SONOGRAPHIC DETERMINATION OF NORMAL
SUBCUTANEOUS FAT THICKNESS IN CHILDREN IN
CALABAR, CROSS RIVER STATE, NIGERIA

BY

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT
FOR THE AWARD OF THE FELLOWSHIP OF THE
NATIONAL POSTGRADUATE MEDICAL COLLEGE OF
NIGERIA IN THE FACULTY OF RADIOLOGY.

NOVEMBER 2016.
DECLARATION

I hereby declare that this work was carried out by me during the period of my residency training in the department of Radiology of University of Calabar Teaching Hospital.

......................................................

Dr, Affiong Ifop Ngaji
ATTESTATION

It is hereby attest that this work was carried out by Dr. A. I. Ngaji in the department of Radiology of University of Calabar Teaching Hospital under our supervision.

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I do hereby certify that this work was carried out by Dr. A. I. Ngaji during the course of her residency program in the Department of Radiology, Lagos State University Teaching Hospital Ikeja, Lagos.

…………………………

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SUMMARY

Background: Subcutaneous fat was originally perceived as a passive storage site for excess fat but now considered a highly active metabolic tissue that exerts control on numerous biochemical and physiological processes in health and disease. Children are particularly susceptible to the problem of undernutrition and over nutrition hence the need to measure subcutaneous fat thickness which can be used to determine their body composition. Ultrasonography could provide an easy, affordable, non-invasive, readily available technique of measuring subcutaneous fat thickness.

Objective: The aim of this study was to determine normal values of subcutaneous fat thickness (SFT) at the triceps, subscapular and abdomen in children aged one to five years using ultrasound in Cross River State, Nigeria. This will serve as baseline for assessing undernutrition and overnutrition.

Methods: This was a prospective study of 1,750 (one thousand seven hundred and fifty) healthy children aged one to five years in nursery and primary schools in Calabar. Their body mass indexes (BMI) were calculated from their weights and heights while their triceps fat thickness (TFT), subscapular fat thickness (SuFT) and abdominal fat thickness (AFT) were measured using a 7.5MHz linear array transducer of a C- Picker portable Ultrasound machine.

Results: The mean TFT value for girls was 4.6 ± 2.0mm and 3.99 ± 1.8mm for boys. Girls had mean SuFT value of 2.37 ± 1.41mm and 2.14 ± 1.02mm for boys. The mean AFT value for girls was 5.53 ± 2.94mm and 4.53 ± 2.37mm for boys. The values at all sites were generally higher in females than in males.

Conclusion: This work has provided a sonographic normogram of SFT at various sites for preschool children in Nigeria. This will play an important role in assessing children in health and disease in clinical paediatric practice.

Keywords: Children, Subcutaneous fat thickness, Ultrasonography.
INTRODUCTION

Subcutaneous fat is the fatty or adipose tissue lying directly below the skin in a region called the dermis. Recent advances in molecular biology are helping to redefine the role of adipose tissue. This organ was perceived as a passive storage site for excess fat but it is now considered a highly active, finely tuned metabolic tissue exerting control on numerous biochemical and physiological processes in both health and disease. Measurement of the thickness of subcutaneous fat is important in several areas of medicine. Its major use is in the assessment of nutritional status or in the monitoring of dietary manipulation in order to alter this status. The most commonly used indirect method for estimating body fat is based on measurements of subcutaneous fat tissue.

The most widely used technique for measuring the thickness of subcutaneous fat, which is often used as an estimate of whole body fat, is the skinfold calipers. Unfortunately, it is difficult to obtain accurate measurements with the caliper method which is simple and inexpensive because of the compressive action of the calipers, its inability to exactly separate muscle from fat and it is very painful in infants.

Other techniques include the total body water, bioelectrical impedance, densitometry. Densitometry is a technique that uses Air Displacement Plethysmography. It is extremely simple to operate, safe and non-invasive but it is expensive. Total Body Water is based on the nutrition model of body composition. Bioelectrical impedance determines body composition based on the body measured impedance to passing current.

Imaging modalities such as Plain Chest Radiography, Computed Tomography,
Magnetic Resonance Imaging, Dual Energy X-ray Absorptiometry and Ultrasonography can also be used in measuring subcutaneous fat thickness.

Most are clearly unsuitable for neonatal and childhood studies both for technical and practical reasons ranging from cost to non-availability, technical complexities, inaccuracy and radiation exposure.² ⁶

Ultrasound on the other hand is a cheap, easy to operate and readily available method of measuring subcutaneous fat thickness with no exposure to radiation. ³ It is painless, non-invasive, therefore the most suitable imaging modality.
AIMS AND OBJECTIVES

GENERAL

• To measure normal values of subcutaneous fat thickness in children in Nigeria using B-mode Ultrasonography and anthropometric parameters that affect value.

SPECIFIC

• To determine normal values of subcutaneous fat thickness in children in Calabar, Nigeria that can be used as baseline for assessing malnutrition or obesity.

