BODY FAT COMPOSITION AND DYSLIPIDEMIA AMONG STUDENTS AT THE DAR ES SALAAM UNIVERSITY COLLEGE OF EDUCATION, TANZANIA

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Department of Internal Medicine

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By

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A Dissertation Submitted in (partial) Fulfillment of the Requirement for the Degree of Masters of Medicine in Internal Medicine

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CERTIFICATION

The undersigned certifies that she has read and hereby recommended for acceptance by Muhimbili University of Health and Allied Sciences a dissertation entitled ***"Body fat composition and dyslipidemia among students at the Dar es Salaam university College of Education in Tanzania*** in (partila) fulfillment of the requirements for the degree of Master of Medicine (Internal Medicine) of Muhimbili University of Health and Allied Sciences.

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Prof. Janet Lutale

Supervisor

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Date

DECLARATION AND COPYRIGHT

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

Signature.. **Date**...

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DEDICATION

To my lovely wife, Julieth, for her support, understanding and tolerance during the period of my studies.

To our children, Emmanuel and Joan

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ABSTRACT

Background: Obesity, defined as excessive body fat accumulation, has a significant role on the occurrence of cardiometabolic dysregulation. Obesity is associated with dyslipidemia, impaired glucose metabolism and hypertension all of which exacerbate atherosclerosis.

Accurate determination of body fat composition is the mainstay of early detection of obesity and prevention of its cardiometaboliccomplications.

The BMI, a commonly used surrogate marker for adiposity, only measures weight relative to height and does not provide information on excessive body fat contribution to the overall body weight. Bielectric impedance analysis isone of the non invasive methods used to measure BF%. However, whether BMI or BF% predicts better cardiovascular risks remained to be answered.

Objective: To determine and compare body fat composition by body mass index and by body fat percentage and corelate it with dyslipidemia, hypertension and diabetes mellitus among DUCE students.

Methodology: A descriptive cross-sectional study among DUCE students. The Body fat percentage (BF%) was estimated by a bioelectric impedance analysis (BIA) method and theBMI was measured using standardized method. Blood pressure measurement, blood samples for lipid profiles and blood glucose estimation were taken from each student.

SPSS version 23 was used for data analysis. Pearson Chi square statistics test used to compare group differences for categorical variables. BMI and BF% prediction of cardiovascular risks were examined using logistic regression analysis

Results: Of the 275 students, 23(8.4%) were obese by BF% criteria andbased on BMI criteria, 14(5.1%) students were found to be obese. BF% to an extent correlated with BMI on measuring obesity (r=0.658, p<0.001). The overall prevalence of dyslipidemia was 27.3%, hypertension 11.6% and diabetes mellitus was 2.9%.Students with high BF% had 3.9 times greater odds of being hypertensive and 13 times greater odds of being diabetic than students with normal or low BF%, on the other hand students with high BMI had 6.4 times greater odds of having dyslipidemia than students with normal and below normal BMI.

Conclusion: This study revealed a high prevalence of obesity and dyslipidemia among a relatively young adult population. There was a correlation between BF% and BMI on measuring obesity which implied that an increase in BMI corresponded also with an increase in BF%. However, high BF% was associated with the occurrence of hypertension and diabetes mellitus, while high BMI was associated with the occurrence of dyslipidemia.

Even though both BF% and BMI were somehow comparable in obesity determination, they were different in predicting the associated cardiovascular risk factors.

It is therefore recommended that more studies be carried out in other specific as well as the general population to further describe how the two methods work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACE	American Council on Exercise
AI	Atherogenic Index
B.A	Bachelor of Arts
B.Ed	Bachelor of Education
BF%	Body Fat Percentage
BIA	Bioelectric Impedance Analysis
BMI	Body Mass Index
BP	Blood Pressure
B. Sc	Bachelor of Science
CI	Confidence Intervals
CVD	Cardiovascular Disease
DEXA	Dual Energy X-ray Absorptiometry
DUCE	Dar Es Salaam University College of Education
HDL-C	High Density Lipoprotein Cholesterol
IPAQ	International Physical Activity Questionnaire
LDL-C	Low Density Lipoprotein Cholesterol
MD	Doctor of Medicine
METs	Metabolic Equivalent of Task (Metabolic Equivalent)
MNH	Muhimbili National Hospital
MRI	Magnetic Resonance Imaging
MUHAS	Muhimbili University of Health and Allied Services
NIMR	National Institute for Medical Research
OR	Odds Ratio
PGDE	Postgraduate diploma in Education
SPSS	Statistical Package for Social Sciences
TC	Total Cholesterol
TG	Triglycerides
US	United States
WC	Waist Circumference
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 Body Fat Composition

