ASSOCIATION BETWEEN BODY FAT COMPOSITION AND BLOOD PRESSURE LEVEL AMONG SECONDARY SCHOOL ADOLESCENTS IN DAR ES SALAAM

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By

Brighton Mushengezi, MD

A dissertation submitted in partial fulfillment of Requirements for the Degree of Master of Medicine (Internal Medicine) of the Muhimbili University of Health Sciences

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CERTIFICATION

The undersigned certify that she has read and hereby recommend for acceptance by the Muhimbili University of Health and Allied Sciences a dissertation entitled: **"*Association between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam*"** in fulfillment of the requirements for the degree of Master of Medicine in Internal Medicine of the Muhimbili University of Health and Allied Sciences.

Dr. Pilly Chillo; (MD, MMed, PhD)

(Supervisor)

Date

DECLARATION AND COPYRIGHT

I, **Brighton Mushengezi,** declare that this **dissertation** is my own original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

Signature_______________________________ Date__________________________

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I wish to express my sincere gratitude to all whom in one way or another made the production of this dissertation possible.

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Last but not least, I thank my family; father and mother Mr. and Mrs. Israel Gervase Mushengezi and my sisters; Fadhili, Perpetua, Lydia and Wema for their help and moral support throughout my academic carrier.

DEDICATION

This dissertation is dedicated to my beloved parents, my father Mr. Israel Gervase Mushengezi and my mother Mary Daniel Sindiheba for laying an excellent foundation for totality of my life including a successful career.

SUMMARY

Background: Excess body fat and high blood pressure are important risk factors for increased cardiovascular morbidity and mortality, and both may have their roots of occurrence in childhood and during adolescence. However, less is known about the association between body fat composition and blood pressure levels among Tanzanian adolescents.

Aim: To study the association between body fat composition and blood pressure levels among secondary school adolescents in Dar es Salaam.

Methods: A total of 582 (52.1% males and 47.9% females) adolescents from 5 secondary schools within Dar es Salaam region were selected using systematic random sampling method. A structured questionnaire was used to collect information on demographic characteristics as well as other cardiovascular risk factors. Blood pressure, height, weight, waist circumference and hip circumference were measured following standard methods. Body fat composition was assessed using skinfold thickness method and individuals were categorized as underfat, healthy, overfat or obese according to World Health Organization cut off points for adolescents. Systolic and diastolic hypertension was defined as $\geq 90^{th}$ percentile for age, height and gender of the adolescent. Data management and analysis was performed using SPSS software, version 20. A *p*-value of <0.05 was considered to indicate a significant statistical difference.

Results: The mean ±SD age of the total population was 16.5±1.8 years, with boys being slightly but significantly older than girls (16.9± 1.7 versus 16.2 ± 1.9 years, p<0.001). The proportion of adolescents with overweight or obesity by body mass index (BMI) categorization was found to be 17.4% while overfat or obesity by fat percentage categorization was present in 22.2% of the total population studied. Girls had significantly higher proportion of overweight and obesity by both categories when compared to boys being 10.5% versus 6.9% for BMI and 15.6% and 6.5% for fat percentage respectively, all p< 0.001. The mean ±SD systolic and diastolic blood pressure of the total population was 120±11 and 69± 8 mmHg respectively. The proportions of adolescents with systolic, diastolic and combined hypertension in the total population were 17.5%, 5.5%, and 4.0% respectively.

In the total population both mean systolic and diastolic blood pressure positively and significantly correlated with BMI (r = 0.24 for SBP and 0.24 for DBP) and with waist circumference (r = 0.18 for SBP and 0.22 for DBP), all p<0.05. Furthermore, in the total population the mean diastolic blood pressure also had a positive and significant correlation with mean body fat percentage (r = 0.25, p<0.001), while this was not the case for mean systolic blood pressure (r = -0.02, p = 0.56). Analyses done separately for boys and girls showed that boys had same findings as those obtained in the total population, while girls had in addition a significant positive correlation between mean systolic blood pressure and mean body fat percentage (r = 0.18, p < 0.05).

Conclusion and recommendations: A high proportion of adolescents with elevated BP was seen among those with elevated BMI values (overweight and obesity) compared to those with normal BMI, girls being significantly more hypertensive and obese than boys.

BMI predicted blood pressure level better in this population compared to body fat percentage method. We recommend further studies to assess efficacy of skinfold thickness method in other populations in predicting blood pressure level. Also educational programs on modifiable risk factors particularly promoting weight loss may help prevent high blood pressure in adolescents.

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LIST OF ABBREVIATIONS

1. BMI – Body Mass Index
2. BP – Blood Pressure
3. DEXA – Dual Energy X-ray Absoptiometry
4. HDL-C – High Density Lipoprotein Cholesterol
5. LDL-C – Low Density Lipoprotein Cholesterol
6. MAP – Mean arterial pressure
7. MUHAS – Muhimbili University of Health and Allied Sciences
8. W.C – Waist circumference

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CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 Prevalence of overweight, obesity and hypertension among adolescents

Excess body weight and high blood pressure (BP) are important risk factors for increased morbidity and mortality[(1)], not only in high-income but also in medium and low-income countries[(2)]. Worldwide, the prevalence of overweight and obesity in children and adolescents has shown a remarkable increase over the last two to three decades [(3-5)]. Among adults, the overall prevalence of hypertension has been reported to be 40% worldwide, with the African region having the highest prevalence of 46%[(6)]. While the prevalence of hypertension among adolescents is still low, studies have shown an increasing trend, especially in middle and high-income countries[(4)].

Currently 35.9% of African-American children between 2 to 19 years of age are overweight, whereas 31.7% of all children of those ages are overweight[(7)]. 11.4% of young African-Americans of ages 2 to 5 are already obese[(8)]. Over the past two decades, the prevalence of obesity has almost doubled from 10.5% to 18.1% among adolescents aged 12 to 19 years[(7)]. Within the same period the prevalence of obesity for African-American rose from 13.4% to 24.4% [(7, 9)]. The highest prevalence of any age group by gender, race or ethnicity has been seen among adolescent girls of ages 12 to 19 years of African-American ethnicity whereby the prevalence of obesity was shown to be 29.2%[(10)].

Studies have shown that children who are overweight are more likely to become overweight or obese adults [11-13] . Overweight and obesity are known to be risk factors for health conditions including hypertension and type 2 diabetes which have significant influence on morbidity and mortality [14-16]. Moreover, overweight and obesity during childhood and adolescence have short term negative health impact, causing metabolic effects such as impaired growth, musculoskeletal and respiratory conditions [17]. Negative psychosocial consequences have also been shown to impact obese children and adolescents including sadness, loneliness and nervousness leading to engaging oneself in risk taking behavior such as alcohol consumption and cigarette smoking[17]. Up to 24% of African-American and Hispanic children are over the 95th percentile for body mass index (BMI) showing that they are at a higher risk for being overweight or obese than other children in the United States of America [18]. Furthermore, the highest prevalence of obesity among girls has been observed in African-Americans whereas the highest prevalence among boys was found in Hispanics [18].

In 2011 a study done by Salman, et al on obesity associated hypertension among primary school children aged 6 – 12 years found that overweight and obesity are highly prevalent among primary school children in urban Sudan and are strongly associated with hypertension [19]. He also found that obesity is associated with current hypertension and not with family history of hypertension. 14.8% of children were overweight; 10.5% were obese; 4.9% were pre-hypertensive and 4.9% were hypertensive [19]. In a recent study done in Lagos, Nigeria on obesity and elevated blood pressure among adolescents, Oduwole et al found a high prevalence of hypertension among obese adolescents [20]. The prevalence of overweight and obesity were 13.8% and 9.4% respectively. Obesity was significantly associated with pre-hypertensive and hypertensive-range systolic BP in overweight and obese subjects and with hypertensive-range diastolic BP only in obese subjects [20].

In a previous study done among primary school children aged 6 – 15 years from rural Morogoro and Urban Dar es Salaam, the prevalence of obesity was found to be 5.3%. 11.4% of subjects were found to have systolic hypertension, 8.1% diastolic hypertension and 3.9% had both systolic and diastolic hypertension [21]. In the same study, children from more affluent schools were more likely to be obese as well as having higher blood pressure [21]. In another study done in Tanzanian adolescents on coronary heart disease risk factors in 1993, Kitange et al [22] found that BP increased with age and was slightly but significantly higher in young women than in young men (115/67 mmHg versus 113/65 mmHg). Only 0.4% subjects had blood pressure greater than 140 and/or 90 mmHg in that study and there were no urban-rural differences. Overweight was found in only 0.6% at age 15 years but 5.4% at age 19 years [22].

1.2 The relationship between overweight and obesity with other cardiovascular risk factors

Body mass index is positively and independently associated with morbidity and mortality from hypertension, type 2 diabetes, dyslipidemia and other cardiovascular diseases [23]. A strong association has also been shown between BMI and mortality among various populations including Caucasian and Asian populations [23-27]. Clinical trials and observational studies have documented evidence that weight is directly associated with level of BP [28]. Among adults in United States of America, approximately 65% are either overweight or obese; i.e. have a BMI ≥ 25 kg/m^2; whereas 30% are clinically obese [28]. Among children, an increase in prevalence of overweight over the last decade has shown a corresponding increase in levels of BP [29].

