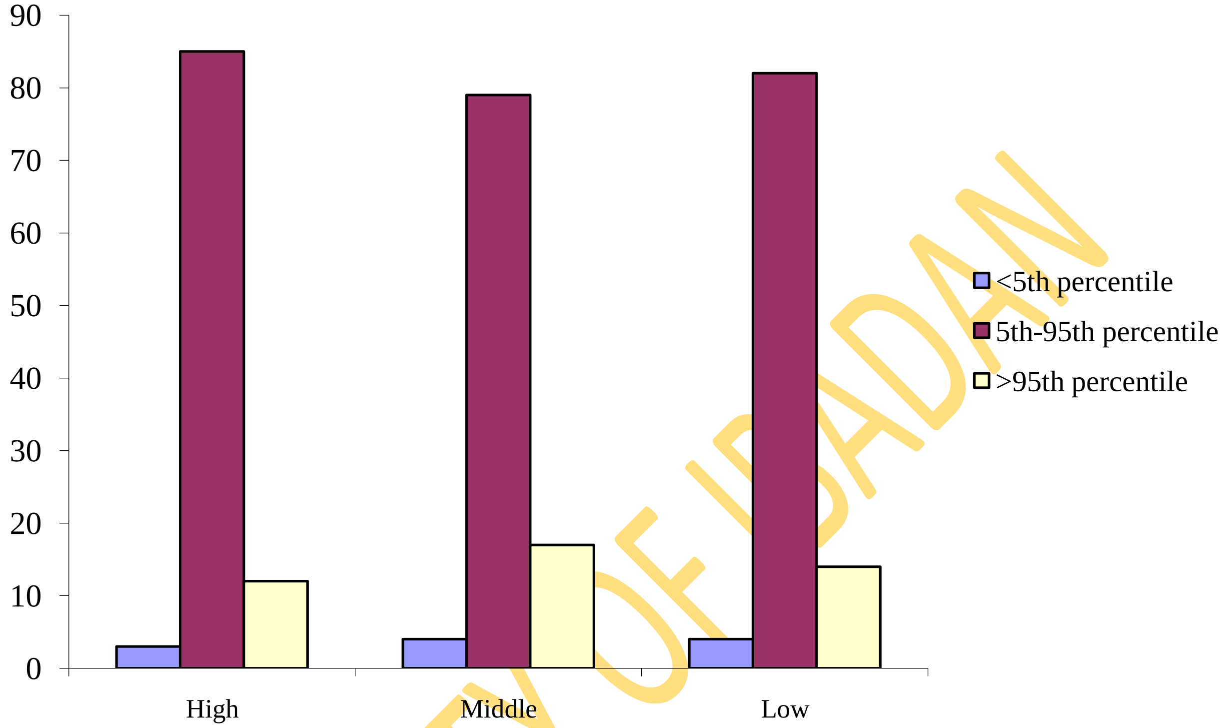


Figure 4.6.3 PBF categories for high, middle and low socio-economic classes among female adolescents in Ibadan North Local Government Area, Nigeria



4.7 Physical Activity

The overall mean physical activity score (PAS) was 2.4±0.6. Mean physical activity score for male (2.5±0.6) was higher than that of female (2.3±0.6) ($p = 0.000$).

Generally, there was a negative correlation between PBF and PAS ($r = -0.174$, $p = 0.000$). However when split by sex, there was no significant correlation between PBF and PAS for male ($r = -0.135$, $p = 0.070$) and female ($r = -0.080$, $p = 0.148$).

Similarly, there was no relationship between physical activity and PBF category for both male and female adolescents as seen in Table 4.7.1.

Table 4.7.1 Relationship between physical activity and PBF categories of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	Physical Activity	PBF Category				
		$<5^{th}$ n (%)	5^{th}-95^{th} n (%)	$>95^{th}$ n (%)	X^2	P
Male	**Low physical activity**	1 (2.3)	29 (67.4)	13 (30.2)	0.835	0.934
	Moderate physical activity	6 (3.4)	124 (70.9)	45 (25.7)		
	High physical activity	1 (5.9)	12 (70.6)	4 (23.5)		
Female	**Low physical activity**	6 (5.0)	100 (83.3)	14 (11.7)	3.046	0.550
	Moderate physical activity	9 (3.8)	191 (80.6)	37 (15.6)		
	High physical activity	0 (0.0)	8 (100.0)	0 (0.0)		

4.8 Dietary Intake

Table 4.8.1 below summarises the dietary intake of adolescents in this study using a food frequency table. Table 4.8.2 below summarises the relationship between each food item and the PBF categories. Table 4.8.3 shows the relationship between the food items that were found to be significant and consumed every day, and the PBF category.

Among male adolescents, Garri (X^2= 21.167, p = 0.020), Amala (X^2 = 21.076, p = 0.021), Fish (X^2= 41.521, p = 0.000) and Apple (X^2= 19.456, p = 0.035) were found to be significantly associated with PBF category.

Among female adolescents, Rice (X^2= 23.275, p = 0.003), Pounded yam (X^2= 18.500, p = 0.047), fufu (X^2= 10.950, p = 0.046) and Ginger (X^2= 23.338, p = 0.010) were found to be significantly associated with PBF category.