• To determine the relationship between the subcutaneous fat thickness of these children with the following parameters - age, sex, weight, height, and body mass index (BMI).

HYPOTHESIS

Normal values for subcutaneous tissue thickness can be determined by ultrasonography in our environment.

SUB HYPOTHESIS

Subcutaneous fat thickness is influenced by anthropometric parameters, gender and age in children in Nigeria.
JUSTIFICATION OF STUDY

The measurement of subcutaneous fat is of interest in children when determining body composition in studies of obesity and malnutrition. This is becoming a public health concern in Africa. In our environment, many disease conditions such as protein energy malnutrition, tuberculosis and sickle cell disease are associated with soft tissue wasting and weight loss. Oloyede et al.\(^7\) demonstrated that subcutaneous tissue wasting was an important differentiating feature between pulmonary tuberculosis and paragonomiasis in children. It is therefore imperative to establish reference values for subcutaneous tissue thickness in order to appropriately diagnose and monitor these disease conditions. There is no known data for normal values of subcutaneous tissue thickness in Nigeria. Lagundoye et al.\(^8\) did a study on children with kwashiorkor more than three decades ago, hence the need for this work.

Most of the techniques used in measuring subcutaneous fat thickness may be of limited use for children in our environment due to high cost, non-availability and exposure to ionizing radiation. Ultrasound on the other hand is cheap, painless, non-invasive and readily available.
GROSS ANATOMY OF SUBCUTANEOUS FAT TISSUE

The skin is divided into three main regions, the epidermis, the dermis and the hypodermis. The subcutaneous fat is the fatty or adipose tissue lies directly below the dermis in a region called the hypodermis. It consists of connective tissue septa and fat lobules. The size of this layer varies throughout the body and from person to person. In the abdomen, it comprises of three layers: a superficial adipose layer, a membranous layer and a deep adipose layer.

Superficial adipose tissue is the first layer of adipose tissue underneath the dermis. It is formed by large fat lobules encased between fibrous septae in a honeycomb-like structure. These septae are well defined, mostly oriented perpendicular to the surface, are mechanically strong, anchoring the dermis to the deeper planes. The fat lobules are organized in single to multiple layers depending on its fat content and thickness in the subject. It has high structural ability and elastic properties hence can regain their original position and shape after displacement.

Underneath this, is a fibroelastic tissue with membranous appearance. It is a well-defined layer with differential thickness in different parts of the body. The deep adipose tissue demonstrates regional variation with respect to its fascial framework but is contained within relatively loose, less organized and widely spaced fascial septa. It is bounded by the subcutaneous fascia above and the muscle fascia below. Hence, it shows tendency towards displacement with limited capacity for regaining the original relationship. This explains the sliding nature of the subcutaneous tissue over the deep fascia. Vascular and nervous structures are seen in this layer.
Its main role is to store energy in the form of lipids which can be burned to meet the energy needs of the body. The fat tissue, once considered as a depot for energy substrate is a metabolically active tissue. The fat cells produce agents that regulate a host of physiological and biochemical processes. In recent years, adipose tissue has been recognized as a major endocrine organ as it secretes hormones such as adiponectin, leptin, resistin and cytokines, angiotensinogen, plasminogen activator-1 and steroids hormones which influences energy homeostasis, glucose and lipid metabolism, vascular homeostasis, immune response and even reproduction.
SONOGRAPHIC ANATOMY OF SUBCUTANEOUS FAT TISSUE

Subcutaneous fat is defined as the depth from the skin to muscle. The epidermis and dermis cannot be differentiated - they are shown together as a thin hyperechoic layer. The subcutaneous layer appears hypoechoic with two components - hypoechoic fat interspersed with hyperechoic linear echoes which represent connective tissue septa running mostly parallel to the skin. Fascia appears as a linear hyperechoic layer.

**Figure 2A & B**: Longitudinal Sonogram and Schematic diagram of the Subcutaneous Tissue of the Abdomen –

A - Epidermis and Dermis
B - Subcutaneous Fat
C - Deep Fascia
D - Skeletal Muscle
E - Peritoneal Cavity.
LITERATURE REVIEW

During growth, the human body increases in size and changes proportion of various components due to hormone mediators. Growth is a complex biological process regulated by multiple factors. These include genetic, nutritional intake, physical activity, age, gender and endocrine balance. They influence a child's height and body composition during the growth years. Hence, accurate measurement of body composition will enhance clinical assessment and nutritional status of a child during the growth years.

The anatomical distribution of adipose tissue show distinct patterns of changes with age, gender and maturation. In general, subcutaneous adipose tissue increases in trunk of boys during adolescence while gluteal and femoral tissue increase in girls. These changes are associated with the stage of sexual maturation.

The thickness of subcutaneous fat layer is greatly influenced by health and chronic illnesses. This is reflected as weight gain or loss in children.