Various studies have shown a dose – response relationship between the degree of weight loss and reduction in BP independent of sodium intake [30, 31]. A 5 - 10% weight loss is associated with clinically significant reductions in BP [32]. With each 1kg body weight loss there is a corresponding 2 and 1 mmHg mean reduction in systolic and diastolic BP respectively [33]. With this evidence, weight reduction has been considered an effective non-pharmacological therapy for lowering BP in obese patients [34-36]. In adults obesity has been found to be strongly associated with insulin resistance in both normoglycemic persons and those with type 2 diabetes [37, 38]. According to the Framingham study weight gain was found to be a significant risk factor for development of type 2 diabetes, especially in women [39].

On the other hand there has been a reported association between adiposity and insulin resistance in both adults and children [40, 41]. Loss of weight is associated with a decrease in insulin concentration and an increase in insulin sensitivity in adults [42] as well as in adolescents [43]. One study involving adolescents showed that insulin resistance was significantly related to obesity and varied directly with the degree of adiposity [44].

In the United States of America, studies have shown ethnic and sex differences in insulin resistance syndrome with a greater prevalence shown in men and in African Americans [45]. Body fat particularly visceral fat has been proven to be a risk factor significantly associated with body lipids and lipoproteins [46, 47]. Obesity has been shown to be associated with high LDL-Cholesterol, low HDL-Cholesterol as well as high triglycerides both in adults and children [48, 49]. Level of visceral fat has been shown to be associated with level of secretion of free fatty acids and dyslipidemia as well as insulin resistance and hypertension [47, 50, 51].

1.3 Body fat composition versus body mass index (BMI) as a measure of increased cardiovascular risk

Several studies have shown tracking of overweight from adolescence to adulthood [52]. BMI levels invariably defined overweight in these studies. Obesity, however, is defined as an excess of body fat, and it is the amount of this fatness that is associated with morbidities, more strongly so than BMI. Therefore, the assessment of obesity should ideally be based on measurement of body fatness. Because BMI does not distinguish between fat mass and lean body mass, a high tracking of BMI from adolescence to adulthood can also represent a high tracking of body build rather than fatness. Skinfold thickness is likely to be a better alternative for determining body fatness in children and adolescents and for monitoring obesity in children. It measures subcutaneous fat located directly beneath the skin by grasping a fold of skin and subcutaneous fat and measuring its thickness using calipers. Formulas that take account of age and sex are used to convert skinfold measurements into an estimate of an individual's percentage body fat [53]. One study using DEXA (Dual-energy X- ray absoptiometry) as a reference of comparing other methods of estimating body fat found that skin fold method had a correlation coefficient of 0.87 while BMI had a correlation coefficient of 0.81 [54].

1.4 Methods of measuring body fat

There are various methods that are used to measure body fat composition. They include BMI, Waist circumference, Skinfold thickness, Hydrostatic weighing as well as Bioelectric Impedance Analysis.

1.4.1 Skin-fold thickness

This is a body composition testing method used for assessing percent body fat. A skinfold caliper is an equipment designed specifically for simple and accurate measurements of subcutaneous tissue. Equations are used to predict body fat percentage based on these measurements. The method uses standard anatomical sites around the body i.e. triceps (the back of the upper arm); pectoral (the mid-chest just forward of the armpit); subscapular (beneath the edge of the scapular); mid-axilla (midline of the side of the torso); abdomen (next to the umbilicus); suprailiac (just above the iliac crest of the hip bone) and quadriceps (middle of the upper thigh).

A skin pinch is made at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle. The calipers are applied at right angles to the pinch and a reading (in mm) taken two seconds later. A mean of three measurements should be taken. The method is easy to use and it is an inexpensive way of estimating percentage body fat. It is convenient, effective, accurate, non-invasive method to measure body fat composition.

1.4.2 Body Mass Index (BMI)

Body fat can be estimated from BMI, a person's weight in kilograms divided by the square of the height in meters.

Advantages: This is a simple, quick, effective method and applies to adult men and women, as well as children. It is a useful tool for quickly assessing weight classification and it is more accurate at approximating degree of body fatness when compared to weight measurements alone.

Disadvantages: It is somehow an indirect and imperfect measurement since it does not distinguish between body fat and lean body mass. Because it is not a measure of body fatness, very muscular individuals often fall into the overweight category when they are not overly fat. Not as accurate a predictor of body fat in the elderly as it is in younger and middle-aged adults. At the same BMI, women have, on average, more body fat than men, and Asians have more body fat than whites.

1.4.3 Waist circumference (W.C)

Waist circumference is the simplest and most common way to measure abdominal obesity i.e. the extra fat found around the middle abdomen that is an important factor in health, even independent of BMI. It's the circumference of the abdomen, measured at the natural waist (in between the lowest rib and the top of the hip bone), the umbilicus, or at the narrowest point of the midsection.

Advantages: It is easy to measure, inexpensive, strongly correlated with body fat in adults as measured by the most accurate methods. Studies show waist circumference predicts development of disease and death.

Disadvantages: There is lack of good comparison standards (reference data) for waist circumference in children. The method may be difficult to measure and less accurate in individuals with a BMI of 35 or higher.

1.4.4 Bioelectrical impedance analysis (BIA)

Bioelectrical impedance measures the resistance of body tissues to the flow of a small, harmless electrical signal. Current flows more easily through the parts of the body that are composed mostly of water (blood, urine and muscle) than it does through bone, fat or air. Bioelectrical impedance measures the strength and speed of the electrical signal sent through the body (impedance measure). It then uses this measurement and information such as height, weight and gender to predict how much body fat a person has.

Advantages: It's safe and can measure long-term changes in body fat. Private home measurement is possible, without a need of a special technician

Disadvantages: It tends to over-predict body fat in lean and athletic people unless the machine is equipped with an "athlete" mode with appropriate predictive formulas. It does not take into account the location of body fat. People with pacemakers are not candidates for this method.

1.4.5 Hydrostatic weighing

Hydrostatic weighing, also known as Hydrodensitometry or underwater weighing is a classic measure of body composition. The dry weight of the subject is first determined. The subject, in minimal clothing, then sits on a specialized seat, expels all the air from their lungs, and is lowered into the tank until all body parts are emerged. The person must remain motionless underwater while the underwater weight is recorded.

Advantages: Underwater weighing is the most widely used test of body density and in the past was the criterion measure for other indirect measures.

Disadvantages: The equipment required to do underwater weighing is expensive. The tanks are mostly located at university or other research institutions, and there is generally not easy access for the general population. This method may underestimate body fat percentage of athletes as they tend to have denser bones and muscles than non-athletes, and may overestimate body fat percentage of elderly patients suffering from osteoporosis.

1.4.6 Dual Energy X-ray Absoptiometry (DEXA)

DEXA systems assess body composition by measuring the differential absorption of x-rays at two frequencies and can separate tissue into fat, lean, and bone minerals. The person lies on the scanner, with the x-ray sources mounted beneath a table and a detector overhead. The person is scanned with photons that are generated by two low-dose x-rays at different energy levels (approximately 1/6 to 1/2 the exposure from a standard chest x-ray). The body's absorption of the photons at the two levels is measured. The ratios can then be used to predict total body fat, fat-free mass and total body bone mineral.

Advantages: This method is precise, accurate, and reliable. It is based on a three compartmental model (bone, lean mass and fat tissue mass) rather than two compartments as in most other methods. It can distinguish regional as well as whole body parameters of body composition. It is considered a reference standard.

Disadvantages: The equipment is expensive, and often requires trained radiology personnel to operate.

2.0 PROBLEM STATEMENT AND RATIONALE

Hypertension and excess body weight are upcoming major health problems in this region and primary prevention is an important intervention. As adolescents represent a transition from childhood to adulthood, behaviors tend to form at this point and it is the best time to instill healthy lifestyles as these tend to track into adulthood. Only a few studies have been done to assess the effect of excess body fat on cardiovascular risk factors including hypertension among adolescents. Previous studies done in Tanzania have estimated excess body weight based on BMI measurements alone. However, BMI may not accurately measure excess body fat and it is not known whether excess body fat measured by skinfold thickness is a better correlate of blood pressure levels among adolescents in Tanzania. To-date, no study has been done in Tanzania to assess the association between excess body fat using skin fold thickness and blood pressure levels among adolescents.

3.0 OBJECTIVES

Broad Objective

To study the association between body fat composition measured by skinfold thickness and blood pressure levels among secondary school adolescents in Dar es Salaam.

Specific Objectives

1. To determine the proportion of four categories of fat composition (underfat, healthy, overfat and obese) among secondary school adolescents in Dar es Salaam

2. To determine the correlation between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam.

3. To compare the relationships of body fat composition, body mass index and waist circumference to blood pressure levels among secondary school adolescents in Dar es Salaam.