Table 4.8.1 Food Frequency Table of Secondary School Adolescents in Ibadan North Local Government Area, Nigeria

Food Item	Every Day	2-3 Times/ Day	Once/ Week	2-3 Times/ Week	2-3 Times/ Month	Never
Rice	317(50.9)	92(14.8)	37(5.9)	174(27.9)	1(0.2)	1(0.2)
Pap	36(5.8)	58(9.3)	208(33.4)	99(15.9)	79(12.7)	142(22.8)
Bread	177(28.4)	134(21.5)	89(14.3)	177(28.4)	23(3.7)	21(3.4)
Tuwo	25(4.0)	19(3.0)	72(11.0)	33(5.3)	58(9.3)	412(66.1)
Beans	123(19.7)	103(16.5)	171(27.4)	138(22.2)	51(8.2)	36(5.8)
Maize	18(2.9)	48(7.7)	178(28.6)	58(9.3)	143(23.0)	175(28.1)
Sorghum	18(2.9)	26(4.2)	64(10.3)	25(4.0)	27(4.3)	461(74.0)
Semovita	68(10.9)	61(9.8)	123(19.7)	107(16.4)	107(17.2)	158(25.4)
Akara	81(13.0)	100(16.1)	203(32.6)	108(17.3)	74(11.9)	56(9.0)
Melon	45(7.2)	64(10.3)	151(24.2)	122(19.6)	101(16.2)	136(21.8)
Millet	40(6.4)	53(8.5)	96(15.4)	31(5.0)	60(9.6)	340(54.6)
Moinmoin	78(12.5)	93(14.9)	190(30.5)	106(17.0)	91(14.6)	62(10.0)
Cashew	20(3.2)	36(5.8)	76(12.2)	26(4.2)	105(16.9)	358(57.5)
Potatoes	101(16.2)	82(13.2)	143(23.0)	86(13.8)	108(17.3)	101(16.2)
Groundnut	153(24.6)	92(14.8)	141(22.6)	109(17.5)	57(9.1)	69(11.1)
Yam	126(20.2)	122(19.6)	162(26.0)	160(25.7)	41(6.6)	8(1.3)
Amala	166(26.6)	85(13.6)	139(22.3)	132(21.2)	26(4.2)	71(11.4)
Yam Porridge	41(6.6)	64(10.3)	181(29.1)	87(14.0)	142(22.8)	103(16.5)
Palm Oil	370(59.4)	59(9.5)	78(12.5)	64(10.3)	20(3.2)	30(4.8)
Butter	134(21.5)	91(14.6)	158(25.4)	104(16.7)	58(9.3)	73(11.7)
Mayonnaise	55(8.8)	41(6.6)	79(12.7)	46(7.4)	51(8.2)	340(54.6)
Vegetable Oil	332(53.3)	89(14.3)	90(14.4)	79(12.7)	14(2.2)	16(2.6)
Fufu	57(9.1)	54(8.7)	129(20.7)	81(13.0)	112(18.0)	186(29.9)
Pounded Yam	59(9.5)	70(11.2)	163(26.2)	104(16.7)	148(23.8)	78(12.5)
Garri	177(28.4)	116(17.8)	144(23.1)	113(18.1)	44(7.1)	31(5.0)
Meat	417(66.9)	72(11.6)	36(5.8)	82(13.2)	11(1.8)	4(0.6)
Chicken	147(23.6)	102(16.4)	170(27.3)	90(14.4)	90(14.4)	23(3.7)
Fish	386(62.0)	71(11.4)	61(9.8)	78(12.5)	11(1.8)	15(2.4)
Egg	214(34.3)	92(14.8)	126(20.2)	137(22.0)	34(5.5)	17(2.7)
Yoghurt	301(48.3)	99(15.9)	73(11.7)	101(16.2)	25(4.0)	16(2.6)
Ewedu	173(27.8)	94(15.1)	157(25.2)	98(15.7)	32(5.1)	67(10.8)
Ugwu	67(10.8)	49(7.9)	118(18.9)	72(11.6)	94(15.1)	220(35.3)
Spinach	50(8.0)	49(7.9)	103(16.5)	66(10.6)	54(8.7)	297(47.7)
Bitterleaf	65(10.4)	52(8.3)	120(19.3)	75(12.0)	118(18.9)	190(30.5)
Effirin	30(4.8)	41(6.6)	88(14.1)	52(8.3)	100(16.1)	307(49.3)
Waterleaf	60(9.6)	61(9.8)	131(21.0)	81(13.0)	116(18.6)	171(27.4)
Ogbono	22(3.5)	23(3.7)	66(10.6)	49(7.9)	89(14.3)	369(59.2)
Okra	83(13.3)	68(10.9)	155(24.9)	88(14.1)	78(12.5)	144(23.1)

Orange	237(38.0)	103(16.5)	112(18.0)	97(15.6)	41(6.6)	30(4.8)
Pawpaw	162(26.0)	106(17.0)	131(21.0)	91(14.6)	77(12.4)	53(8.5)
Pineapple	139(22.3)	88(14.1)	143(23.0)	93(14.9)	103(16.5)	53(8.5)
Banana	210(33.7)	81(13.0)	130(20.9)	108(17.3)	52(8.3)	41(6.6)
Tomato	317(50.9)	88(14.1)	85(13.6)	72(11.6)	27(4.3)	31(5.0)
Mango	109(17.5)	61(9.8)	127(20.4)	69(11.1)	170(27.3)	82(13.2)
Apple	147(23.6)	71(11.4)	139(22.3)	84(13.5)	119(19.1)	59(9.5)
Carrot	140(22.5)	66(10.6)	142(22.8)	77(12.4)	122(19.6)	73(11.7)
Plantain	183(29.4)	93(14.9)	126(20.2)	124(19.9)	64(10.3)	29(4.7)
Garden Egg	99(15.9)	51(8.2)	114(18.3)	68(10.9)	117(18.80	172(27.6)
Pepper	430(69.0)	60(9.6)	47(7.5)	39(6.3)	20(3.2)	24(3.9)
Onions	425(68.2)	62(10.0)	50(8.0)	42(6.7)	15(2.4)	25(4.0)
Locust Beans	203(32.6)	88(14.1)	107(17.2)	59(9.5)	41(6.6)	122(19.6)
Garlic	56(9.0)	58(9.3)	88(14.1)	52(8.3)	58(9.3)	308(49.4)
Ginger	95(15.2)	60(9.6)	111(17.8)	61(9.8)	70(11.2)	224(36.0)

Table 4.8.2 Relationship between dietary intake and PBF category of secondary school adolescents in Ibadan North Local Government Area, Nigeria