Subcutaneous wasting is one of the common manifestations of some chronic illnesses in children, such as kwashiorkor, pulmonary tuberculosis, HIV infection and AIDS and chronic diarrhoea.

In a study by Lagundoye and Reddy, a definite reduction in soft tissue thickness of the lateral chest wall was demonstrated in patients with kwashiorkor.

On the other hand, the prevalence of obesity in children has increased dramatically over the last 20 to 30 years. Between 1988 to 1991, the overall prevalence of all children with a BMI > 95th percentile was 11% while 22% were above the 85th percentile. These results suggest that
efforts should be made to prevent onset of obesity which begins in very young children. Hence, the importance of measuring the subcutaneous fat thickness and subsequent body composition analysis in children therefore cannot be over emphasized.

Several techniques exist for measuring subcutaneous fat thickness and body composition analysis. These include the Skin fold Calipers, Chest Radiography, Computed Tomography, Magnetic Resonance Imaging, Ultrasonography, Densitometry, Total body Water (TBW), Bioelectrical Impedance (BIA), Dual Energy X-ray Absorptiometry.

The most widely used technique for measuring the thickness of subcutaneous fat is the Skinfold Caliper measurement. It is often used to obtain estimates of whole body fat. Using a hand-held Caliper that exerts pressure, the skinfold thickness is measured at various body locations including the triceps, biceps, subscapular, paraumbilical and quadriceps regions. Then a formula is used to derive a bodyweight percentage based on the sum of the measurement. The caliper method is based on the assumption that the thickness of subcutaneous fat reflects a constant proportion of the total body fat and that the sites selected for measurement represent the average thickness of the subcutaneous fat. It is a simple, inexpensive and portable method. However, it is difficult to obtain accurate measurements because of the compressive action of the calipers and lack of exact separation of muscle and fat. It is painful in children, difficult to complete measurement in very obese individual and subject to observer error. Black et al observed that skinfold calipers gave results significantly lower than the ultrasound measurement due to its compressive effect on fat.

Chest Radiography is regarded as an important component of clinical investigation of patients. In our environment, plain chest radiography is one of the baseline and sometimes the only radiological examination that is required in most patients. It also remains one of the
widely used radiographic means of assessing subcutaneous wasting in children with chronic illnesses. Obesity can also be suggested by this means. It is affordable, available and accessible to most patients. It is done through objective assessment of the lateral chest wall soft tissue thickness. However, it involves radiation exposure.

Computed Tomography (CT) is an imaging modality that is used for diagnostic purposes in Medicine. It is also suitable for measuring body composition including soft tissue thickness. The obvious differences in attenuation intervals between bone, adipose and fat free tissue make this technique appropriate for quantification of separate fat deposits and whole body composition. However, high cost, low availability and exposure to ionizing radiation prevent it from being used.

Magnetic Resonance Imaging (MRI) is safer than CT in terms of radiation exposure because it uses non-ionizing radiation. It also has the advantage of quantifying total and discrete adipose tissue depot, therefore ideal for examining changes over time. CT and MRI measurements are highly reproducible and allow assessment of fat deposit volume with multi-slice approaches. The subject is placed in a strong magnetic field and irradiated by radio-frequency pulses. The visualization of adipose tissue is usually based on the fact that adipose tissue has a considerably shorter longitudinal relaxation time compared to other soft tissues with high water content. It takes about 30 - 45 minutes for images to be acquired from the subject. High cost of equipment and time of analysis limit its use in our environment. Immobilization of the child is also required.

Dual Energy X-ray Absorptiometry (DEXA) is a technique that was originally developed for determining bone mineral content in the detection and treatment of osteoporosis. More
recently, application of the technique has been expanded to include the analysis of fat and lean mass of soft tissue in addition to bone mass. It is a relatively new technology that is very accurate, precise and reliable. DEXA is based on a three compartment model that divides the body into total body mineral, fat free mass and fat tissue mass. It uses a whole body scanner that has low dose x-ray at different sources that read bone and soft tissue mass simultaneously. A source is mounted beneath a table with a detector overhead. The scan takes five to ten minutes. It is safe and non-invasive. It allows fat distribution throughout the entire body to be read in a single scan. However, it is relatively expensive, operator dependent, unavailable in our environment and cannot estimate soft tissue thickness in morbidly obese patients.

Densitometry is a technique that uses Air Displacement Plethysmography. An infant's body composition (fat and fat-free mass) are calculated from body density (Density_{body} = \text{Mass}_{body}/\text{volume}_{body}). It is a complete turnkey system, It is based on the same principle as hydrostatic (underwater) weighting. It is extremely simple to operate, with software prompts guiding the operator through various steps of the process. These include inputting infant information into the software, weighing the infant and measuring the infant's body volume inside the PEA POD chamber. Testing is completely safe and non-invasive and there are no compliance issues. The temperature-controlled test chamber provides a comfortable test environment for the infant and a complete analysis takes five minutes. The ease of use, minimum safety concerns and bedside accessibility makes the PEA POD highly suitable for monitoring changes in body composition during infant growth in research and clinical settings. Its non-availability in our environment prevents its use.