CHAPTER TWO

4.0 METHODOLOGY

4.1 Study design

- Cross sectional school based study

4.2 Study population

- Secondary school adolescents

4.3 Inclusion criteria

- All consenting adolescents aged 11-19 years

4.4 Exclusion criteria

- Those with known chronic illnesses and those who self-reported to be sick from acute illnesses

4.5 Sample size

Based on the prevalence of overweight and obesity in Nigeria (overweight 13.8% and obesity 9.4%), [20] then; The sample size was obtained using the following formula

$n = Z^2 p (1-p)/ d^2$

where n = the required sample size

z = 1.96 (95% confidence interval)

d = maximum likely error, 2.5%

p = prevalence 9.4%[20]

The sample size was **523.**

4.6 Study procedure

A list of all secondary schools in Dar es Salaam was obtained from the Ministry of Education and Vocational Training. Of the 5 schools that were obtained by random sampling; 4 were government schools (Azania, Benjamin Mkapa, Jangwani and Tambaza) and one was a private school (St. Anthony's Secondary School). Multistage sampling was performed to obtain the participating subjects from a list of all classes and lists of students from the selected classes. Each school was visited twice whereby on day 1 submission of consent forms was done and these were sent to parents/guardians. Also explanation of the study objectives and procedures was given to the students and their teachers. Data collection was done on day 2.

A structured questionnaire was used to obtain demographic characteristics (e.g. age, sex, etc) and to obtain history of other cardiovascular risk factors. Anthropometric measurements were taken whereby height was measured using a stadiometer (Seca, CEO123, USA), with subjects wearing no shoes and averaged to the nearest centimeter. Weight was measured by a weighing scale (Momert, China) and recorded in kilogram. Waist circumference was measured using a tape measure mid way between the anterior superior iliac spine and the lowest rib and was recorded to the nearest centimeter. Hip circumference was measured at the maximum circumference of the hips (above the gluteal folds) and recorded to the nearest centimeter. Obesity and overweight was defined as BMI $\geq 30 kg/m^2$ and ≥ 25 kg/m^2 respectively for those $\geq$ 18 years, and according to adolescents' BMI charts for those <18 years[55].

Blood pressure was taken using a digital BP machine (OMRON CEO 197, Kyoto, Japan.). This was done in a quiet room after a 5 minutes rest. A total of three readings was taken and the average of the last two readings was taken as the subject's BP. Hypertension was defined as blood pressure ≥140/90mmHg for those ≥18years, and according to adolescents' blood pressure charts for those <18years[56].

Skin fold thickness was obtained using a skin fold caliper (Harpenden Skinfold Caliper, Barty International, CE 120, England) at standardized sites for males and females. Measurements were done at all the sites for all subjects i.e. triceps, pectoral, axillary, abdominal, subscapular, suprailiac and thigh skinfold. All skinfold measurements were taken on the right side of the body and recorded in millimeters. The skinfold was picked between the thumb and the index finger so as to include two thicknesses of the skin and subcutaneous fat. Calipers were located about one centimeter from the finger with the calipers halfway up the fold of the skin. Measurements were done twice and an average value was recorded. The sum of three skinfold measurements was taken and used to assess percentage body fat.

Body fat percent was obtained first by determining body density followed by calculating the percent fat. Estimation of Body Density was done using Jackson and Pollock formula[57, 58] based on the sum of 3 skinfold measurements. For females; triceps, suprailiac and thigh skinfold measurements were used and for males chest, abdominal and thigh skinfold measurements were used to calculate body density.

For females body density was calculated as follows;

$$\text{Body Density} = 1.0994921 - 0.0009929*\text{sum} + 0.0000023*\text{sum}^2 - 0.0001392*\text{age}$$

For males body density was calculated as follows;

$$\text{Body Density} = 1.1093800 - 0.0008267*\text{sum} + 0.0000016*\text{sum}^2 - 0.0002574*\text{age}$$

Estimation of body fat percent was done using the following formula (Siri formula[59];

Percent Fat = [(495 / Body Density) -450] * 100

Increased percent fat was defined as overfat and obesity which is >85th percentile and >95th percentile respectively according to specific charts for age and sex[60].

4.7 Statistical Methods

Data entry and analysis was done using SPSS version 20. Descriptive statistics were done using mean ±SD for continuous variables and percentages for categorical variables. Groups were compared using Chi square test, Student's *t*-test, or Analysis of Variance (ANOVA) as appropriate. Univariate analysis was done using Pearson's correlation coefficient. Multivariate linear regression analysis was used to determine multiple correlated variables. A two-sided *p*-value of <0.05 was considered statistically significant.

4.8 Ethical issues

Ethical clearance was obtained from the Research and Publication Committee of Muhimbili University of Health and Allied Sciences (MUHAS). Subjects 18 years and above signed an informed consent form. For minors (17 years and below), parents/guardians signed on their behalf. Permission was also sought from the heads of schools.

CHAPTER THREE

5.0 RESULTS

The study population included 582 (303 males and 279 females) adolescents, of whom 137 (23.5%) were from private and the remaining 445 (76.4%) from government schools. The mean ±SD age of the total population was 16.5 ±1.8 years, with boys being on average 0.7 years older than girls (Table 1).

Significantly more girls (78.1%) were mostly sedentary during their spare time when compared to boys (44.9%), $p<0.001$. Girls were also more likely to have a positive family history of hypertension (15.1% versus 8.9%), while boys were more likely to be exposed to passive smoking (16.8% versus 11.1%), all $p<0.05$, Table 1.

The mean ±SD systolic and diastolic blood pressure of the total population was 120 ±11 mmHg and 69 ±8 mmHg, respectively. Boys had higher mean values of systolic blood pressure (121 ±11 versus 118 ±10mmHg), however there was no difference between boys and girls in terms of the proportions with systolic hypertension, Table 1.

The mean diastolic blood pressure was higher in girls (71 ±8 versus 68 ± 8mmHg), and significantly more girls had diastolic hypertension when compared to boys (7.5% versus 3.6%) $p<0.05$ for both, Table 1. Only 23 (4%) of the total studied had a combination of both systolic and diastolic hypertension.

Table 1: Demographic characteristics of the study population by gender

Characteristic	**Male (N = 303)**	**Female (N = 279)**	***p*-value**
Age (years)	16.9 ± 1.7	16.2 ± 1.9	<0.001
School category n (%)			
Private schools	93 (30.7)	123 (44.1)	0.001
Government schools	210 (69.3)	156 (55.9)	
Means of transport to school n (%)			
Private	69 (22.8)	68 (24.4)	0.650
Public or walking	234 (77.2)	211 (75.6)	
Level of exercise n (%)			
Mostly sedentary	136 (44.9)	218 (78.1)	<0.001
At least once/day	167 (55.1)	61 (21.9)	
Positive family history of hypertension n (%)	27 (8.9)	42 (15.1)	0.022
Proportion exposed to passive smoking n (%)	51 (16.8)	31 (11.1)	0.048
Systolic blood pressure (mmHg)	121 ± 11	118 ± 10	0.002
Proportion with systolic hypertension n (%)	46 (15.2)	56 (20.1)	0.121
Diastolic blood pressure (mmHg)	68 ± 8	71 ± 8	<0.001
Proportion with diastolic hypertension n (%)	11 (3.6)	21 (7.5)	0.039
Mean arterial pressure (mmHg)	86 ± 8	87 ± 8	0.107
Proportion with systolic and diastolic hypertension n (%)	8 (2.6)	15 (5.4)	0.091

Results are mean ± SD, unless stated otherwise

On average boys were taller than girls, (164.8 ± 9.0cm versus 157.0 ± 6.0 cm), $p<0.001$, however there was no significant difference in the mean weight among boys and girls, Table 2. When compared to boys, girls had significantly higher mean values for BMI, both waist and hip circumferences and they were more likely to be overweight and obese as well to have increased waist to hip ratio, all $p<0.01$, Table 2.

Table 2: Anthropometric measurements by gender

Characteristic	**Male (N = 303)**	**Female (N = 279)**	***p*-value**
Height (cm)	164.8 ± 9.0	157.0 ± 6.0	<0.001
Weight (kg)	56.3 ± 8.7	55.0 ± 10.4	0.86
Body mass index (kg/m^2)	20.8 ± 3.1	22.3 ± 3.9	<0.001
Proportion with overweight and obesity n (%)	40 (13.2)	61 (21.9)	0.006
Waist circumference (cm)	73 ± 8	76 ± 11	0.001
Hip circumference (cm)	91 ± 7	97 ± 10	<0.001
Waist to hip ratio (WHR)	0.81 ± 0.05	0.78 ± 0.09	<0.001
Proportion with increased WHR n (%)	13 (4.3)	35 (12.5)	<0.001

Results are mean ± SD, unless stated otherwise

The proportions of adolescents with underweight, healthy, overweight and obesity by BMI categorization was 13.9%, 72.9%, 12.5% and 0.7% respectively among boys, and 5.4%, 72.8%, 14.3% and 7.5% respectively among girls. This difference was statistically significant, $p<0.001$, figure 1.