	Male		Female	
Food Item	**X^2**	**P**	**X^2**	**P**
Rice	8.953	0.346	23.275	0.003
Maize	7.041	0.722	12.945	0.227
Pap	7.028	0.723	5.315	0.869
Sorghum	11.498	0.320	7.821	0.646
Bread	11.471	0.322	9.246	0.509
Millet	4.664	0.912	6.029	0.813
Tuwo	15.349	0.120	15.060	0.130
Semovita	6.720	0.752	17.496	0.064
Beans	12.984	0.225	16.506	0.086
Groundnut	5.546	0.852	8.079	0.621
Akara	7.757	0.653	14.040	0.171
Moin Moin	10.114	0.431	9.300	0.504
Melon	10.071	0.434	10.448	0.402
Ogbono	8.609	0.570	5.964	0.818
Cashew	6.285	0.791	13.123	0.217
Yam	7.323	0.836	10.526	0.396
Potatoes	9.291	0.505	11.868	0.294
Garri	21.167	0.020	7.993	0.630
Amala	21.076	0.021	18.244	0.051
Pounded Yam	12.923	0.228	18.500	0.047
Yam Porridge	14.837	0.138	8.484	0.582
Fufu	10.950	0.361	18.591	0.046
Palm oil	6.675	0.756	12.383	0.260
Vegetable oil	9.712	0.466	16.047	0.098
Butter	8.457	0.584	15.626	0.111

Mayonnaise	10.295	0.415	8.907	0.711
Meat	9.303	0.504	5.960	0.819
Chicken	9.022	0.530	13.427	0.201
Fish	41.521	0.000	12.693	0.241
Egg	11.884	0.293	7.448	0.683
Yoghurt	3.655	0.962	4.048	0.945
Ewedu	7.538	0.674	11.096	0.350
Ugwu	12.402	0.259	5.828	0.830
Spinach	1.763	0.998	14.452	0.153
Bitterleaf	9.523	0.483	10.849	0.369
Effirin	17.771	0.059	12.908	0.229
Waterleaf	10.120	0.430	12.096	0.279
Okra	14.773	0.142	11.551	0.482
Orange	12.199	0.272	11.867	0.294
Pawpaw	8.274	0.602	12.296	0.266
Pineapple	13.975	0.174	9.664	0.470
Banana	3.907	0.951	10.772	0.376
Tomato	16.337	0.090	6.790	0.871
Mango	7.871	0.641	8.299	0.761
Apple	19.456	0.035	13.665	0.189
Carrot	7.121	0.714	11.847	0.295
Plantain	8.400	0.590	4.115	0.942
Garden egg	9.290	0.505	10.806	0.373
Pepper	10.409	0.405	9.531	0.483
Onions	15.855	0.104	7.520	0.676
Locust beans	5.856	0.827	13.312	0.207
Garlic	16.549	0.085	10.080	0.433
Ginger	16.881	0.077	23.338	0.010
Curry	4.027	0.946	16.238	0.093

Table 4.8.3: Relationship between food consumed everyday and PBF category of secondary school adolescents in Ibadan North Local Government Area, Nigeria

Food Item	PBF category				
	Low (<5th)	Normal (5th-95th)	High (>95th)	X^2	P
		Female			
Rice	6 (2.9%)	162 (79.0%)	37 (68.5%)	23.275	0.003
Pounded Yam	3 (8.6%)	25 (71.4%)	7 (20.0%)	18.500	0.047
Fufu	3(8.1%)	28 (75.7%)	6 (16.2%)	10.950	0.046
Ginger	7 (10.8%)	51 (78.5%)	7 (10.8%)	23.338	0.010
		Male			
Garri	1 (1.2%)	58 (71.6%)	22 (27.2%)	21.167	0.020
Amala	1 (1.5%)	44 (65.7%)	22 (32.8%)	21.076	0.021
Fish	3 (2.0%)	98 (64.9%)	50 (33.1%)	41.521	0.000
Apple	1 (1.9%)	32 (61.5%)	19 (36.5%)	19.456	0.035

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

Studies have revealed that there is an epidemiologic shift, as obesity, which was once evident in developed countries, is gradually becoming a major public health problem of developing countries including Nigeria. The risk for the tremendous long-term consequences associated with increased percentage body fat (PBF), including cardiovascular disease, hypertension and increased risk for diabetes has also increased. As adolescents undergo significant body composition changes which may lead to increased body fat, it is important to determine their fat status in order to estimate their level of risk. This study was conducted to determine the percentage body fat (PBF) of secondary school adolescents in Ibadan North Local Government Area, Nigeria.

Female adolescents in this study had significantly higher weight than males. This is expected, especially at early and mid adolescence in the study population. However, at the highest age groups, it was observed that the males caught up and eventually surpasses the weight of female adolescents at age group 18-19. Towards late adolescence, there is an increase in bone density among males which usually results in higher weight than females. Generally, overweight adolescents are at risk for a number of weight-related physical and psychosocial consequences which may be difficult to manage and can have long term psychological implications (Duggan, Watkins and Walker, 2008). However, the classification of weight status in adolescents is complicated by the fact that height and body compositions are constantly changing, and such changes occur at different rates and times in different populations. Similarly, adolescent females in this study were seen to be taller than males up to age 15. From age 16 upwards, males were taller than females. This is expected as changes in height gain are linked to pubertal status. This change is expected as it is well known that females attain puberty earlier than males (Vizmanos and Martı´-Henneberg, 2000). Also, the growth spurt is found earlier in females and the males later catch up. This study further buttresses the fact that overall, adolescent females weigh more while adolescent males eventually become taller.

Adolescent females in this study had a larger waist circumference across all age groups and overall. Larger waist circumferences reflect increases in obesity-related health risks such as cardiovascular diseases and other forms of chronic disease, though the risk may vary in different populations (Janssen, Katzmarzyk, and Ross, 2004). PBF was seen to be positively correlated with WC in both male and female adolescents. Similarly, hip circumference of females was higher than that of males from ages 12 to 17 years though it is surprising to note that at age 18-19, the males had higher hip circumference. Pubertal females are known to have increased hip circumferences. This finding may be as a result of the fact that adolescent females at this age group are more conscious of overweight status and may make conscious efforts to maintain a body stature, when compared to females in early adolescence. The higher HC in adolescent females was found to be positively correlated with increased PBF, meaning that HC contributes significantly to body fat. Again, Body Mass Index (BMI) was generally higher among female. This is explained by the fact that females in this study had higher weight and shorter height; it therefore means than in the computation of their BMI, a higher numerator will result in a higher BMI. PBF was positively correlated with BMI for all adolescents.