Body fat composition is the body's relative amount of body fat to fat-free mass, the latter of which is made up of organs, bones, muscles and body tissue. Body fat includes essential and storage fat.Essential body fat is the minimum amount of fat necessary for basic physical and physiological health. The percentage of essential body fat is greater in women than men due to the demands of childbearing and other hormonal functions. The percentage of essential body fat is 3–5% in men, and 8–12% in women(1).

Storage body fat, referred to as subcutaneous fat, constitute about 80% of total body fat in men and 90% in women. Visceral body fat surrounds the internal organs in the chest and abdominal cavity. The roles of storage and visceral fat are insulation to retain body heat, protection of internal organs against trauma and reservoir substrates for energy(2).

1.2 Obesity

Obesity, especially visceral obesity, causes insulin resistance and is associated with dyslipidemia, impaired glucose metabolism, type 2 diabetes mellitus and hypertension all of which exacerbate atherosclerosis, a driver of cardiovascular diseases(3,4,5)

Obesity is often defined simply as a condition of excessive fat accumulation in the body in relation to lean body mass, to the extent that health and wellbeing are adversely affected (6).

Use of body mass index (BMI) to define obesity

Conventionally, obesity has been defined based on body mass index (BMI), a measure of excess weight rather than excess body fat.BMI system is more and tried and tested than calculating one's body fat percentage. It's been around for a while and has been refined with time to take into account the averages for different nationalities. It is also easy to calculate.BMI is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m^2). Aperson is categorized as underweight if the BMI<18.5kg/m^2, normal 18.5-24.9kg/m^2, overweight 25-29.9 kg/m^2, obesity class I 30.0-34.9 kg/m^2, obesity class II 35.0-39. 9 kg/m^2, or obesity class III $\geq$ 40.0 kg/m^2(6,7).

Use of Body Fat Percentage to define obesity

The Body Fat Percentage (BF%) is defined as the proportion of individual's total fat mass over total body mass (8). BMI takes into account only two factors, height and weight while the body fat percentage tells you exactly how much fat the body has. For instance a person with high bone density could have a high BMI, hence calculating one's body fat percentage gives a clearer picture of a person's level of healthiness and fitness. In addition various studies have found that people with abdominal fat were likelier to suffer from heart-related issues than a person with no abdominal fat and similar BMI. The BMI, is simply too general to give an accurate picture. There are however still not enough research done to ascertain exactly how body fat percentage corresponds to diseases. A study in 2000 by the *American Journal of Clinical Nutrition* showed that body-fat percentage might be a better indicator of weight-related disease ailments than BMI.

The bioelectrical impedance analysis is a test where a low current is sent through the body which works on the principle that fats put up more resistance. Another test called the DEXA Scan is a more accurate method but requires one to undergo an X-ray and then the weight of the various organs and bones are calculated to ascertain your body fat percentage. There is no generally accepted definition of obesity based on BF%. Most researchers have used BF% above 25% in men and 32% in women, as cut-points to define obesity.

The body fat percentage is a more accurate, but still there isn't enough data to suggest how or what percentage would describe one to be unhealthy. The BMI on the other hand has been around for a long time and is tried and tested.

The American Council on Exercise (ACE) chart is one of the most commonly used body fat chart (Table 1).

Table 1: Body fat percentage classification according to ACE (2009)

ACE (2009)**Body Fat Percentage Chart**		
Description	**Women**	**Men**
Essential fat	10 – 13%	2 – 5%
Athletes	14 – 20%	6 – 13%
Fitness	21 – 24%	14 – 17%
Average	25 – 31%	18 – 24%
Obese	≥ 32%	≥ 25%

1.2.1 Risk Factors For Obesity

Diet

The principal cause of obesity is an imbalance between calories consumed and calories expended as a result of an increased intake of energy-dense foods that are high in fat and sugars but low in vitamins, minerals and other micronutrients(9).