Figure 1: Proportion of underweight, healthy, overweight and obese adolescents by BMI

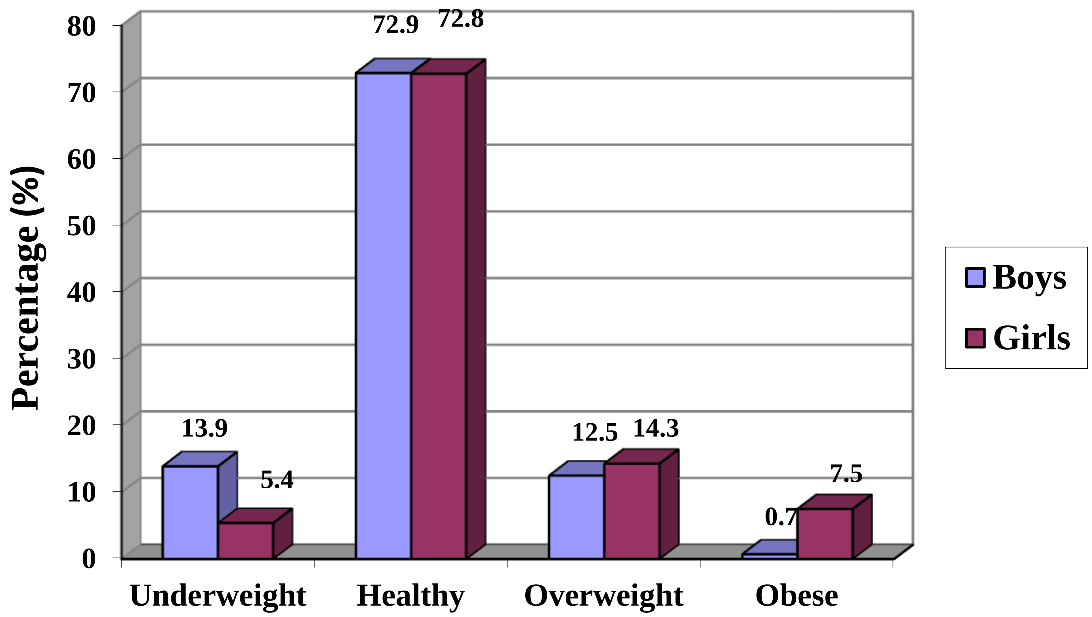


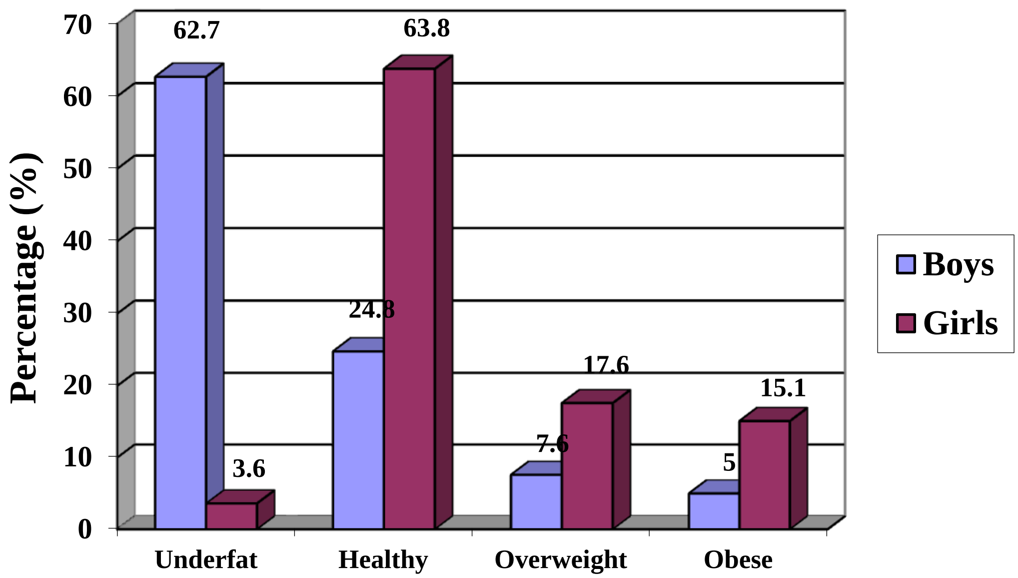
Table 3: Body fat composition by gender

Characteristic	Male (N = 303)	Female (N = 279)	*p*-value
Triceps skinfold thickness (mm)	12.7 ± 7.4	21.9 ± 6.8	<0.001
Subscapular skinfold thickness (mm)	13.3 ± 5.9	19.6 ± 7.6	<0.001
Axillary skinfold thickness (mm)	12.0 ± 6.3	21.0 ± 9.1	<0.001
Pectoral skinfold thickness (mm)	9.8 ± 5.5	17.9 ± 6.9	<0.001
Abdominal skinfold thickness (mm)	16.4 ± 8.6	27.9 ± 9.5	<0.001
Suprailiac skinfold thickness (mm)	12.7 ± 7.3	21.1 ± 7.9	<0.001
Thigh skinfold thickness (mm)	16.1 ± 9.8	32.7 ± 10.6	<0.001
Sum of skinfold thickness (mm)	42.2 ± 22.4	76.8 ± 27.2	<0.001
Body density (g/cm^3)	1.074 ± 0.014	1.036 ± 0.015	<0.001
Total body fat percent (%)	11.1 ± 6.2	27.8 ± 6.7	<0.001
Proportion with overfat and obesity n (%)	38 (12.5)	91 (32.6)	<0.001

Results are mean ± SD, unless stated otherwise.

Girls had higher mean values for skinfold measurements in all the seven sites (i.e. triceps, subscapular, axilla, pectoral, abdomen, suprailiac and thigh) when compared to boys. Consequently, the mean sum of skinfold thickness was significantly higher for girls (76.8 ±27.2 versus 42.2 ± 22.4mm), all p<0.001, Table 3. The mean total body fat percent for girls was more than twice that of boys (27.8 ± 6.7% versus 11.1 ± 6.2%) and significantly more girls had increased total body fat percent (32.6% versus 12.5%), all p<0.001, Table 3. The proportion of adolescents with underfat, healthy, overfat and obesity by fat percentage categorization was 62.7%, 24.8%, 7.6% and 5.0% respectively among boys and 3.6%, 63.8%, 17.6% and 15.1% respectively among girls, figure 2. This difference was statistically significant, p<0.001.

Figure 2: Proportion of underfat, healthy, overfat and obese adolescents by body fat percentage



There was great variation of proportions of underfat, healthy, overfat and obese adolescents within each body fat percent category. Majority of the boys were categorized as being underfat (62.7%), while majority of girls were in the healthy category (63.8%), figure 2.

Table 4: Correlates of total body fat percent in the total population and in boys and girls

Variable	Total population	Boys	Girls
	Pearson correlation (r)	Pearson correlation (r)	Pearson correlation (r)
Age (years)	-0.18**	-0.21**	0.12*
Height (cm)	-0.49**	-0.35**	-0.13*
Weight (kg)	0.29**	0.43**	0.67**
BMI (kg/m^2)	0.61**	0.73**	0.78*
Waist circumference (cm)	0.45**	0.57**	0.57**
Hip circumference (cm)	0.64**	0.67**	0.65**
Waist to hip ratio	-0.04^{NS}	0.12*	0.15*
Systolic blood pressure (mmHg)	-0.02^{NS}	0.09^{NS}	0.18*
Diastolic blood pressure (mmHg)	0.25**	0.19*	0.14*
Mean Arterial Pressure (mmHg)	0.16**	0.17**	0.16**

** indicates significance at *p*<0.001, * indicates *p*<0.05, NS = not significant

In the total population, increase in body fat percentage was associated with increased weight, BMI as well as waist and hip circumferences, while age and height were negatively associated with increase in body fat percentage, all p<0.001, Table 4. Increase in diastolic blood pressure (r = 0.25) and mean arterial pressure (r = 0.16) positively correlated with increase in fat percentage, both p<0.001), Table 4. When analysis was done separately in boys and girls, boys had almost similar correlation pattern as in the total population, whereas girls had also a weak, but positive and significant correlation between increase in fat percentage and systolic blood pressure ($r = 0.18$, $p<0.05$), Table 4. Interestingly, the waist to hip ratio did not have a significant correlation with fat percentage in the total population, it however positively correlated with both boys and girls separately, Table 4.

Table 5: Correlation between mean systolic blood pressure with measures of adiposity in the total population and in boys and girls

	Total population	**Boys**	**Girls**
Variable	**Pearson's correlation (r)**	**Pearson's correlation (r)**	**Pearson's correlation (r)**
Age (years)	0.14*	0.16*	0.08 NS
Height (cm)	0.23**	0.25**	0.12*
Weight (kg)	0.37**	0.42**	0.32**
BMI (kg/m^2)	0.24**	0.26**	0.29**
Waist circumference (cm)	0.18**	0.28**	0.14*
Hip circumference (cm)	0.23**	0.35**	0.25**
Waist to hip ratio	0.001 NS	0.03 NS	-0.05 NS
Triceps (mm)	-0.04 NS	0.002 NS	0.09 NS
Sub scapular (mm)	0.07 NS	0.11*	0.17*
Axillary (mm)	0.06 NS	0.12*	0.16*
Pectoral (mm)	-0.03 NS	0.05 NS	0.06 NS
Abdomen (mm)	0.04 NS	0.12*	0.15*
Supra iliac (mm)	0.04 NS	0.10 NS	0.14*
Thigh (mm)	0.01 NS	0.05 NS	0.19*
Sum skin (mm)	0.02 NS	0.08 NS	0.15*
Body density (g/cm^3)	0.03 NS	-0.09 NS	-0.18*
Body fat percent (%)	-0.02 NS	0.09 NS	0.18*

** indicates significance at $p<0.001$, * indicates $p<0.05$, NS = not significant

In the total population, increase in the mean systolic blood pressure was associated with increase in age, height, weight, body mass index, waist as well as the hip circumference, with weight showing the best correlation ($r = 0.37$, $p<0.001$), Table 5. Measures of skinfold thickness at all sites as well as the mean sum of skinfold thickness did not show any significant correlation with mean systolic blood pressure in the total population, Table 5. When analysis was separated for boys and girls, all the conventional measures of adiposity (age, height, weight, BMI, waist circumference, hip circumference) correlated positively with increase in mean systolic blood pressure, again weight of the individual showing the best correlation, both in boys ($r = 0.42$, $p<0.001$) and in girls ($r = 0.32$, $p<0.001$), Table 5.