**Bioelectrical Impedance (BIA):** - BIA measurements rely on the fact that the body contains
intracellular and extracellular fluids that conduct electricity by passing a high frequency electric current through the body. BIA determines body composition based on the body's measured impedance in passing the current and known impedance values for human muscle tissue. However, this method can be greatly affected by the hydration state of the subject and by variations in temperature of both the subject and the surrounding environment. BIA has not been successfully applied with infant subjects. A recent study shows that BIA provides insignificant additional information when compared to anthropometry alone; that is, infant weight was a better predictor of FFM when compared to the impedance index.

B-mode ultrasonography provides a non-invasive, cheaper, fast, painless and more portable imaging modality compared to CT, MRI, and DEXA. It is also less technically demanding, readily accessible and available in our environment. These make it a suitable and preferred alternative method in assessing subcutaneous fat thickness and hence body composition in children in our environment.

In a comparative study using ultrasound and Skinfold Caliper in the measurement of subcutaneous fat tissue, Black et al observed that ultrasound can make more accurate measurement of fat thickness than calipers while Weits et al concluded that body fat can be estimated with the same degree of accuracy using either the Skinfold Caliper or ultrasound technique but for estimates of actual subcutaneous fat thickness, ultrasound is preferred.

This method is based on generating sound waves with frequencies that exceed the audible range (>20,000Hz). This is produced by sending an oscillatory voltage signal to a transducer (i.e. Piezoelectric crystal). The transducer vibrates with the frequency of the voltage signal usually selected to be the resonant frequency of the crystal producing the ultrasound waves. The waves penetrate the tissue and are attenuated, reflected or transmitted to different degrees by different tissues. The reflected sound wave is received by the transducer and converted into
an electronic signal.\textsuperscript{28}

B-mode ultrasonography is one of the methods of displaying an ultrasound signal. It displays an image obtained by sweeping the sound beam through a plane. The amplitude of the reflected wave determines the brightness of each pixel in the display. Selection of the appropriate transducer is an important aspect of bedside ultrasonography. The subcutaneous tissue is located beneath the dermis and is superficial; a high frequency 7 – 12 MHz linear transducer is most useful and provides a good balance between imaging depth and resolution.\textsuperscript{27}

Loanniset al\textsuperscript{20} in a study using ultrasound to assess regional adiposity concluded that sonographic results correlated strongly with those of much more expensive imaging techniques and the use of specialized indexes contributes to direct assessment of cardiovascular and metabolic risk hence it is plausible that sonography will be used in clinical practice for the routine assessment of regional adiposity.
MATERIALS AND METHOD

STUDY DESIGN

This was a prospective study on healthy children aged one to five years in nursery and elementary schools in Calabar, Cross River State. Duration of study was nine months.

PARTICIPANTS

Participants for the study were healthy children aged one - five years were randomly selected from private and public schools.

SAMPLE SIZE

Sample size for each age was determined using the formula

\[ N = \frac{4O^2(Z_{crit})^2}{D^2} \]

Where:

\( O \) - is the assumed standard deviation for the group being studied.

\( D \) - total width of the expected confidence interval

\( Z_{crit} \) - Standard normal deviation set at 1.96 which corresponds to 95% confidence interval for the mean

\[ 4 \times (2.61)^2 \times (1.96)^2 / 0.3^2 \]

= 349 for triceps

= 152 for abdominal (D of 0.1 used)

= 207 for subscapular.

.
The above computation was for only one age group. Based on the D for similar works done using the same age group i.e. 1-5 years, the following sample size were derived for each of the three sites.29, 30, 31

The total sample size for each age was therefore the largest size for the sites which is 349 approximately 350 for each age group = 350 x 5 = 1,750.

Thus minimum sample size was 1,750.
RECRUITMENT

There are 129 nursery schools in Calabar; 106 (82%) are privately owned while 23 (18%) are public schools. Random selection of 16 schools from the private and 4 from the public schools were carried out using a table of random numbers. Three hundred and fifty children (20%) were from the public schools while 1400 children (80%) were from the private schools. Two streams for each class from nursery to elementary classes were selected (each class roughly representing an age group). All the children in the selected stream were recruited into the study but not before obtaining duly signed informed consent from parents and guardians.

ETHICAL CONSIDERATION

Ethical clearance for the study was obtained from the Health Ethics Committee of University of Calabar Teaching Hospital (see Appendix V - Ethical Clearance Certificate).

Written informed consent was obtained from the State Ministry of Health, the Head Teachers and parent(s) before recruiting the children into the study. (See Appendix I and II).

INCLUSION CRITERIA

i) Children aged 1 to 5 years

ii) Children whose parent(s) gave consent

iii) Children without acute or chronic illness.