Physical inactivity

Physical inactivity is the risk factor for obesity, diabetes, hypertension, dyslipidemia and cardiovascular diseases(10).

Regular aerobic physical activity increases exercise capacity and physical fitness, which can lead to many health benefits. Three types of physical activity assessment methods are regularly used namely, the criterion, the objective and the subjective assessment method. The criterion methods include measurements like doubly labeled water, indirect calorimetry and direct observation are the most reliable and valid measurements against which all other physical activity assessments methods are validated. The objective physical activity assessment methods include use of activity monitors (pedometers and accelerometers) and heart rate monitoring. Finally, questionnaires and activity diaries are considered subjective methods(11).

Physical activity of all kinds can be performed in a variety of intensities, ranging between light, moderate, and vigorous intensity activity. Metabolic Equivalent of Task (MET) is a convenient and standard method for describing absolute intensity of physical activities. One METis the amount of oxygen consumed while sitting at rest. Light intensity activity is an activity that is classified as less than 3 metabolic equivalents (METs). Some examples of light physical activities includewalking slowly around the office, sitting at your computer, making the bed, eating, preparing food, and washing dishes. Moderate intensity physicalactivities, defined as activities ranging between 3 - 6 METs, include sweeping the floor, walking briskly, slow dancing, vacuuming, washing windows or shooting a basketball. Vigorous intensity activities, defined as activities ≥ 6 METs, include runningat 5 mph or more, swimming, soccer, jumping rope or carrying heavy loads such as bricks(12,13).

Genetic susceptibility to obesity

In recent years there has been increasing interest in determining the role of genetic factors in the pathogenesis of obesity. In general, genetic factors are considered to have a role in determining inter-individual variability in body weight. However, in adults with more severe obesity, less than 5% will harbor obesity-associated mutations such as those that cause leptin deficiency or leptin receptor dysfunction(14).

Age

It has been shown that prevalence of obesity increases with age. Muscle mass tend to decrease with age leading to decreased metabolism. These changes also reduce calorie needs and leading to deposition of fat to the adipose tissues. The association of obesity and age can be explained, in part, by a decrease in the degree of physical activity with advancing age in both men and women(15).

Sex

A number of physiological processes are believed to contribute to an increased storage of fat in females. Such fat deposits are believed to be essential in ensuring female reproductive capacity. There is an association between total and regional adiposity with gender. Women have substantially more total adipose tissue than men, with ‘normal’ levels being 20–30% in women and 12–20% in men(16).

Most studies in black African population revealed higher prevalence of obesity among women than men.In the Durban study 3.7% in men versus 22.6% in women was observed. In Nigeria, 8.3% among men and 35.7% among women (17).The study among Tanzanian adolescents reported the mean BMI of 20.8 kg/m^2 for women and 18.5 kg/m^2 for men, prevalence of overweight being higher among women than men, 4.6% versus 0.4%(18).

Smoking

Smoking causes a marked increase in metabolic rate and tends to reduce food intake compared with that of non-smokers. Smoking and body weight are inversely relatedand smokers frequently gain weight when they give up the habit(19).

Alcohol

Based on the fact that 1 gram of alcohol provides 7.1 kcal and energy consumed as alcohol is additive to that from other dietary sources, increased energy intake with alcohol use can certainly promote a positive energy balance and ultimately weight gain (20).

The amount of alcohol consumption per drinking occasion is positively correlated with BMI, while the frequency of drinking is negatively correlated, suggesting that frequent light drinking might offer a protective effect(21).

Ethnicity

The WHO proposed different BMI cut-offs for different ethnic groups due to the fact that some ethnic groups have higher metabolic and cardiovascular risks at lower BMI. This might be explained by differences in body shape and fat distribution(22). Studies have found that for the same age, sex and BMI, south Asians have higher BF% than white Caucasians. In Caucasian men, a BMI of 30kg/m^2 corresponds to 25% body fat(23,24), whereas in south Asian men, a BMI of less than 25kg/m^2 corresponds to 33% body fat(25).