Sub scapular, axillary and abdomen skinfold thicknesses had weak, but positive and significant correlations with mean systolic blood pressure both in boys and girls separately. In addition, among girls supra iliac and thigh skinfolds thicknesses significantly correlated with mean systolic blood pressure. The mean sum of skinfold thicknesses and body fat percent positively correlated with increase in mean systolic blood pressure in girls alone, Table 5.

Table 6: Correlation between mean diastolic blood pressure with measures of adiposity in the total population and in boys and girls

	Total population	**Boys**	**Girls**
Variable	**Pearson's correlation (r)**	**Pearson's correlation (r)**	**Pearson's correlation (r)**
Age (years)	-0.01 NS	0.02 NS	0.03 NS
Height (cm)	0.01 NS	0.09 NS	0.11 NS
Weight (kg)	0.23**	0.27**	0.23**
BMI (kg/m^2)	0.24**	0.22**	0.20*
Waist circumference (cm)	0.22**	0.31**	0.13*
Hip circumference (cm)	0.31**	0.27**	0.28**
Waist to hip ratio	-0.01 NS	0.17*	-0.09 NS
Triceps (cm)	0.19**	0.13*	0.09 NS
Sub scapular (cm)	0.23**	0.20*	0.15*
Axillary (cm)	0.23**	0.18*	0.15*
Pectoral (cm)	0.24**	0.18*	0.18*
Abdomen (cm)	0.24**	0.21**	0.13*
Supra iliac (cm)	0.19**	0.15*	0.09 NS
Thigh (cm)	0.24**	0.17*	0.17*
Sum skin (cm)	0.23**	0.20*	0.12*
Body density (g/cm^3)	-0.25**	-0.19*	-0.14*
Body fat percent (%)	0.25**	0.20*	0.14*

** indicates significance at $p<0.001$, * indicates $p<0.05$, NS = not significant

Increase in mean diastolic blood pressure was associated with increase in weight, body mass index, waist as well as hip circumference in the total population and when analysis was separated for boys and girls, Table 6. Interestingly, age and height did not show any relationship with mean diastolic blood pressure either in the total population or in boys and girls alone. Contrary to findings with mean systolic blood pressure, measures of adiposity by skinfold measurements showed fairly good correlations with mean diastolic blood pressure in the total population as well as in boys and girls, with all skinfold thicknesses at the seven sites showing significant and positive correlations with mean diastolic blood pressure in the total population and in boys. Among girls, only sub scapular, axillary, pectoral, abdomen and thigh skinfold thicknesses positively correlated with mean diastolic blood pressure, Table 6.

Interestingly, and contrary to the findings in mean systolic blood pressure, both mean sum of skinfold thickness and body fat percentage positively and significantly correlated with mean diastolic blood pressure in the total population and in boys and girls separately, Table 6.

Table 7: Correlation between mean arterial blood pressure (MAP) with measures of adiposity in the total population and in boys and girls

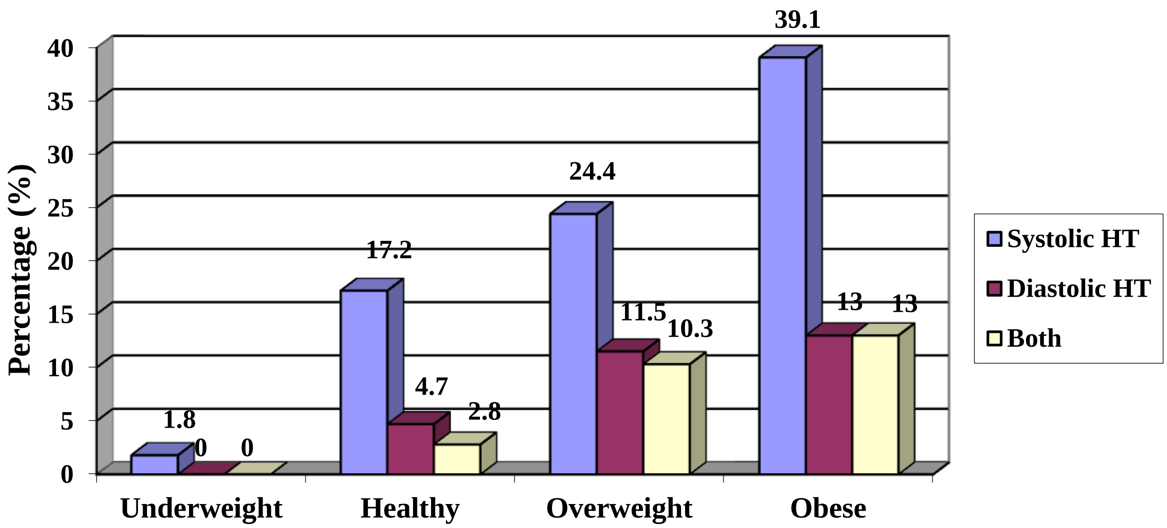
	Total population	**Boys**	**Girls**
Variable	**Pearson's correlation (r)**	**Pearson's correlation (r)**	**Pearson's correlation (r)**
Age (years)	0.05^{NS}	0.08^{NS}	0.05^{NS}
Height (cm)	0.11*	0.17*	0.12*
Weight (kg)	0.32**	0.36**	0.29**
BMI (kg/m^2)	0.26**	0.26**	0.26**
Waist (cm)	0.25**	0.33**	0.18*
Hip (cm)	0.31**	0.34**	0.29**
WHR (cm)	0.02^{NS}	0.13*	-0.05*
Triceps (cm)	0.11*	0.09^{NS}	0.10^{NS}
Subscapular (cm)	0.19**	0.18*	0.17*
Axillar (cm)	0.18**	0.17*	0.17*
Pectoral (cm)	0.15**	0.14*	0.14*
Abdomen (cm)	0.18**	0.20*	0.15*
Suprailiac (cm)	0.15**	0.14*	0.12*
Thigh (cm)	0.17**	0.14*	0.19*
Sum skin (cm)	0.16**	0.17*	0.14*
Body density (g/cm^3)	-0.16**	-0.17*	-0.17*
Body fat percent (%)	0.16**	0.17*	0.17*

** indicates significance at p<0.001, * indicates p<0.05, NS = not significant

Except for age and waist to hip ratio, the rest of the measures of adiposity correlated positively and significantly with mean arterial pressure (MAP) in the total population (all $p<0.05$). Only body density correlated negatively and significantly with mean arterial pressure.

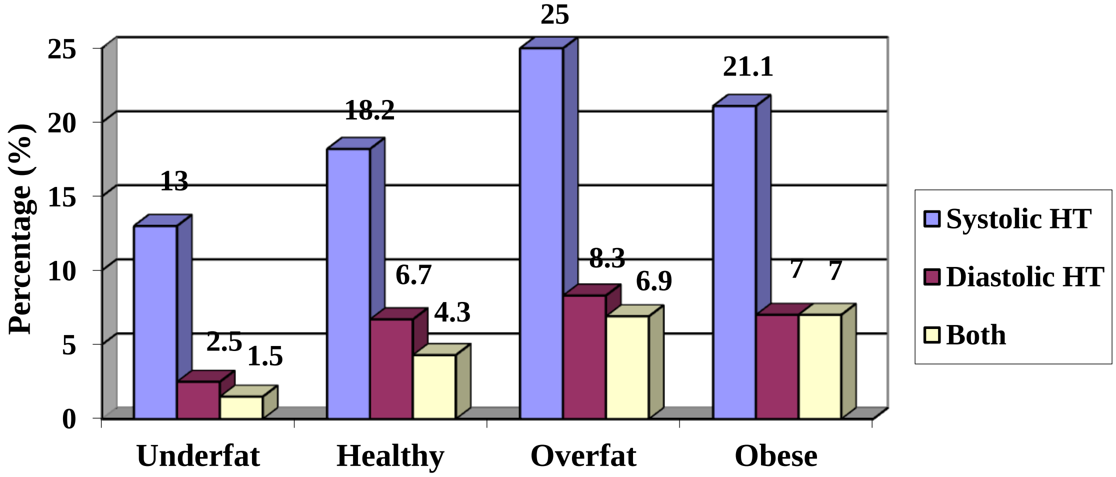
When analysis was done separately; age and triceps skinfold thickness did not correlate with mean arterial pressure in boys and girls. Other measures of adiposity correlated positively and significantly with mean arterial pressure both in boys and girls (all $p<0.05$). Similar to total population, body density correlated negatively and significantly with mean arterial pressure among boys and girls.