EXCLUSION CRITERIA

i) Children with genetic disorder like sickle cell disease, congenital disorder or skin lesions such as burns with resultant contracture, trauma and ulcers.
MATERIALS
1. Ultrasound machine (Picker model EUB-405)
2. 7.5 MHz linear transducer
3. Acoustic gel
4. Weighing scale
5. Measuring tape
6. Infantometer
7. Stadiometer

METHODOLOGY

Brief information such as the age, sex, gender, and any history of chronic illness was taken for each child.

Anthropometric measurement was taken using the following procedures:

WEIGHT

Participants were weighed in their underpants only and without shoes using a weighing scale. They stood in the centre of the scale platform facing the recorder, hands at side and looking straight ahead.

RECUMBENT LENGTH

This was done using infantometer for all children less than 2 years of age. All hair ornaments were removed. The child was laid on the infantometer with the feet toward the foot piece and the head against the fixed head piece with only diaper or underpants on.
The recorder supported the child's head while the examiner positioned the feet and ensured that the head lies in horizontal plane. A gentle traction was applied to bring the top of the head in contact with the fixed headpiece. Mild pressure was applied gently over the knees while the other hand, slid the footpiece to rest firmly at the child's heel. The toes pointed directly upward with both soles of the feet flexed perpendicular against the foot piece. Reading was taken after the child was correctly positioned.

STANDING HEIGHT

This was measured using a stadiometer for children who can stand unsupported with a fixed vertical backboard and an adjustable head piece and was used in children who were able to stand unassisted. All hair ornaments, jewelry, buns were removed from the top of the head during measurement.\textsuperscript{31}

The participants stood up straight against the backboard and both feet on the platform with the heels together and toes apart (with the body weight evenly distributed). The back of the head, shoulder blades, buttocks and heels made contact with the backboard.

MID UPPER ARM CIRCUMFERENCE

This was measured on the left arm at the level of the upper arm mid-point mark. The recorder stood facing the subject's left side. The measuring tape was positioned perpendicular to the long axis of the arm and wrapped around the arm at the level of the upper arm midpoint between the acromion process of scapula and olecranon process. The two ends of the overlapping tape were pulled together so that the zero end sits below the measurement value and the result lies on the lateral aspect of the arm. Measurement was taken to the nearest 0.1cm.\textsuperscript{31}
SONOGRAPHIC MEASUREMENT OF THE SUBCUTANEOUS FAT THICKNESS

An ultrasound system equipped with a 7.5 MHz linear transducer was used by the same investigator.

With the patient in supine position, measurements were taken at the following anatomical landmarks on the left upper arm, midway between the tip of the acromium process and the olecranon for triceps adipose tissue, the subscapular adipose tissue below the inferior angle of the left scapula and the abdominal adipose tissue was measured 2cm to the left of the umbilicus.

The triceps adipose tissue was measured with the transducer held along the length of the arm. The subscapular and abdominal adipose tissues were measured perpendicular to the length of the spine. For optimal demarcation of the fat layer, the ultrasound screen was made as dark as possible. A large amount of transmission gel was used to avoid compression of the adipose tissue by the transducer.

The thickness of the subcutaneous fat was measured three times with each measurement separated by an interval of a few seconds and the mean value taken. The transducer was lifted up and repositioned before each new measurement (in order to avoid compression of the fat layer). The thickness was measured from the frozen ultrasound image with electronic calipers. All measurements were performed at the end of quiet inspiration. A typical examination took 5 minutes to 10 minutes.
METHOD OF DATA ANALYSIS

Data was recorded in the participant's ultrasound worksheet and transferred into Microsoft Excel (Microsoft Corporation, USA) and Statistical Package for Social Science for windows (SPSS Inc Chicago IL, USA) version 16.0 and double checked to ensure accuracy of the entry. Means, ± standard deviation, median and 5th to 97th percentiles were computed for each parameter for each age. Graphs were also derived from the percentiles computed.

Pearson's correlation was used to determine the degree of relationship between anthropometric parameters and subcutaneous fat thickness at each site of measurement.
LIMITATION OF STUDY

1. There is paucity of local data in our country hence no standards are available for appropriate comparison.
RESULTS

A total of 1,750 (one thousand seven hundred and fifty) children were recruited into the study with age range one to five years. The overall mean age was 3.79 years with standard deviation (SD) of 1.033. The mean age for girls was 3.8 years and 3.77 years for boys. The distribution of the children by age is shown in table 1 below.