The waist to height ratio (WHtR) was slightly higher in female than male adolescents. Higher values of WHtR indicate higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity (Lee, Huxley, Wildman and Woodward, 2008). The waist hip ratio was not significantly different for male and female adolescents. PBF was found to be positively correlated with WHtR and BMI for both male and female adolescents. This means that measurement of PBF is strongly correlated with other measurements of overweight and obesity and is a useful tool in obesity research.

Analysis of the dietary intake of adolescents showed that daily consumption of garri, amala, fish and apple had a positive association with PBF among male adolescents. Furthermore, 27.2%, 32.8%, 33.1% and 36.5% of male respondents that consumed garri, amala, fish and apple respectively had high PBF compared to 1.2%, 1.5%, 2.0% and 1.9% that had low PBF. Similarly, daily consumption of rice, pounded yam, fufu and ginger had positive association with PBF category for female adolescents in this study. Again, 18.0%, 20.0%, 16.2% and 10.8% of females that consumed rice, pounded yam, fufu and ginger respectively had high

PBF as compared to 2.9%, 8.6%, 8.1% and 10.8% that had low PBF, Garri, amala, fufu and pounded yam are good carbohydrate sources while fish and apple are protein and fruit respectively. Also, percentage fat content of these carbohydrate foods are low as seen in literature (Reinehr, Roth, Alexy, Kersting, Kiess and Andler, 2005), and these food items may not be a major contributor to the high PBF of adolescents.

As regards physical activity, PAS was generally average (2.4±0.6) on a scale of 1 to 5. For combined sex, there was a negative correlation between PBF and PAS ($r=-0.174$, $p=0.000$). However, on segregation on PAS by sex, there was a negative, though not significant, correlation between PBF and PAS for both male and female adolescents. The findings from this study show that physical activity had no influence on PBF for both male and female adolescents.

Another major finding of this study was the fact that percentage body fat (PBF) of females was significantly higher than males. This is expected, as during puberty, males gain greater amounts of fat free mass and skeletal mass, whereas females acquire significantly more fat mass. This difference is probably due to the fact that boys gain more muscle during puberty and less fat (Forbes, 1978). Girls tend to gain more fat during puberty as a result of breast and hip development and other fatty tissues. Similar results have been reported by other studies (Papandreou et al, 2010; Sung et al, 2009; McCarthy et al, 2006; Mueller et al, 2004). Findings from this study was a bit contrasted by findings from another study which revealed that PBF remained fairly stable from age 6 to 18 years in boys; with only a slight decrease at 13 to 14 years and a slow steady increase after the age of 14 years (Sung et al, 2009). The study by Sung and others also revealed that in girls, PBF increased steadily from 6 to 18 years of age. The mean PAS was slightly higher in male (2.5±0.6) that female (2.3±0.6) adolescents ($p=0.000$), however, PAS was not significantly correlated with PBF for both male and female adolescents in this study.

It is worthy to note that the PBF values obtained in this study were generally smaller than those obtained in previous studies (Owa and Adejuyigbe, 1997; Papandreou et al, 2010; Sung et al, 2009; McCarthy et al, 2006). Previous studies of body composition in children reported ethnic differences among white, black, Hispanic, and South Asians. To compare these findings with the standards from other ethnic groups is complicated, because of the different sampling methods and BIA machines used or real biological differences may exist when comparing the subjects. It is also very complicated to compare these results with other body composition measurements in children from other studies due to racial differences in sampled population, age differences and other factors including time of the day, consideration of feeding or hydration levels and diet, among other factors (Sung et al, 2009; McCarthy et al, 2006; Mueller et al, 2004; Chumlea et al, 2002; Shaw et al, 2007).

In comparing PBF values across age groups of both sexes, this study found no significant correlation between PBF and age among female participants but a significant, though weak negative correlation was observed between PBF and age in male participants. The negative correlation between PBF and age in the male participants may be attributed to pubertal status, as boys gain more muscle and their fat content usually reduces during puberty (Forbes, 1978), however, girls have been shown to gain more fat and less muscle. As PAS was not significantly associated with PBF for male and female adolescents, physical activity in this study may not have contributed to this.

In contrast to PBF values, PFFM as shown in this study was higher among males than females. This was expected, as other studies have revealed similar patterns. Generally, it is known that PBF is inversely proportional to PFFM, hence, the higher the PBF values, the lower the PFFM values and vice versa. The difference in FFM between sexes is usually pronounced during adolescence. It has been reported that FFM in boys increases rapidly between 12 and 15 years of age, and continues to age 18, while that of girls increases steadily until about 15 years of age (Duggan et al, 2008). This is consistent with the findings of this study, although in this study, the FFM of girls increased up till age group 16-17, after which there is a decline. The pattern of growth in FFM is correlated with changes in height. Similarly, PBW was consistently higher among male than female adolescents. Males generally have higher body water content than females (Vella and Kravitz, 2002). When the PBF values of both sexes were grouped into percentiles, at each age group, female adolescents had higher PBF values at various percentiles. This is also consistent with the fact that females have generally higher PBF values than males.

It is expected that majority of adolescents will fall between 5th-95th percentile for their age and sex. An interesting finding worthy of note in this study was that males more than female adolescents tended to have PBF >95th percentile (high PBF) for their age and sex. This finding was supported by the study in the Youth Risk Behaviour Surveillance- United States, which contended that boys are generally more likely to be overweight and at risk than girls (Grunbaum et al, 2001). However, another study reported that African American girls have significantly higher rates of overweight than boys, and in Native American children no gender differences are apparent (Crawford, Story, Wang, Ritchie, and Sarby, 2001). Again, other reasons such as heredity and ethnicity may have contributed to this.