Figure 3: Prevalence of systolic, diastolic and both hypertension in underweight, healthy, overweight and obese adolescents according to body mass index



In the total population, the prevalence of systolic and diastolic hypertension increased in a step-wise fashion with increase in body mass index. For systolic hypertension, the prevalences were 1.8%, 17.2%, 24.4% and 39.1% among adolescents who were underweight, healthy, overweight and obese, respectively, $p<0.001$, figure 3. Diastolic hypertension showed the same trend, and it was found in 0%, 4.7%, 11.5% and 13% among underweight, healthy, overweight and obese adolescents respectively, $p<0.001$, figure 3.

Figure 4: Prevalence of systolic, diastolic and both hypertension in underfat, healthy, overfat and obese adolescents according to body fat percentage



When body fat percent was used to categorize adolescents into underfat, healthy, overweight and obese groups, there was generally a trend towards increase in the prevalence of both systolic and diastolic hypertension. However, the fat percentage categorization could not differentiate those with overweight and obesity in terms of the prevalences of both systolic and diastolic hypertension. Systolic and diastolic hypertension increased from underfat, to healthy and to overweight adolescents and slightly but not significantly decreased in those who were obese, figure 4. The prevalence of systolic hypertension using fat percent category were 13%, 18.2%, 25% and 21.1% among underfat, healthy, overweight and obese adolescents, respectively. The prevalence of diastolic hypertension was 2.5%, 6.7%, 8.3% and 7% among underfat, healthy, overweight and obese adolescents, respectively, figure 4.

Table 8: Independent predictors of higher mean arterial pressure (MAP) in the total population identified in multivariate linear regression analysis

Variable	**Beta coefficient (β)**	**t**	***p*-value**
Age (years)	0.033	0.804	0.422
Gender (boys vs. girls)	-0.081	-1.006	0.315
Waist circumference (cm)	0.120	1.962	0.049
Body mass index (kg/m^2)	0.206	2.657	0.008
Body fat percent (%)	-0.085	-0.845	0.399

In multivariate linear regression analysis, higher mean arterial pressure was independently associated with higher body mass index (β = 0.21, p = 0.008) and higher waist circumference (β = 0.12, p = 0.049), but not with higher body fat percent. These associations were independent of age and gender of the adolescent, Table 7.

CHAPTER FOUR

6.0 DISCUSSION

Hypertension and other cardiovascular diseases are on the increase in sub Saharan Africa and estimates show that by 2030 cardiovascular diseases will bypass communicable disease including tuberculosis and malaria as the most important cause of morbidity and mortality in the region[(61)]. Understanding the roots of hypertension is therefore of major public health importance in order for primary intervention to take place and one area that may be of interest is to learn the occurrence of hypertension from adolescence. The present study found that the proportion of adolescents with systolic and diastolic hypertension as defined as >95th percentile for age, height and sex to be 17.5% and 5.5% respectively while 4% of the total studied had both systolic and diastolic hypertension. These results are similar to those found in Nigeria among 9 – 18 year olds in Lagos[(20)] and among 10-18 year olds in Enugu adolescents[(62)]. The findings are however different to those found in urban school children in Chennai, India in which the prevalences were 21.5% for both systolic and diastolic hypertension. In that study, the prevalence of isolated systolic hypertension was 16.3% and no student had isolated diastolic hypertension[(63)]. Previous studies in Tanzanian adolescents had found the prevalence for hypertension to be much lower and this difference could be explained by the general observations that hypertension prevalence is on the increase and partly the difference could also be due to the differences in the population studied. In the study by Kitange et al, adolescents were from rural and semi-urban areas, partly explaining the lower prevalences as hypertension is known to be more prevalent among urban dwellers. Combined systolic and diastolic hypertension was found only in 0.4% of the subjects studied and it was 0.2% in girls and 0.1% in boys[(22)]. Although the study by Chillo et al[(21)] included a much younger age group (6- 15years old), the prevalence of systolic, diastolic and both hypertension was almost similar to the present study among 12 – 19 year old adolescents. As also noted in the literature the prevalence of systolic hypertension was 11.4%, that of diastolic hypertension was 8.1% and 3.9% had both systolic and diastolic hypertension in the study by Chillo, et al.

This study found that mean systolic blood pressure was greater in adolescent boys than girls while the mean diastolic blood pressure was greater in adolescent girls than boys. This finding is not unique to this study, as Fitzpatrick et al had similar findings among African American adolescents(64) and Ujunwa et al found similar pattern among adolescent Nigerians attending secondary schools in Enugu metropolis(62). The finding in this study could be explained by the fact that girls had higher BMI as well as higher body fat percentage and were more likely to be overweight and obese when compared to boys. As shown in the findings, diastolic blood pressure was much more associated with fat percent than systolic blood pressure and hence the difference between boys and girls. Girls were also more likely to report a family history of hypertension and generally girls were mostly sedentary. Both family history of hypertension and sedentary lifestyle are known risk factors for hypertension.

Apart from observed findings from this study other studies with similar findings such as that by Ujunwa et al(62), suggested that blood pressure gender differences may be a result of the influence of sex steroids and rapid hormonal changes seen in girls compared to boys and the attendant higher rates of puberty seen in girls than boys. Also the stress of menarche and menstruation which is seen in girls only may be associated with higher levels of blood pressure in girls(62).

The relationship between body composition and blood pressure levels has well been established in epidemiological studies, and in adolescents and childhood blood pressure is positively correlated with age, weight, height as well as height/weight measurements[19, 20]. Traditionally, body composition has been estimated by BMI as well as waist circumference or waist to hip ratio measurements and these have been shown to positively correlate with levels of blood pressure. This study found height, weight, BMI, waist circumference to positively and significantly correlate with both systolic and diastolic blood pressure. As an alternative and may be more appropriate measure of adiposity, body fat percentage ideally would have been the best estimate of excess fat and therefore would have correlated better with blood pressure levels. In the present study, we found percent body fat to correlate with diastolic but not systolic blood pressure in the total population and when compared to the conventional body build measurements, it was not better. Even when different sites were considered differently, the correlates were rather weak when compare to BMI. Furthermore, in multivariate analysis body fat percent was not independently associated with mean arterial blood pressure, which is a measure that takes account the systolic and diastolic blood pressure of the individual. These findings have been reported by other previous researchers [4, 65]. It is possible that body fat percentage is the best measure among adults as in adolescents and children subcutaneous fat may be a normal growing pattern, especially in girls and blood pressure differences are actually differences in body build and normal growth patterns. Although inaccurate skinfold measurements could have contributed to the poor or lack of association between body fat percentage and blood pressure, this factor if present would be negligible as all measurements were done by the same person and in pre-specified anatomical sites.

Our findings showed that among all the skinfold sites measured, triceps skin fold thickness which is commonly used as a rough estimate of body fat percentage and obesity[65], had the best correlate with body fat percentage. But with regard to association between triceps skinfold thickness and blood pressure level, the literature is inconclusive though our findings show significant positive correlation with diastolic blood pressure but not with systolic blood pressure.

Though some studies have shown weight to be more significant in predicting blood pressure level than subcutaneous fatness[66], this finding in our study was only true for systolic blood pressure where weight showed the strongest correlate but for diastolic blood pressure body fat percentage showed the strongest correlate.

The finding that there was a big difference in the proportion of underfat and underweight by the fat percentage and BMI categorization warrants some explanation. In this study, the proportion of underfat adolescents, especially in boys was alarming, being found in 62.2% of the boys. This finding could have been a true picture and indicates that many adolescents are otherwise underfat and therefore at an increased risk of conditions of malnutrition and stunting. On the other hand, this could be just an over-estimation of the underfat category as with the conventional BMI, the proportion of underweight was in the contrary not alarming, again showing that still the best measure of body build in our setting is BMI. Widiyani et al found the proportion of adolescents with underfat to be 12.5% using the same cut-off points,[67] therefore suggesting that the present results could as well be a true picture of the state of the adolescents in this study population and maybe in the country, underscoring the importance of looking into both overweight and obesity end as well as the lower end of underfat as it is also not without disease risk, even cardiovascular and renal disease in the future.

One of the most important finding of this study is that categorization of underweight, healthy, overweight and obesity was associated with a clear step-wise increase in the proportion of adolescents with both systolic and diastolic hypertension while this was not very clear with fat percentage. This finding further shows the superiority of BMI over fat percentage in this study population in terms of blood pressure and hypertension.

CHAPTER FIVE

7.0 STUDY LIMITATIONS

Use of skinfold measurements on estimating body fat percent, instead of more accurate methods like dual energy x-ray absorptiometry or bioelectric impedance analysis may have contributed to differences in association between body fat percent and BP, however the skinfold thickness method is one of the validated methods of measuring body fat composition and can easily be applied in clinical settings. For practical reasons we measured BP three times on the same visit which may lead to misclassifying adolescents as having elevated blood pressure. It was difficult to ascertain adolescents' responses as to the presence of type 2 diabetes among their parents.