Table 1: Age distribution of children aged 1-5 years

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative</th>
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</thead>
<tbody>
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<td>1-1.99</td>
<td>6</td>
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<td>0.34</td>
</tr>
<tr>
<td>2-2.99</td>
<td>237</td>
<td>13.5</td>
<td>13.89</td>
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<td>3-3.99</td>
<td>415</td>
<td>23.71</td>
<td>37.60</td>
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<td>4-4.99</td>
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<td>32.0</td>
<td>69.60</td>
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<tr>
<td>5-5.99</td>
<td>532</td>
<td>30.40</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>1,750</td>
<td>100</td>
<td></td>
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</tbody>
</table>
The majority of the children were aged four and five years accounting for 32% and 30.4% respectively while only 0.34% of the children were aged one year.

Nine hundred and eighteen children (918) representing 52.46% of the children were girls and eight hundred and thirty-two (832) representing 47.54% were boys.

The mean weight for girls was 18.77 ± 14.90Kg whereas the mean age for boys was 18.01 ± 8.39 Kg.

The mean height for girls was 1.03 ± 1.15m and 1.04 ± 3.41m for boys.

The mean body mass index (BMI) for girls was 16.86 ± 4.9Kg/m² and 16.72 ± 4.5 Kg/m² for boys.
SUBCUTANEOUS FAT THICKNESS

Reference values for triceps, subscapular and abdominal subcutaneous fat thicknesses are presented as percentiles. The age–specific subcutaneous fat thickness percentile tables and curves for triceps, subscapular and abdomen are also shown below. Ten percentile values were computed (3rd, 5th, 10th, 25th, 50th, 75th, 85th, 95th, 97th) within the age group one to five years. The normal range of SFT at the three sites will fall within the 5th and 85th percentiles for all age group and sex. Children at less than 5th percentile should be investigated for undernutrition while children above 85th percentile should be investigated for overnutrition.
Table 1b: Percentiles for triceps fat thickness- for age (mm): boys aged 1-5 years

<table>
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<tr>
<th></th>
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Figure 2: Percentile curves of triceps fat thickness for boys aged 1-5 years
### Table 3: Percentiles for triceps fat thickness for age (mm): girls aged 1-5 years

<table>
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<th>Age (yrs)</th>
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<th>4</th>
<th>5</th>
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<td>1.8</td>
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### Figure 3: Percentile curves of triceps for girls aged 1-5 years

**Age (yrs)**
Table 4: Percentiles for subscapular fat thickness – for- age (mm): boys aged 1-5 years

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Figure 4: Percentile curves for subscapular fat thickness for boys aged 1-5 years
Table 5: Percentiles for subscapular fat thickness – for age (mm): girls aged one- five years

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Figure 5: Percentile curve of subscapular fat thickness for girls aged 1-5 years
Table 6: Percentiles for abdominal fat thickness– age (mm): boys aged 1-5 years

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Figure 6: Percentile curves for abdominal fat thickness for boys aged 1-5 years
Table 7: Percentiles for abdominal fat thickness – for age (mm): girls aged 1-5 years

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Figure 7: Percentile curve of abdominal fat thickness for girls aged 1-5 years
CORRELATION OF SUBCUTANEOUS FAT THICKNESS WITH ANTHROPOMETRIC PARAMETERS

Table 8: Correlation of fat thickness with anthropometric parameters matrix for boys aged 1-5 years

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<th>SuFT</th>
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BMI - body mass index

MUAC - Mid upper arm circumference

TFT- Triceps fat thickness

SuFT – Subscapular fat thickness

AFT- Abdominal fat thickness
Table 9: Correlation of fat thickness with anthropometric parameters for girls aged 1-5 years

<table>
<thead>
<tr>
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<th>TFT</th>
<th>SuFT</th>
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<tr>
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The percentiles describe the pattern of subcutaneous fat thickness (SFT) development with age and the expected sex differences.

In boys, TFT 50th percentile ranged from 2.2mm at one year to 3.4mm at five years whereas in girls, this ranged from 3.3mm at one year to 4.0mm at five years as shown in tables 2 and 3 as well as figures 2 and 3. The mean value for females was $4.6 + 2.0$mm and $3.99 + 1.8$mm for males.

The 50th percentile for SuFT in boys ranged from 1.6mm at one year to 2.0mm at five years as shown in table 4 and figure 4. Similar values were recorded for girls as shown in table 5 and figure 5. The mean value of SFT for females was $2.37 + 1.41$mm and $2.14 + 1.02$mm for males.

The 50th percentile for AFT in boys ranged from 2.3mm at one year to 4.0mm at five years whereas in girls, this ranged for 4.3mm at one year to 4.3mm at five years as shown in tables 6 and 7 as well as figure 6 and 7. The mean value of AFT for females was $5.53 + 2.94$mm and $4.53 + 2.37$mm for boys.

The normal range of SFT at the three sites will fall within the $5^{th}$ and $<85^{th}$ percentiles for all age groups and sex as shown in tables 1-6 above.

The values for TFT, SuFT and AFT increase from one year and peak at three years, then begin to decrease.

For the first year, the curves for boys and girls are practically super imposable especially for TFT.