1.2.2 Screening and diagnosis of obesity

In epidemiological studies, surrogate measures of body fatness such as BMI, waist circumference (WC), waist-hip ratio and skin fold thickness have been used extensively. However, these techniques do not precisely characterize persons by body composition (percentage of body fat or muscle mass), and there is substantial variation across age, sex and ethnic groups (26).

Several techniques have been used to assess body fat percentage including caliper-derived measurements of skin-fold thickness, underwater weighing (densitometry), dual energy x-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA) and magnetic resonance imaging (MRI). However, densitometry, DEXA and MRI are expensive, inconvenient for the participant, and not feasible to conduct in the field because they require large sophiscated equipment. For these reasons, their use in large epidemiological studies is limited(27).

Bioelectrical Impedance Analysis

Use of BIA for body fat composition estimation as a measure of obesity is currently the favored method as it takes into consideration of the age, sex, weight and height of a person.

BIA is a relatively simple, quick (takes about 3 to 5 minutes), and is a non-invasive method which gives reliable measurements of body composition with minimal intra and inter-observer variability (26). The results are available immediately and reproducible with <1% marginal error on repeated measurements (28). This technique requires inexpensive, portable equipment, making it an appealing alternative to assess body composition in epidemiological studies (29).

Principle used by BIA

The BIA technique is based on the principle that an electrical current flows more rapidly through tissues with higher water and electrolyte content than through tissues which are less hydrated such as fat tissue. It measures the impedance or opposition to the flow of an electric current through the body fluids contained mainly in the lean and fat tissue(30).

Body fat, being a poor conducting material, has high resistance to the flow of electric currency. Resistance recorded is used to calculate the Fat-Free mass of a person and body fat percentage is then calculated by subtracting Fat-Free mass from the weight of a person, dividing by the weight and multiply by hundred(31).

1.3 Dyslipidemia

Primary dyslipidemia that is related to obesity is characterized by increased total cholesterol, increased triglycerides, decreased high density lipoprotein levels and increased low density lipoprotein composition (4).

Dyslipidemia is defined as a state that arises as a result of abnormalities in the plasma lipids. These abnormalities could be quantitative, qualitative or both. Quantitatively, dyslipidemia is due to elevated plasma total cholesterol (TC), elevated low-density lipoprotein cholesterol (LDL-C), elevated triglycerides (TG) and reduced high-density lipoprotein cholesterol (HDL-C) levels, occurring singly or in combinations. Qualitatively, dyslipidemia implies changes in composition of LDL-C which includes small dense LDL-C, increased TG content or increased electronegativity of LDL-C (32).

According to the WHO, dyslipidemia is defined as as the presence of at least one of the following; TG >1.7mmol/l, TC >5.2 mmol/l, LDL-C >3.5 mmol/l, HDL-C <0.9 mmol/l in men, <1.0 mmol/l in women, or Atherogenic index AI (TC ÷ HDL-C) more than five (33).

1.4 Literature Review

The prevalence of obesity is increasing throughout the world at an alarming rate. Worldwide obesity has more than doubled since 1980.In 2014, thirty nine percent (over 1.9billion) of adults aged 18 years and older were overweight. Of these, 13% (over 600 million) were obese(34). Obesity is predicted to affect more than one billion people by the year 2020. Most of the world's population lives in countries where obesity kills more people than underweight. Obesity and its related non-communicable diseases are largely preventable (35).

Studies from US and Europe have shown that obesity is closely associated with increased risks of disease and reduced life expectancy. For instance the prevalence of obesity in USA rose from 15% to 30% between 1980 and 2000 (36).

While obesity remains an area of significant public health importance to Africans, particularly in urban areas, there is little evidence on its proper diagnosis, treatment and prevention(37).

A cross-sectional study assessed the rate of obesity and other cardiovascular disease (CVD) risk factors in a random sample of 200 urban adults in Benin, West Africa and explored the associations between these factors and socio-economic status, urbanization as well as lifestyle patterns. The most prevalent CVD risk factors were overall obesity (18%), abdominal obesity (32%), hypertension (23%), and low HDL-cholesterol (13%). The prevalence of overall obesity was roughly four times higher in women than in men (28 vs. 8%). After controlling for age and sex, the odds of obesity increased significantly with socio-economic status (38).