8.0 CONCLUSIONS

Though the proportion of adolescents with hypertension was found to be low among the studied population, this study has clearly shown a significant association between blood pressure level and BMI; with higher proportions of adolescents with elevated blood pressure being seen in high BMI categories (overweight and obesity) compared to other categories.

Skinfold thickness method did not predict blood pressure level better than BMI in this population but it is one of the various methods that have been validated to measure body fat percentage. It is a cheaper method and can easily be applied in clinical settings when compared to other sophisticated methods such as bioelectric impedance analysis and duo energy x-ray absorpriometry. There is room for conducting further studies to assess the efficacy of skinfold thickness method in predicting blood pressure level in other populations apart from adolescents.

9.0 RECOMMENDATIONS

Instituting education programs on lifestyle modification particularly in preventing further weight gain and /or promoting weight loss may help prevent high blood pressure in adolescents. There is a need for the ministry of health to be involved in setting aside policies that can help promote lifestyle modification. This can be achieved through the use of media, posters, etc. to all stakeholders namely students, parents and teachers to effectively combat obesity and its complications. School programs need to include adequate time for physical exercises for students frequently and regularly each week.

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APPENDICES

APPENDIX 1: English questionnaire

QUESTIONNAIRE ON ASSOCIATION BETWEEN BODY COMPOSITION AND BLOOD PRESSURE LEVEL AMONG ADOLESCENTS IN DAR ES SALAAM

Circle one choice or fill the gaps as appropriate

1) Date of birth…………/…………/……….. (Age…………years)
2) Gender/sex …………..
   a) Male b) Female
3) Have you been diagnosed with diabetes?
   a) Yes b) No c) I don't know
4) Have you been diagnosed with hypertension?
   a) Yes b) No c) I don't know
5) Is your mother diagnosed with diabetes type 2? (adult onset)
   a)Yes b)No c)I don't know
6) Is your mother diagnosed with hypertension?
   a) Yes b) No c)I don't know
7) Is your father diagnosed with hypertension?
   a)Yes b)No c)I don't know
8) Is your father diagnosed with diabetes type 2? (adult onset)
   a)Yes b)No c)I don't know
9) How do you get to school daily
   a) By a private car b) by a daladala c) on foot
10) Exercise level
   a) less than once per week b)once to 3 times per week c)four to five times a week d)more than 5 times a week
11) How usually do you eat fried foods?
   a) Less than once a week b)1-2 times a week c) 3-6 times a week d) everyday
12) How many servings of sweet foods (e.g. cakes, chocolates, biscuits) do you usually eat a day
   a) Usually none b) 1-2 serves c) more than 2 serves a day
13) How many cups of coffee do you usually drink a day?
   a)usually none b)1-2 cups daily c)3-4 cups daily d)5 or more cups daily
14) How much soft drink do you consume on average?
   a)less than 500 mills a week b)1-2 liters a week c)3-4 liters a week d) 5 or more liters per week
15) How many pieces of fruit do you usually eat a day?
   a)usually none b)1-3 pieces daily c) 4 or more pieces daily
16) Do you smoke?
   a) Never smoked b) ex- smoker c) current smoker <20 cigarettes a day d) current smoker>20 cigarettes a day
17) Do you have a history of passive smoking? (non smoker exposed to smoke most days at home/ school)
   a) Yes b) No

18) Do you take alcohol?
a) Average 0 drinks daily b) average 1 drink daily c) average 2 drinks daily d) average 3 or more drinks daily
19) Height…………..…..cm
20) Weight……….……..kg
21) Waist circumference…………………..cm
22) Hip circumference ………………….……cm
23) Blood pressure 1)………….mmHg PULSE………
2)……………mmHg PULSE………. 3) …………mmHg PULSE………
24) Skin fold measurements a. Triceps…..…mm b. Subscapular…….. c. Axillary………. d) Pectoral……….. e) Abdominal………… f) suprailiac……….. g) Thigh…………..

APPENDIX 2: Swahili questionnaire

DODOSO JUU YA UHUSIANO KATI YA MAFUTA-MWILI NA SHINIKIZO LA DAMUKATIKA VIJANA WA SEKONDARI – DAR ES SALAAM

1) Tarehe ya kuzaliwa………/………/……… (Umri miaka………)
2) Jinsia ……………..a) Kiume b) Kike
3) Je, una ugonjwa wa kisukari? a) Ndiyo b) Hapana c) Sijui
4) Je, una ugonjwa wa shinikizo la damu? a) Ndiyo b) Hapana c) Sijui
5) Je, mama yako ana ugonjwa wa kisukari uliogundulika akiwa mtu mzima? a) Ndiyo b) Hapana c) Sijui
6) Je, mama yako ana ugonjwa wa shinikizo la damu?
   a) Ndiyo b) Hapana c) Sijui
7) Je, baba yako ana ugonjwa wa shinikizo la damu?
   a) Ndiyo b) Hapana c) Sijui
8) Je, baba yako ana ugonjwa wa kisukari uliogundulika akiwa mtu mzima
   a) Ndiyo b)Hapana c) Sijui
9) Je, wewe unakwenda shuleni kwa njia gani?
   a) usafiri binafsi b)kwa daladala c)kwa miguu
10) Kiwango chako cha mazoezi a)chini ya mara moja kwa wiki b)mara moja hadi tatu kwa wiki c) mara nne hadi tano kwa wiki d) zaidi ya mara tano kwa wiki
11) Je, ni mara ngapi katika juma unakula vyakula vya kukaanga
    a)chini ya mara 1 kwa juma b) mara 1-2 kwa juma c) mara 3-6 d) kila siku
12) Ni mara ngapi kwa siku unakula vyakula vyenye asili ya sukari sukari
    a)huwa situmii b) mara 1-2 kwa siku c) zaidi ya mara 2
13) Unakunywa vikombe vingapi vya kahawa kwa siku
    a)situmii b)kikombe 1-2 kwa siku c) vikombe 3-4 d) vikombe 5 au zaidi
14) Je unakunywa vinywaji baridi vyenye sukari (kama soda) kwa kiasi gani
    a)chini ya ½ kwa siku b)lita 1-2 kwa siku c) lita 3-4 d) lita 5 au zaidi
15) Unakula vipande vingapi vya matunda kwa wastani
    a)huwa sili b) 1-3 kwa siku c) 4 au zaidi kwa siku
16) Je, unavuta sigara? a) sijawahi b) niliwahi ila nikaacha c) ninavuta <sigara 20 kwa siku d)ninavuta > sigara 20 kwa siku
17) Je, unaishi na mtu anayevuta sigara? (unavuta moshi wa sigara mara kwa mara nyumbani ama shuleni) a) Ndiyo b) Hapana
18) Je, unakunywa pombe?
    a)chupa 0 kwa siku b)chupa 1 kwa siku c chupa 2 kwa siku d) chupa 3 au zaidi kwa siku
19) Height……………..cm
20) Weight……………..kg
21) Waist circumference…………………….cm
22) Hip circumference………………..cm
23) Blood pressure 1)………………. mmHg PULSE….2)…………………..mmHg PULSE…….. 3)…………………mmHg PULSE…….
24) Unene ngozi
    a. Triceps……………………..mm
    b. Subscapular ……….……………mm
    c. Axillary……………………….mm

d. Pectoral………………………….mm
e. Abdomen…………..…………mm
f. Suprailiac……………………..mm
g. Thigh ……………………………mm

APPENDIX 3: Consent form - English

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

P. O. BOX 65007

DAR ES SALAAM

TITLE; ASSOCIATION BETWEEN BODY FAT COMPOSITION AND BLOOD PRESSURE LEVEL AMONG ADOLESCENTS IN SECONDARY SCHOOLS IN DAR ES SALAAM

CONSENT FORM

A. PURPOSE AND BACKGROUND

Under the supervision of Dr. Pilly Chillo, Lecturer, Muhimbili University of Health and Allied sciences, department of Internal Medicine; Dr. Brighton Mushengezi , a resident in Internal Medicine is conducting research on Association between body fat composition and blood pressure level among adolescents in Secondary Schools in Dar es Salaam.

B. PROCEDURE

If you agree to participate or for your child to participate in this study the following will occur;-

1. Your child will be asked to fill in a structured questionnaire about his/her medical information as well as his/her parents' medical information.
2. Your child will be asked to participate in taking various anthropometric measurements such as weight, height, blood pressure, waist circumference, hip circumference and skinfold thickness.
3. Participation in this study will take about an hour.
4. There will be no consequences if your child chooses to not participate.

C. RISKS

Risks will include possible discomfort at answering some questions, possible loss of privacy and inconvenience.

D. CONFIDENTIALITY

The information gathered from this study will be kept as confidential as possible. Your child's name will not be used and any identifying personal information will be avoided.

E. DIRECT BENEFITS

There are no guaranteed benefits to you or your child.

F. COSTS

There will be no costs to your child or you as a result of your child taking part in this research study.

G. CONSENT

I have read and understood this consent form. My child is free to decline to participate in this research study or I may withdraw their participation at any point without penalty. Their decision on whether or not to participate in this research study will have no influence on their present or future status.

My child ____has my consent to participate in this research study.