Generally, the values are also higher in girls than in boys of same age.
In both boys and girls, there is a positive correlation between mid upper arm circumference (MUAC) and age, weight, height, body mass index (BMI), triceps, subscapular and abdominal fat thicknesses as indicated in table 8 and 9.

There was strong correlation between the TFT and AFT with the MUAC (p=0.0000). The AFT also correlated strongly with TFT (p=0.0000) as indicated in table 8 and 9.

BMI correlated very strongly with sonographic measurements of fat thicknesses at the three sites (p= 0.000) as shown on table 8 and 9.

The MUAC and fat thicknesses at the three sites correlated very strongly with BMI (p=0.0000) as shown on table 8 and 9.
DISCUSSION

The pre-school years (i.e. one to five years) are very important. This is the period of rapid and dramatic postnatal brain development and fundamental acquisition of interpersonal skills and cognitive development such as working memory, attention, and inhibition control.\textsuperscript{33} This is a critical period for the development of overweight and onset of obesity and the risk increases for subsequent obesity later in adulthood.\textsuperscript{34} It is a time of transition from a direct maternal mediation /selection of diet-based nutrition to food selection that is based on self-selection and gratification.\textsuperscript{33}

As important as this is, very little work has been done in this age group as regards determination of body fat. Majority of the studies done involved the older children and adolescents.\textsuperscript{35,36,37} The reason for this could be that the toddlers and children of preschool years are generally considered the most difficult phase of life to study because their performance is influenced by factors outside of experimental control such as emotional state, motivation, persistence and comprehension of instruction.\textsuperscript{33}

Most of the studies involving this age-group were done using the skinfold calipers to measure triceps, subscapular, biceps and abdominal skinfold thicknesses.\textsuperscript{35, 36, 37} The skinfold calipers has several limitations such as its inability to separate muscle from fat and difficulty in obtaining accurate measurements due to its compressive effect on fat.\textsuperscript{2, 4} More so, it is painful in infants and it is also difficult to complete measurement in very obese individuals and it is subject to observer error.\textsuperscript{2, 3}

This work provides the first locally derived sonographic normograph for subcutaneous fat thickness in Nigeria. In this study, the values for triceps, subscapular and abdominal fat
thicknesses increased from one year of age reaching a peak at three years with subsequent decrease in value noted. This is similar to the pattern demonstrated by Addo et al\textsuperscript{29} among American children using skinfold calipers. However, they recorded higher values than that obtained by sonography, therefore the results may not have been as accurate as the results of the present study because of the limitations of calipers as stated above\textsuperscript{2,5} which include its inability to separate muscle from fat as well as its compressive effect on fat.

The decrease in fat thickness at the three sites after three years may be as a result of stored fat being converted to energy due to increased activity associated with increasing independency from this age onwards.

Subcutaneous fat thicknesses (SFT) at the three sites were generally higher in girls than in boys in the age group studied. This is similar to findings in other studies done in the adolescent age group in Nigeria.\textsuperscript{35,36,37} The reason proffered for this is that the girls lose fat less rapidly than boys so that they become fatter than boys to a steadily increasing degree during the period from one to about seven years when the overall width of subcutaneous fat layer begins to decrease.\textsuperscript{35}

SFT at all the sites correlated strongly with the anthropometric parameters of weight, height, mid upper arm circumference and BMI in the age range studied. This indicates that SFT by ultrasonography can serve as a suitable surrogate for these parameters, particularly the BMI.

With increasing prevalence of overweight, obesity and at the same time increasing incidence of undernutrition in Nigeria,\textsuperscript{38} determination of SFT using ultrasonography should play an important role in paediatric clinical practice.
The normal values for SFT for all the sites (triceps, subscapular and abdomen) as determined by this study lie between the 5th and <85th percentiles. Children at less than the 5th percentile should be investigated for undernutrition while children being above 85th percentile should be investigated for overnutrition.

**CONCLUSION**

This study has provided a sonographic normogram of SFT for children in Nigeria aged one to five years. It has also demonstrated that SFT strongly correlates with anthropometric parameters of age, sex, weight, height, mid arm circumference and BMI. Children below 5th and above 85th percentiles should be investigated for undernutrition and overnutrition respectively.

**RECOMMENDATIONS**

1. With the availability, affordability and practicability of ultrasonography, the assessment of SFT by skinfold calipers should be abandoned. Clinicians should use ultrasonography to assess adiposity.

2. The ease, accuracy and availability of mobile ultrasound machine and the non-invasive nature of ultrasonography make this mode of investigation readily accessible in our environment. The availability of machine that can be powered by battery further makes it practicable in our environment with its erratic power supply. This will be particularly useful in rural community setting for assessment of subcutaneous fat thickness.
LINES OF FURTHER RESEARCH

1. Multicentre study in Nigeria to draw a normogram for the whole country is encouraged.

2. Further studies should be done to relate SFT to the metabolic profile of those children especially lipid profile.
REFERENCES


27. Weits T. Van der Beek EJ, Weldel M. Comparison of ultrasound and skinfold caliper


APPENDIX I

SONOGRAPHIC DETERMINATION OF NORMAL SUBCUTANEOUS FAT THICKNESS IN CHILDREN IN CROSS RIVER STATE, NIGERIA

INFORMED CONSENT FORM

I am a Senior Registrar in the Department of Radiology, University of Calabar Teaching Hospital, Calabar. I am currently carrying out a research project on the sonographic determination of normal subcutaneous fat thickness in children in Cross River State.