A systematic review of papers published on the prevalence of obesity among adults in Nigeria revealed the prevalence of overweight individuals ranged from 20.3%–35.1%, while the prevalence of obesity ranged from 8.1%–22.2%(39).

As it is for other developing countries, Tanzania is also experiencing an enormous increase in the burden of overweight and obesity. In 2016 WHO reported overall prevalence of obesity of 5.9% among adults, 9.5% among females and 2.4% among males(40). Sedentary lifestyle and consumption of modern foods are some of the factors which are thought to mitigate change in trend from arithmetic to geometric increase (41).

The study done to determine the prevalence of obesityamong adults aged 18 - 65 years in Kinondoni municipality,Tanzania from April 2007 to April 2008 revealed the overall obesity prevalence of 19.2%. Obesity prevalence was significantly higher among women (24.7%) than men (9%) (42).

1.4.1 Caveats of using BMI

BMI is the most widely used measure to diagnose obesity. However, the diagnostic accuracy of BMI to detect excess in body adiposity is largely unknown (43).

Although BMI has been widely used to measure obesity it does not distinguish between excess fat and lean body mass nor does it provide any indication of the distribution of fat among individuals (44).

Several factors can influence the relationship between BMI and body fat. Age and sex significantly influence this relationship in that older adults tends to have less body fat than younger adults for an equivalent BMI, women have greater amounts of total body fat than men with an equivalent BMI and muscular individuals, or highly-trained athletes, may have a high BMI because of increased muscle mass (45).

Previous studies have shown that increased BMI is associated with an increased risk of metabolic derangement-related diseases and may be used as an indicator for the prediction of these diseases (46). However, because of the inability of BMI to discriminate between body fat and lean mass, its diagnostic performance in intermediate ranges of body weight is limited; it cannot accurately categorize individuals who have a normal body weight with too much body fat but too little muscle and those who have an excessive body weight with too little body fat but too much muscle (47).

A cross-sectional study was done to assess the degree of misclassification on the diagnosis of obesity using BMI as compared with direct body fat percentage (BF%) determination and compared the cardiovascular and metabolic risk of non-obese and obese BMI-classified subjects with similar BF%. A total of 6123 (924 lean, 1637 overweight and 3562 obese classified according to BMI) Caucasian subjects, aged 18–80 years, were included in the study. The study revealed that 29% of subjects classified as lean and 80% of individuals classified as overweight according to BMI had a BF% within the obesity range (48).

The study was done to compare the National Institute of Health's (NIH) body mass index (BMI)-based classification to identify obesity in comparison with the World Health Organization (WHO) percent Body fat (BF%)-based reference standard among white, black and Hispanic women of reproductive age. BMI cutoff values recommended by the NIH failed to identify nearly half of study participants who met the criteria for obesity by BF%. Using race/ethnic specific BMI cutoff values would more accurately identify obesity in this population than the existing classification system (49).

1.4.2 Use of body fat composition to define obesity

Accurate determination of body fat could provide clinically useful guidance for physicians to assess disease risks in patients with obesity and optimize preventive or therapeutic remedies for these patients(50).

A cross-sectional study was done among 13,601 subjects aged between 20–79 years from the Third National Health and Nutrition Examination Survey. Bioelectrical impedance analysis was used to estimate the body fat percentage (BF %). The study assessed the diagnostic performance of BMI using the WHO reference standard for obesity of BF % > 25% in men and > 35% in women. The correlation between BMI and both, BF % and lean mass by sex and age groups were also assessed. BMI-defined obesity was present in 21% of men and 31% of women, while BF %-defined obesity was present in 50% and 62%, respectively. A BMI ≥30 kg/m^2 had a high specificity (95% in men and 99% in women), but a poor sensitivity (36% and 49 %, respectively) to detect BF%-defined obesity. The diagnostic performance of BMI diminished as age increased(43).

Meta-analysis of 32 different studies comprising a total of 31,968 patients revealed that the commonly used BMI cut-off values to diagnose obesity fail to identify half of the people with excess percent body fat. Commonly used BMI cut-off values to diagnose obesity have high specificity, but low sensitivity to identify adiposity, as they fail to identify half of the people with excess BF%(51).