The participants in the study represent adolescents from an urban community in Ibadan, Nigeria with representation from high, middle and low socioeconomic groups. Participants were drawn from both private and public schools. Males generally had a higher PBF in private than public schools, though this finding was not significant for females. This study also sought to explore differences in PBF percentiles based on school type. This segregation was done based on the assumption that adolescents from the higher socioeconomic class were more likely to attend private schools than those from the lower socioeconomic class. Rather, findings revealed males falling more >95th percentile both in public and private schools, though this was more significant in public schools. Dietary practices could play a key role in this. The proliferation of fast food joints in Ibadan Metropolis and also the common staple foods which are usually high in starch might minimise, if not eliminate, the differences in PBF based on school type. Again, participants were grouped into socioeconomic classes, yet this did not affect the PBF of participants as the mean PBF were in no particular order among socioeconomic classes within female participants. Males generally had increasing mean PBF with the rise in socioeconomic class. The reason for this is not very clear, though this finding is still consistent among males when grouped by school type.

5.2 Conclusion

The average PBF of adolescents in this study was 12.6±7.1% with female adolescents (14.9±6.7%) having a higher PBF than male adolescents (8.5±5.6%). PBF was positively correlated with BMI, WC and WHtR in male adolescents and positively correlated with age, weight, BMI, WC, HC and WHtR in female adolescents. PBF was negatively correlated with age and height in male adolescents and negatively correlated with height in female adolescents. PBF showed no significant difference among male and female adolescents irrespective of socioeconomic group. 5th and 95th percentiles were used as cut-offs for PBF in the adolescents, following the Gaussian distribution and PBF was grouped as low (<5th), normal (5th-95th) and high (>95th). More male than female adolescents high PBF estimates for age and sex in the study population irrespective of socioeconomic status especially in public school.

5.3 Recommendation

Percentage Body Fat (PBF) is a useful predictor of overweight and obesity as it is strongly correlated with other measures. Further studies to estimate prediction equations for estimating PBF based on simple anthropometric parameters would be very useful in obesity research and should be adequately explored. Also, pre-and post intervention studies should be carried out to identify the impact of dietary intervention on PBF of adolescents.

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APPENDIX I

ETHICAL APPROVAL

TELEGRAMS...... TELEPHONE......

MINISTRY OF HEALTH

DEPARTMENT OF PLANNING, RESEARCH & STATISTICS DIVISION

PRIVATE MAIL BAG NO. 5027, OYO STATE OF NIGERIA

Your Ref. No. ....
All communications should be addressed to the Honourable Commissioner quoting
Our Ref. No: AD 13/479/84

Date 19th November, 2010

The Principal Investigator,
Institute of Child Health,
College of Medicine,
University of Ibadan,
Ibadan.

Attention: Oyom Comfort Runyi

Ethical Approval for the Implementation of Your Research Proposal in Oyo State.

This acknowledges the receipt of the corrected version of your Research Proposal titled ``*Body Mass Estimation by Bioelectric Impedance and Anthropometric Techniques in Secondary School Students in Ibadan North Local Government Area''*.

The Committee has noted your compliance with all the ethical concerns raised in the initial review of the proposal. In the light of this, I am pleased to convey, to you, the approval of the committee for the implementation of the Research Proposal in Oyo State, Nigeria.

Please, note that the committee will monitor, closely, and follow up the implementation of the research study. However, the Ministry of Health would like to have a copy of the results and conclusions of the findings as this will help in policy making in the health sector.

Wishing you all the best

Adepoju

Mrs V.A. Adepoju
Director, Planning, Research & Statistics
Secretary, Oyo State, Research Ethical Review Committee.

APPENDIX II

QUESTIONNAIRE

BODY MASS ESTIMATION BY BIOELECTRIC IMPEDANCE AND ANTHROPOMETRIC TECHNIQUES IN SECONDARY SCHOOL STUDENTS IN IBADAN NORTH LOCAL GOVERNMENT AREA

INSTRUCTION: Completion of questionnaire should be assisted by the interviewer

Identification Number: [ ]

Date:

Section A: SOCIODEMOGRAPHIC CHARACTERISTICS

1. Sex: 2.Age: 3.Class:

4. Tribe: 5.Religion: 6.School:

7. Where do you live? (a) With parents (b) with relatives (c) others, Specify ________

8. Family type (a) monogamous (b) Polygamous (c) single parent

9. No of siblings from father _________

10. No of siblings from mother__________

11. Educational status of parents: (write code for each parent)

University graduate and equivalents = 1 Mother: ______________

Post-Secondary certificate, not University =2

Secondary School or grade II Certificate = 3 Father: _______________

Modern 3 and Primary 6 Certificate = 4

No formal education = 5

12. Occupation of parents:

Senior public servant, professional, manager, contractor, large scale trader = 1

Intermediate grade, public servant, senior school teachers = 2 Mother: __________

Junior school teacher, driver, artisan = 3

Petty trader, labourer, messenger, similar grades = 4 Father: ___________

Unemployed, fulltime house wife, student, subsistence farmer

Section B: PHYSICAL ACTIVITY QUESTIONNAIRE

We are trying to find out about your level of physical activity from ***the last 7 days*** (in the last week). This includes activities that make you sweat, make your legs feel tired, or make you breathe hard, such as team sports, running, strenuous occupational activities, and others.

Remember:

- There are no right and wrong answers— this is not a test
- Please answer all the questions as honestly and accurately as you can — this is very important

13. Physical activity in your spare time: Have you done any of the following activities **in the past 7 days** (last week)? If yes, how many times? (Mark only one circle per row.)

	No	**1-2**	**3-4**	**5-6**	**7 times or more**
Tennis					
Walking for exercise					
Heavy yard work					
Jogging or Running					
Bicycling					
Aerobics (or other exercise class)					
Swimming					
Dance					
Football					
Badminton					
Volleyball					
Basketball					
Martial arts					
Weight training					
Other:					

14. In the last 7 days *during the morning*, how often were you very active (for example: playing sports, exercise classes, strenuous occupational activity, strenuous household or child rearing tasks)? (Check one only.)