Ultrasonography is the use of high frequency sound waves to image the body organs. There is no pain or discomfort during the study. It does not have side effect and is safe at diagnostic frequency.

I would be grateful if you would allow me to perform an ultrasonography study on your child.

I will ask a few questions, collect your child's bio-data, measure his/her weight and height/length and determine his/her subcutaneous fat thickness by Ultrasound. This will only take about 10 minutes of your child's time.

Your participation in the study is voluntary. You will be informed and advised on your child's parameters.
APPENDIX II

PARENT'S CONSENT FOR SONOGRAPHIC PROCEDURE.

Having had a clear understanding of the procedure and the purpose of the study, I hereby consent to participate in this study.

Sign:………………………... Sign:………………………...
Date:………………………... Date:………………………...
Subject's Parent Witness

Sign:………………………... Sign:………………………...
Date:………………………... Date:………………………...
Doctor Doctor's Witness

In case of any enquiry, please contact Dr. Ngaji, Affiong Ifop 07064544339, Radiology Department, UCTH, Calabar.
GOVERNMENT OF CROSS RIVER STATE
MINISTRY OF HEALTH, CALABAR
RESEARCH ETHICS COMMITTEE
E-mail: crsmohresearchethics@yahoo.com
+234 0803 404 7926

CRS/MH/CGS/E-H/018/Vol.I/90

11TH April, 2013

Dr. A. I. Ngaji

CERTIFICATE OF ETHICAL APPROVAL

I am directed to inform you that the Cross River State Health Research Ethics Committee (CRS-HREC) having reviewed your application for Ethical Approval of the Research titled “Sonographic Determination of Normal Subcutaneous Fat Thickness in Children in Cross River State, Nigeria”, has granted FULL ETHICAL APPROVAL.

This approval is valid for ONE YEAR from the date of its issuance.

You may proceed with your study in accordance with the protocol. You are requested to abide by every professional and ethical code for the conduct of this research, including advising the CRS-HREC of any changes to your protocol in advance.

The CR-HREC reserves the right to request an audit of this research at any time during or post implementation.

Yours sincerely,

[Signature]

PROF. EDET OKON NKPOSONG
Chairman CR-HREC
APPENDIX IV

HEALTH RESEARCH ETHICS COMMITTEE
UNIVERSITY OF CALABAR TEACHING HOSPITAL
P. M. B. 1278, CALABAR, NIGERIA

CHIEF MEDICAL DIRECTOR:
Dr. Thomas U. Agan
B.Med, SC (Anat), MB, FWACS, FMCOG, FCAI

CHAIRMAN
Prof. Martin Meremikwu
MB, BCH, MSC, FMC, Paed.

CHAIRMAN, MEDICAL ADVISORY COMMITTEE
Dr. Queeneth Kalu
MBBCH, DA (WACS), BA (WFSA)

SECRETARY:
Edoede Eyoma Esq.
BA, LLB, BL, MPA, DIP-Comp. Sc, ANIM, AIHSAN

Our Ref: ____________________________ 3rd JULY, 2013

Your Ref: ____________________________ Date: ____________________________

NOTICE OF REQUEST FOR MODIFICATION OF PROTOCOL
SONOGRAPHIC DETERMINATION OF NORMAL SUBCUTANEOUS FAT THICKNESS
IN CHILDREN IN CALABAR, CROSS RIVER STATE, NIGERIA

UCHTH HEALTH RESEARCH ETHICS COMMITTEE REG. NUMBER: NHREC/07/10/2012

Health Research Ethics Committee Protocol Assigned Number: UCHHREC/33/156

Name of Principal Investigator: NGAJI, AFFIOM IFOPO

Address of Principal Investigator: DEPT OF RADIOLOGY

UCHTH, CALABAR

Date of Receipt of Valid Application: 11th APRIL, 2013

Date of Meeting where final determination of Research was made: 12th JUNE 2013

This is to inform you that the Research described in the submitted protocol, the Consent Forms, and other participant information materials have been reviewed and given full approval by the Health Research Ethics Committee.

This approval dates from 12th June 2013, to 12th June, 2014. If there is delay in starting the research, please inform the HREC so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. In multi year research, endeavour to submit your annual report to the HREC early in order to obtain renewal of your approval and avoid disruption of your research.

The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to the HREC. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit to your research site without previous notification.

Prof. Martin Meremikwu
CHAIRMAN, UCHTH HREC