Previous studies have shown that BF% more accurately reflects body composition than BMI, although both BMI and BF% have been used for the evaluation of human health risks such as cardiovascular risk in clinical practice(52). A higher BF% and/or BMI often indicate a higher level of cardiovascular risk(53). However, the relationship between BF% and BMI is not linear. A high BF% does not necessarily mean a high BMI, and vice versa. Thus, there is a need to accurately determine the cardiovascular risk in individuals who have a normal BF% but a high BMI or a high BF% but a normal BMI. In other words, whether BMI or BF% more accurately predicts cardiovascular risk factors needs to be evaluated(54).

Another study was done in Chennai India aiming at predicting BF% using bioelectrical impedance analysis (BIA), it involved a total of 90 women aged between 20 to 75 years. It was inferred that the predicted BF% was able to clearly distinguish obesity with a sensitivity of 95.5% and specificity of 97.7%. Strengthened by the high levels of sensitivity and specificity obtained from the analysis, the BF% computed from the BIA can be used as an additional tool for screening population for obesity(55).

The LIPGENE dietary intervention study recruited 486 subjects with metabolic syndrome aged 35-70 years with BMI of 20-40 kg/m^2 from eight European countries. Bio-electric impedance measures of body fat composition were performed by a multi-frequency tetra-polar device. The study revealed that about 39% and 87% of subjects classified as normal and overweight respectively by BMI were obese according to their body fat percentage (BF%). In conclusion, screening for obesity using both BF% and BMI methods in the population may help to identify individuals at greater cardio-metabolic risk than BMI alone (56).

In September 2009, a study was done among 3859 Chinese subjects without a history of cardiovascular disease to evaluate the predictive values of body fat percentage (BF %) and body mass index (BMI) for cardiovascular risk factors, especially when BF% and BMI are conflicting. Body Fat percentage was determined by bioelectrical impedance analysis. When age, gender, lifestyle, and family history of obesity were adjusted, BF%, but not BMI correlated with blood glucose and lipid levels. It was concluded that BF%, and not BMI, was independently associated with cardiovascular risk factors, indicating that BF% was a better predictor(54).

A cross-sectional study was conducted between June and November 2013 to assess the association between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam, Tanzania. Body fat was assessed by skin-fold thickness and categorized as underfat, healthy, overfat or obese according to WHO definitions. The proportion of adolescents with overfat or obesity was 22.2%. It was concluded that BMI predicted blood pressure level better than body fat composition by skin-fold and that it should be used as a measure of increased risk for hypertension among adolescents(18).

1.4.3 Obesity and dyslipidemia

The risk of CVD increase with significant changes in lipid profiles as observed in obese subjects. These changes are decreased HDL levels and increased levels of LDL, total cholesterol and triglycerides, all have been shown to be atherogenic. Insulin resistance certainly plays a central role and, in addition, both hormonal and neurologic pathways have recently been found to play an important role(57).

The WHO estimates that dyslipidemia is associated with more than half of global cases of ischemic heart disease and more than 4 million deaths per year (58).

A study done in rural Chinese adults indicated that 36.9% of the population had at least one type of dyslipidemia and 64.4% had at least one type of abnormal lipid concentration(59).

Another study done in rural black population at Limpopo Province in South Africa in 2011, involving 382 adults, indicated high prevalence of obesity and dyslipidemia. The overall prevalence rates were 10.2% hypertriglyceridemia, 9.9% hypercholesterolemia, 6.3% low HDL-C, 13.6% high LDL-C, 23.6% obesity and 30% dyslipidemia risk. Dyslipidemia increased with obesity and age in females but irregularly in males. Obesity and dyslipidemia were thus, highlighted as health problems with risk for dyslipidemia indicating a high risk for developing arterial thrombosis, cardiovascular disease and hypertension(60).

In a study done in 2010 amongst a group of women attending "the August" meeting at Naze, Owerri, South East Nigeria revealed the high prevalence of dyslipidemia(60.5%).

Based on BMI according to WHO criteria, the study revealed high prevalence of overweight and obesity, 38.5% and 20.7% respectively(61).