		Tick one only
1	None	
2	1 time last week	
3	2 or 3 times last week	
4	4 or 5 times last week	
5	6 or 7 times last week	

15. In the last 7 days *after lunch and before supper*, how often were you very active (for example: playing sports, exercise classes, strenuous occupational activity, strenuous household or child rearing tasks)? (Check one only.)

		Tick one only
1	None	
2	1 time last week	
3	2 or 3 times last week	
4	4 or 5 times last week	
5	6 or 7 times last week	

16. In the last 7 days *during the evening*, how often were you very active (for example: playing sports, exercise classes, strenuous occupational activity, strenuous household or child rearing tasks)? (Check one only.)

		Tick one only
1	None	
2	1 time last week	
3	2 or 3 times last week	
4	4 or 5 times last week	
5	6 or 7 times last week	

17. **On the last weekend**, how often were you very active (for example: playing sports, exercise classes, strenuous occupational activity, strenuous household or child rearing tasks)? (Check one only.)

		Tick one only
1	None	
2	1time last week	
3	2 or 3 times last week	
4	4 or 5 times last week	
5	6 or 7 times last week	

18. Which *one* of the following describes you best for the **last 7 days**? Read *all five* statements before deciding on the ***one* answer** that describes you.

A.	All or most of my free time was spent doing things that involve little physical effort.	
B.	I sometimes (1-2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics).	
C.	I often (3-4 times last week) did physical things in my free time.	
D.	I quite often (4-5 times last week) did physical things in my free time.	
E.	I very often (7 or more times last week) did physical things in my free time.	

19. Mark how often you did physical activity (for example: playing sports, exercise classes, strenuous occupational activity).

	None	**Little Bit**	**Medium**	**Often**	**Very Often**
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					

20. Were you sick last week, or did anything prevent you from doing your normal physical activities? (Check one.)

Yes ☐ No ☐

21. If Yes, what prevented you? ☐

Activity Rating

Compared to others of your age and sex, how much physical activity do you get?

Much less active	less active	Averagely active	Active	Much more active

Leisure Time Exercise Questionnaire

22. Considering a **7-day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your **free time**? (Enter the number in the appropriate box).

	TIMES PER WEEK
a. STRENUOUS EXERCISE (HEART BEATS RAPIDLY) (i.e. running, jogging, football, basketball, vigorous swimming, vigorous long distance bicycling)	
b. MODERATE EXERCISE (NOT EXHAUSTING) (i.e. fast walking, tennis, easy bicycling, volleyball, badminton, easy swimming, mild dancing)	
c. MILD EXERCISE (MINIMAL EFFORT) (i.e. walking leisurely or at a regular pace, sweeping, washing plates, clothes or other house work that is not vigorous)	

23. Considering a **7-day period** (a week), during your **leisure-time**, how often do you engage in any regular activity long enough to **work up a sweat** (heart beats rapidly)?

OFTEN	SOMETIMES	NEVER/RARELY

Section C: FOOD FREQUENCY QUESTIONNAIRE

Below is a table showing a list of food items. Please tick how often you eat each of the following food items

	Food groups	Everyday	2-3 times/ day	Once/week	2-3 times/ week	2-3 times/ month	Never
24	**Cereals and Grains.**						
a.	Rice						
b.	Maize						
c.	Pap (Ogi/Eko)						
d.	Sorghum						
e.	Bread						
f.	Millet						
g.	Tuwo						
h.	Semovita						
25	**Legumes and Nuts**						
a.	Beans						
b.	Groundnut						
c.	Akara						
d.	Moinmoin						
e.	Melon						
f.	Ogbono/Apon						
g.	Cashew nut						
26	**Roots and Tubers**						
a.	Yam						
b.	Potatoes						

c.	Garri						
d.	Amala						
e.	Pounded yam						
f.	Yam porridge						
g.	Fufu						
27	**Fats and Oils**						
a.	Palm oil						
b.	Vegetable oil						
c.	Butter/Margarine						
d.	Mayonnaise						
28	**Animal Products**						
a.	Meat						
b.	Chicken						
c.	Fish						
d.	Egg						
e.	Milk and products e.g. yoghurt						
29	**Fruits and Vegetables**						
a.	Ewedu						
b.	Ugwu						
c.	Spinach (Green)						
d.	Bitter leaves						
e.	Effirin						
f.	Water leaves						
g.	Okro						
h.	Orange						
i.	Paw paw						
j.	Pineapple						
k.	Banana						
l.	Tomato						
m.	Mango						
n.	Apple						
o.	Carrot						

p.	Plantain						
q.	Garden egg						
r.	Pepper						
s.	Onions						
30	**Condiments/Spices/Herbs**						
a.	Locust beans						
b.	Garlic						
c.	Ginger						
d.	Curry						

Section D: ANTHROPOMETRY

	Parameter	Date	Reading 1	Reading 2	Reading 3
31	Weight (kg)				
32	Height (cm)				
33	Waist circumference (cm):				
34	Hip circumference (cm)				

Section E: BODY MASS (Using bioelectric impedance analyzer)

35. BODY FAT

Percent …………………....% Amount …………………..kg

Target min. ………………% Target max. ………………%

Body Fat Assessment (a) Above target (b) Within Target (c) Below Target

36. ELECTRICAL Resistance…………………R

37. BODY WEIGHT

BMI………………………...kg/m sq BMR………………………..kcal

Target min…………………kg Target max…………………kg

Body Weight Assessment (a) Above target (b) Within Target (c) Below Target

38. BODY LEAN

Amount……………………..kg Percent……………………..%

39. BODY WATER

Amount………………………lt Percent………………………%

Target min……………………% Target max……………………%

Body Water Assessment (a) Above target (b) Within Target (c) Below Target

Have you eaten today? ………………………… If yes, how long ago …..……………

Did you drink water today? .... If yes, how long ago…………………

Have you done any form of exercise today?............. If yes, how long ago…………………