Parent/guardian signature____________________________Date________________

APPENDIX 4: Consent form - Swahili

CHUO CHA TIBA NA AFYA MUHIMBILI

S. L. P. 65007

DAR ES SALAAM

UHUSIANO KATI YA KIASI CHA MAFUTA-MWILI NA KIWANGO CHA MSUKUMO WA DAMU KATIKA VIJANA WA SHULE ZA SEKONDARI – DAR ES SALAAM

FOMU YA MAKUBALIANO

A. MALENGO

Chini ya uangalizi wa Dr. Pilly Chillo, Mhadhiri katika Chuo cha Tiba na Afya Muhimbili kitengo cha magonjwa ya ndani; Dr. Brighton Mushengezi, mwanachuo wa shahada ya uzamili ya magonjwa ya ndani anafanya uchunguzi wa uhusiano kati ya mafuta mwili na kiwango cha msukumo wa damu katika vijana wa sekondari – Dar es Salaam

B. NJIA

Ikiwa utakubali kushiriki ama mwanao kushiriki katika uchunguzi huu mambo yafuatayo yatafanyika;-

1. Mwanao ataombwa kujaza dodoso kuhusu afya yake na pia ya wazazi wake.
2. Mwanao ataombwa kushiriki katika kupima vipimo mbalimbali kama vile uzito, urefu, msukumo wa damu (blood pressure), mzunguko wa tumbo na unene ngozi (skinfold thickness).
3. Kushiriki katika zoezi hili kutachukua yapata saa moja.
4. Hakutakuwa na madhara yoyote ikiwa mwanao ataamua kutoshiriki katika zoezi hili.

C. MADHARA

Huenda mwanao akapata maudhi madogo madogo yanayohusu kujibu baadhi ya maswali na katika kupima vipimo mbali mbali.

D. USIRI

Habari/maelezo yatakayotokana na uchunguzi huu yatatunzwa katika hali ya usiri kadiri iwezekanavyo. Jina lako ama jina la mwanao halitatumika na habari zozote zinazoweza kupelekea mtu kutambulika hazitahusishwa katika uchunguzi huu.

E. FAIDA

Hakuna faida za wazi ambazo utapata ama mwanao atapata kutokana na uchunguzi huu.

F. GHARAMA

Hakuna gharama ambazo wewe ama mwanao atatakiwa kulipa ikiwa ataamua kushiriki katika uchunguzi huu.

G. MAKUBALIANO

Nimesoma na kuelewa vizuri hii fomu ya maelewano. Mwanangu ana uhuru wa kukataa kushiriki katika uchunguzi huu ama naweza kuzuia ushiriki wake wakati wowote bila kizuizi chochote. Uamuzi wake katika kushiriki ama kutoshiriki katika uchunguzi huu hautakuwa na madhara katika maisha yake ya sasa na ya baadae.

Nakubali mwanangu ashiriki katika uchunguzi huu.

Sahihi ya mzazi/mlezi______________________Tarehe______________________

APPENDIX 5: Introduction letter, ethical clearance and research permits

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

Directorate of Postgraduate Studies

P.O. BOX 65001
DAR ES SALAAM
TANZANIA.

Website: http://www.muhas.ac.tz

Tel: +255-(0)22-2150302 Ext 207.
Tel (Direct): +255-(0)22-2151378
Telefax:255-(0)22-2150465
E-mail: *dpgs@muhas.ac.tz*

Ref. No. HD/MUH/T.15/2011

28th May, 2013

The Permanent Secretary,
Ministry of Education and Vocational Training
P.O. Box, 9121
DAR ES SALAAM.

Re: INTRODUCTION LETTER

The bearer of this letter Dr. Brighton Mushengezi is a student at Muhimbili University of Health and Allied Sciences (MUHAS) pursuing MMed Internal Medicine.

As part of his studies he intends to do a study titled: ***"Association between body fat composition and Blood Pressure level among Secondary School Adolescents in Dar es Salaam".***

The research has been approved by the Chairman of University Senate.

Kindly provide him the necessary assistance to facilitate the conduct of his research.

We thank you for your cooperation.

A. Ndyeikiza
For: DIRECTOR, POSTGRADUATE STUDIES

cc: Dean, School of Medicine
cc: Dr. Brighton Mushengezi

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

Directorate of Postgraduate Studies

P.O. BOX 65001
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E-mail: dpgs@muhas.ac.tz

Ref. No. MU/PGS/SAEC/Vol. VI/

22nd May, 2013

Dr. Brighton Mushengezi
MMed. Internal Medicine
MUHAS.

RE: APPROVAL OF ETHICAL CLEARANCE FOR A STUDY TITLED "ASSOCIATION BETWEEN BODY FAT COMPOSITION AND BLOOD PRESSURE LEVEL AMONG SECONDARY SCHOOL ADOLESCENTS IN DAR ES SALAAM"

Reference is made to the above heading.

I am pleased to inform you that, the Chairman has on behalf of the Senate approved ethical clearance for the above-mentioned study.

Thus ethical clearance is granted and you may proceed with the planned study.

Please liaise with bursar's office to get your research fund.

Prof. O. Ngassapa
DIRECTOR, POSTGRADUATE STUDIES

/emm

cc Vice Chancellor, MUHAS
cc Deputy Vice Chancellor – ARC, MUHAS
cc Dean, School of Medicine, MUHAS

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION AND VOCATIONAL TRAINING

Cable:"ELIMU" DAR ES SALAAM
Telex: 41742 Elimu Tz.
Telephone: 2121287, 2110146
Fax: 2127763
In reply please quote:

POST OFFICE BOX 9121
DAR ES SALAAM

Ref. ED/EP/ERC/VOL V/227

Date: Thursday, May 13th, 2013

The Regional Administrative Secretary: Dar es Salaam

ATT. Regional Education Officer:

RE: RESEARCH CLEARANCE FOR DR. BRIGHTON MUSHENGEZI

The captioned matter above refers to.

The mentioned is bonafide student at Muhimbili University of Health and Allied Sciences (MUHAS) who is conducting research on the topic titled **"Association between Body Fat Composition and Blood Pressure Level among Secondary School Adolescents in Dar es Salaam"** as part of his course programme for the award of Masters of Medicine in Internal Medicine (MMed Internal Medicine)

For the purpose of accomplishing this study, the researcher will therefore need to collect data and necessary information related to the research topic in sampled Secondary schools in your region including Shaaban Robert, Mzizima, Al Muntazir, Tambaza, Jangwani and Azania Secondary schools.

In line with the above information you are being requested to provide the needed assistance that will enable him to complete this study successfully.

The period by which this permission has been granted is from **June to September, 2013.**

By copy of this letter, **Dr. Brighton Mushengezi** is required to submit a copy of the report (or part of it) to *the Permanent Secretary, Ministry of Education and Vocational Training* for documentation and reference.

Yours truly,

Ms. Paulina J. Mkoma
For: PERMANENT SECRETARY

CC: Dr. Brighton Mushengezi –Muhimbili University of Health and Allied Sciences

The United Republic of Tanzania

Prime Ministers' Office

REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

ILALA DISTRICT
Phone Address:
Phone No: 2203185/2203182

DISTRICT COMMISSIONER'S OFFICE
ILALA DISTRICT
P. O. Box 15486,
DAR ES SALAAM

In reply quote:
Ref. No: AB.60/87/01/780

14 June, 2013

Shabani Roberth
Mzizima
Al-Muntazir
Tambaza
Jangwani
Azania
✓ Benjamin Mkapa

RE: RESEARCH PERMIT

Mr, Brighton Mushengezi is a researchers from Muhimbili University of Health and Alied Sciences he has been permitted to undertake a field work research on ***"Association between body fat composition and blood presuure level among secondary school adolescents "in Dar es Salaam", at Ilala District from June, 2013 to September, 2013.***

Therefore, you are asked to give the said researchers necessary assistance and Cooperation.

Benjamini Shayo
for; District Administrative Secretary
ILALA

Copy: Mr, Brighton Mushengezi
DAR ES SALAAM.

Principal/Vice Chancellor,
Muhimbili University of Health and alied Sciences ✓
DAR ES SALAAM

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA WAZIRI MKUU

TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Anwani ya Simu: TEMEKE
Simu Nambari: +255 22 2850004.
Unapojibu tafadhali taja:
Fax Na. 022 2850499
E- Mail dctemeke @dsm.go.tz

OFISI YA MKUU WA WILAYA
WILAYA YA TEMEKE
P.0. BOX 45085
DAR ES SALAAM.

Tarehe 10/10/2013

Kumbukumbu Na……………………..

THE HEADMASTER
ST. ANTHONY'S SEC. SCHOOL
DAR ES SALAAM

RE: RESEACH PERMIT

Fro/Dr/Mr/Mrs/Ms/Miss BRIGHTON MUSHENGEZI

Who is research from MUHIMBILI UNIVERSITY

Has been permit to undertake a research on ASSOCIATION BETWEEN BODY FAT COMPOSITION AND BLOOD PRESSURE LEVEL AMONG SECONDARY SCHOOL ADOLESCENTS IN DAR ES SALAAM FROM OCTOBER 2013 TO NOVEMBER 2013

By this letter you asked to give the needed assistance and Co-operation to the said researcher.

KATIBU TAWALA WILAYA
TEMEKE-DAR-ES SALAAM

M.J. Shirima

KAIMU KATIBU TAWALA WILAYA
TEMEKE