In Sudanese adult study done in 2010 for obesity and cardiovascular disease risk factors based on BMI and waist-hip circumference revealed the prevalence of risky high levels of TG, TC and low levels of HDL to be significantly higher among overweight and obese males (TG: 20% and 20.3%, TC: 15% and 41.6%, HDL: 20% and 45.8%, respectively) compared to normal weight males (TG: 0.0%, TC: 0.0% and HDL: 6.9%,)(62).

Another African study in Ugandan general population, was done in 2011 to assess the ability of anthropometric measures to identify risk of diabetes, hypertension, and dyslipidemia, and considered the optimal cut-off points for BMI and waist circumference (WC). Among men, 6.4% were overweight, 0.6% were obese, 20.6% had hypertension, 16.8% had dyslipidemia and 1.0% had diabetes. Among women, 17.0% were overweight, 5.3% were obese, 20.0% had hypertension, 20.2% had dyslipidemia, and 1.5% had diabetes(63).

The prevalence of obesity and dyslipidemia and the mean frequency of intake of selected dietary factors were studied in 545 participants aged 46-58y and living in three areas in Tanzania. The prevalence of obesity was 22.5% among women and 5.4% among men. Higher rates of obesity were observed in both men and women in an urban area of Dar es Salaam. The prevalence of dyslipidemia among men was higher in a pastoralist’s population of the Maasai in Monduli (22.6%) than in Dar es Salaam (9.6%) and rural Handeni (7.3%). These findings suggest that unhealthy diet and lower energy expenditure are important contributors to obesity and dyslipidemia in Tanzania(64).

1.5 Problem Statement

Over the decades the prevalence of obesity, dyslipidemia and cardiovascular morbidity has increased among our population. According to Tanzania Demographic and Health Survey (TDHS), there is an increasing level of obesity in Tanzania at around 2.7% between 1991 and 1992 when the first survey was implemented(65). A few studies that have been implemented in Tanzania were district-specific and focused on a small population making it difficult to generalize about issues related to obesity prevalence and risk factors(67,68).

In some instances use of BMI alone might not give a clear picture of the cardiovascular risks associated with obesity.

There is a need to improve screening and diagnosis strategies for obesity particularly among individuals with increased cardio-metabolic risk.

1.6 Rationale of the Study

Obesity, dyslipidemia, hypertension and diabetes mellitus are associated with increasing risk to cardiovascular disease, and the use of body fat composition determination techniques may be useful in screening for obesity that is associated with increased risks of cardiovascular disease.

Affordable and easily available methods for accurate screening body fat composition as indicators of obesity are in a great need especially in countries with financial constraints to afford more expensive diagnostic equipment. Currently used diagnostic tools for obesity classification includes waist circumference (WC), BMI, and body fat percentage (BF %). WC does not take whole body fat distribution into consideration. BMI, the traditional diagnostic tool, does not discriminate between lean and fat body mass. Body fat percentage, on the other hand is a measure of body fat composition, estimates the amount of body fat mass of a person and is an important determinant of cardiovascular disease risk. There are limited published data on the use of body fat composition for obesity classification in our setting. Previous study done in Tanzania revealed BMI predicts hypertension better than body fat percentage by skin caliper method and concluded that BMI should be used as a measure of increased risk for hypertension among adolescents.

The study aimed at examining whether body fat percentage measured by BIA method will better describe the cardiovascular risks namely dyslipidemia, hypertension and diabetes mellitus associated with obesity more than the use of BMI only, a traditional diagnostic tool in our setting.