IWE IBEERE

ODIWON BI ARA SE TOBI SI NIPA SISE AMULO ERO IGBALODE LARIN AWON OMO ILE IWE GIRAMA NI IJOBA IBILE ARIWA IBADAN

Ilana atele: Ti yi o pari pelu olubeere

Nomba Idanimo:

Date:

Ipin Kinni: IBEERE NIPA ARA ENI

1. Okunrin ni yin tabi Obinrin
2. Omo odun melo ni yin
3. Kilasi wo ni e wa?
4. Eya wo ni yin?
5. Kinni esin yin
6. Ile iwe
7. Nibo ni e ngbe? (a) Pelu awon obi (b) Pelu awon molebi (c) Awon miran, salaye
8. Iru idile wo ni e ti wa? (a) Oni iyawo kan, oko kan (b) Oni iyawo pupo, oko kan (c) Oni obi kan
9. Iye awon omo baba yin ____________
10. Iye awon omo iya yin ____________

11. Iwe melo ni awon obi yin ka?(ko nomba ti obi kookan)

Akeko jade Ile eko giga(univasiti) ati eyi to jọ = 1 Iya: ______________

Ile iwe to ga ju girama lo sugbon ti kii se univasiti = 2 Baba: _____________

Ile eko girama tabi oniwe eri oni ipo keji(Grade II) = 3

Modern 3 ati oniwe mefa = 4

Won ko ka rara = 5

12. Iru ise wo ni awon obi yin nse:

Oga ni enu ise ijoba, akose mose, alamojuto, agbasese, onisowo nla = 1

Onipele to wa larin, osise ijoba, Oluko ile iwe girama agba = 2 Iya: ________

Oluko ile iwe girama kekere, awako, onise owo = 3 Baba: _________

Oniwoso kekere, Labira, Iranse, onipo kanna = 4

Alainise, Iyawo ile, akeko, agbe alaroje = 5

Ipin Keji: IWEIBEERE NIPA ERE IDARAYA

A n gbiyanju lati mo nipa bi e se se ere idaraya si ni bi ojo meje seyin (ni ose kan seyin)Eyi ni se pelu awon nkan ti e se to mu yin laagun, to je ki ese ro yin tabi ti o je ki e ma mi hele-hele: bi ere idaraya alasepo, ere sisa, ise to le ati awon miran

RANTI:

- Ko si idahun to gbaa tabi sii – eyi kii se idanwo
- E jowo e dahun awon gbogbo ibeee yii pelu ootọ ati dede niwon bi e se le se – eyi se pataki

13. Ere idaraya ni asiko ti e ko ba se nkankan (Asiko isinmi) Nje e se ikankan ninu awon ere idaraya yi ni bi ojo meje seyin (ose to koja) To ba je be, Igba melo? (Sami si eyo kan ninu awon igba ti a ti la kala)

	Iye igba	Ekan si emeji	Emeta si emerin	Emarun si emefa	Emeje tabi ju be lo
Tennis					
Irin rinrin gege bi ere idaraya					
Ise ogba to le					
Ere sisa to dabi irin rinrin tabi ere sisa					
keke wiwa					
Awon ere idaraya miran to lagbara					
Odo wiwe					
Ijo jijo					
Boolu gbigba					
Badminton					
Boolu alafowogba (Volley ball)					
Boolu alapere					
Ere onijakadi					
Igbaradi fun Irin gbigbe					

14. Ni ojo meje seyin ni aaro, bawo ni ara yin ya gaga (Fun apere: lati se ere idaraya, se ise to la wahala lo, se ise ile to ni wahala tabi ise itoju omo)? (sami si eyo kan)

		Sami si eyo kan
1	Rara	
2	Eekan ni ose to koja	
3	Emeji tabi emeta ni ose to koja	
4	Emerin tabi emarun ni ose to koja	
5	Emefa tabi emeje ni ose to koja	

15. Ni ojo meje seyin ni aarin ounje osan si ti ale, bi emelo ni ara yin ya gaga (Fun apere: lati se ere idaraya, se ise to la wahala lo, se ise ile to ni wahala tabi ise itoju omo)? (sami si eyo kan)

		Sami si eyo kan
1	Rara	
2	Eekan ni ose to koja	
3	Emeji tabi emeta ni ose to koja	
4	Emerin tabi emarun ni ose to koja	
5	Emefa tabi emeje ni ose to koja	

16. Ni ojo meje seyin, ni asale / irole bi emelo ni ara yin ya gaga (Fun apere: lati se ere idaraya, se ise to la wahala lo, se ise ile to ni wahala tabi ise itoju omo)? (sami si eyo kan)

		Sami si eyo kan
1	Rara	
2	Eekan ni ose to koja	
3	Emeji tabi emeta ni ose to koja	
4	Emerin tabi emarun ni ose to koja	
5	Emefa tabi emeje ni ose to koja	

17. Ni opin ose ti o koja, bi emelo ni ara yin ya gaga (Fun apere: lati se ere idaraya, se ise to la wahala lo, se ise ile to ni wahala tabi ise itoju omo)? (sami si eyo kan)

		Sami si eyo kan
1	Rara	
2	Eekan ni ose to koja	
3	Emeji tabi emeta ni ose to koja	
4	Emerin tabi emarun ni ose to koja	
5	Emefa tabi emeje ni ose to koja	

18. Ewo ninu awon oro wonyi ni o se apejuwe yin daradara fun ojo meje seyin, e ka awon oro mararun ki e to pinu lati mu idahun ti o se apeyuwe yin

A	Gbogbo tabi igba to po ninu asiko isinmi mi ni mo lo lati se nkan ti ko la agbara pupo lo	
B	Ni igba miran, (ekan si emeji ni ose to koja) mo ma nse ere idaraya ni asiko isinmi mi (bi: ere idaraya sise,ere sisa, odo wiwe, gigun alupupu (okada) sise idayara to lagbara)	
C	Mo maa n saba (emeta si emerin ni ose to koja) se ere idaraya ni igba ti nko ba se nkankan	
D	Ni igba to po die (emerin si emarun ni ose) mo maa n saba se ere idaraya ni igba ti nko ba se nkankan	
E	Ni igba pupo (emeje tabi ju be lo lose to koja) mo maa n saba se ere idaraya ni igba ti nko ba se nkankan	

19. E sami si iye igba ti e se ere idaraya (fun apere: sise ere idaraya, ise to ni wahala ninu)

	Kosi rara	Kekere die	Iwontunwonsi	Opo igba	Opolopo
Ojo Aje					
Ojo Isegun					
Ojo Ojoru					
Ojo Ojobo					
Ojo Eti					
Ojo Abameta					
Ojo Aiku					

Se ara yin ko ya ni ose to koja, tabi ohun kan di yin lowo lati ma se awon ere idaraya ti e ma nse (Mu okan)   Beeni ☐   Beeko ☐

21.   To ba je beeni, ki ni o di yin lowo ☐

Fifi odiwon si ohun ti e nse

Ti e ba fi we ti egbe yin, bawo ni e se nse ere idaraya si?

O kere gan	O kere die	Iwontunwonsi	A po	O po pupo

Iwe ibeere nipa ere idaraya ni asiko isinmi

22.   Ti e ba se agbeyewo ojo meje seyin (ose kan) igba melo ni e se iru ere idaraya yi fun igba ti ju iseju meedogun lo nigba ti e ko se nkankan (kọ iye igba na si inu aye ti a ti pese)

		Iye igba ni ose
A	Ere Idaraya to lagbara (okan n mi hele-hele) (Fun apere: ere sisa, boolu gbigba gbigba boolu alajo Odo wiwe alagbara, wiwa keke lo si ona to jin)	
B	Ere Idaraya sise ni iwontunwonsi (eyi ti ko lo gbogbo agbara) (Fun apere: yiyara rin, gigun keke ni jelenke, odo wiwe diedie, Iji jijo ni jelenke)	
C	Ere idaraya ti ko gba agbara (eyi ti wahala ko po) (Fun apere: irin rinrin ni jelenke, ile gbigba, abo fifo, aso fifo ati awon ise ile miran ti ko la agbara lo)	

23. Ni bi ojo meje seyin (ose kan)nigbati e ko se nkankan, bawo ni e se maa n s e ere idaraya si tabi ohun ti o le je ki e laagun? (Ti okan yin yio ma mi hele-hele)

Pupo	Igba die	Rara / ko wọpọ

Ipin Keta: IWE IBEERE BI E SE MAA N JEUN TELE RA WON SI

Tabili ti o wa ni isale yii n se afihan awon ounje. E jowo e sami si bi e se maa n je okookan ninu awon ounje wonyi si

	Isori Ounje	Ojojumo	Emeji si emeta ni ojumo	Ekan ni ose	Emeji si emeta ni ose	Emeji si emeta ni osu	Rara
24	Ounje onihoro ti won fi ma n se Iyefun						
	Iresi						
	Agbodo						
	Sogumo (Jero)						
	Buredi						
	Oka baba						
	Tuwo						
	Semofita						
25	Awon ounje ti a ri lara Ewa, Epa ati awon ohun ti o jo						
	Ewa						

	Epa						
	Akara						
	Moimoi						
	Ogbono / Apon						
	Kasu						
26	Ounje lati ara gbongbo						
	Isu						
	Anamo						
	Garri						
	Amala						
	Iyan						
	Asaro						
	Fufu						
27	Ora ati Ororo						
	Epo pupa						
	Ororo						
	Buta						
	Mayonnaise						
28	Ohun jije/mimu lati ara eran						
	Eran						
	Eran Adie						

	Eja							
	Eyin							
	Miliki ati awon eroja to jade ninu miliki: fun apere yugoti							
29	Eso ati Ewebe							
	Ewedu							
	Ugwu							
	Tete							
	Ewuro							
	Effirin							
	Gure							
	Ila							
	Osan							
	Ibepe							
	Opon oyinbo							
	Ogede							
	Tomati							
	Mangoro							
	Apple							
	Carrot							
	Ogede Dodo							

	Igbaa						
	Ata						
	Alubosa						
30	Eroja amu obe dun						
	Iru						
	Garlic						
	Ginger						
	Kori						

Ipin Kerin: ISE IWADI NIPA WIWON ATI BI ARA SE TOBI SI

		Date	Akosile Ikini	Akosile Keji	Akosile Keta
31	Iwon (Kg)				
32	Giga (cm)				
33	Bi idi se tobi si				
34	Bi Ibara idi se fe si				

Ipin Karun: BI ARA SE TOBI SI (NIPA LILO IRINSE IGBALODE)

35. ORA ARA

Odiwon . . . . % Iye . . . . Kg

Ofojusun to kere ju . . . . % Ofojusun to po ju . . . . %

Bi Ora ara se po to

(a) O po ju afojusun lo (b) O se dede pelu afojusun (c) O kere si afojusun

36. Electrical Resistance . . . . R

37. Iwon Ara

BMI . . . . Kp/m sq BMR . . . . Keal

Ofojusun to kere ju . . . . % Ofojusun to po ju . . . . %

Bi ara se gbe iwon si

(a) O po ju afojusun lo (b) O se dede pelu afojusun (c) O kere si afojusun

38. Bi Ara se so si

Iye . . . . Kg Odiwon . . . . %

39. Omi Ara

Iye . . . . Kg Odiwon . . . . %

Ofojusun to kere ju . . . . % Ofojusun to po ju . . . . %

Bi Omi se wa para si

(a) O po ju afojusun lo (b) O se dede pelu afojusun (c) O kere si afojusun

Se e ti jeun loni? . . . . To ba je beni, o ti to igba wo seyin . . . .

Se e mu omi loni? . . . . To ba je beni, o ti to igba wo seyin . . . .

Se e ti se ere idaraya kankan loni? . . . . To ba je beni, o ti to igba wo seyin . . . . .