1.7 Objectives

1.7.1 Broad objective

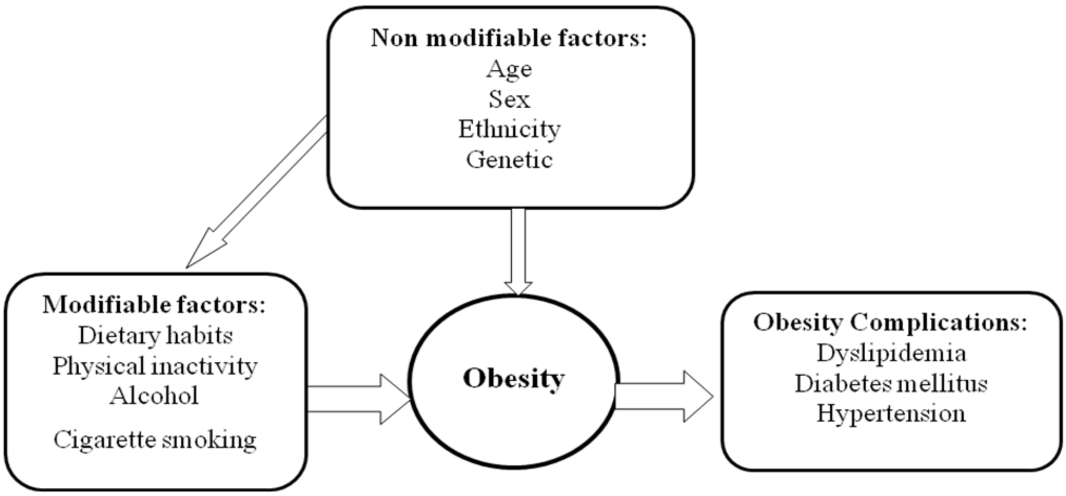
To determine and compare body fat composition by body mass index and by body fat percentage and correlate it with dyslipidemia, hypertension and diabetes mellitus among DUCE students

1.7.2 Specific objectives

1. To determine and compare the proportion of students at DUCE with obesity by BMI and BF%
2. To determine association of obesity with dyslipidemia, hypertension, and diabetes mellitus among students at DUCE

1.8 Conceptual Framework

This conceptual framework summarizes factors contributing to the occurence of obesity and the cardiometabolic complications.



Source: Designed by Johannes A. Ngemera

Figure 1: Conceptual framework for factors associated with obesity and its complications

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study Design

A cross-sectional descriptive study designed to ascertain the body fat composition and dyslipidemia among students at the Dar es Salaam University college of Education

2.2 Study area and study population

The Dar es Salaam University College of Education is a constituent college of the University of Dar es Salaam in Tanzania located in Chang'ombe area, Temeke district about 5 kilometers from Dar es Salaam city centre. It has three faculties namely; Faculty of Education, Faculty of Humanities and Social Sciences and Faculty of Science. The college offers four undergraduate degree programs; Bachelor of Science (B.Sc.) with Education, Bachelor of Education (B.Ed) in Arts, Bachelor of Education with Science, and Bachelor of Arts (B.A) with Education and a Postgraduate Diploma in Education (PGDE). DUCE, a public college, is composed of students from different regions of the United Republic of Tanzania hence providing a representative sample from all over Tanzania.

According to data of February 2016, 4660 students were registered at DUCE pursuing different courses. Female constitute 31% of all students. Bachelor of Science with Education degree had 1074; Bachelor of Education in Arts 198, Bachelor of Education in Science 252, Bachelor of Arts with Education 3068 and Postgraduate diploma in Education had 68 students.

2.3 Study Period

This study was conducted from September to December 2016

2.4 Sample size determination

Sample size was calculated from the following formula:

$$\mathbf{N = \frac{Z^2 P (1 - P)}{E^2}}$$

Where:

N = Minimum sample size

Z=% point corresponding to significant level of 5%=1.96

P= Overall prevalence of obesity among adults in Kinondoni municipality was 19.2% (42)

E= maximum likely error=5%

$$N = \frac{1.96^2 \text{ X } 19.2\ (100 - 19.2)}{5^2} = 238.4$$

; minimum sample size approximately 240

Add 10% for non respondents or refusal to participate 240 + (240 X 10%) = **264**

A total of 275 DUCE students participated in this study

2.5 Sampling Technique

A multistage and weight sampling technique was used to select participants for the study whereby in;

Stage 1: All undergraduates and postgraduates degree programs offered at DUCE were listed down and list, year of study and number of all students from each degree program were obtained (Figure 2).

Stage 2: Weight sampling was used to determine the number of students to represent each degree program whereby a number of students in a particular degree program were divided by the total number of students at DUCE and then multiplied by calculated sample size of the study. For instance for the B.Ed in Arts, there were a total of 198 students , 93 in 1st year, 53 2nd year and 52 3rd year. To get proportion of student to be included into the study, the total number of all students in B.Ed in Arts program was divided by total number of all DUCE students multiplied by calculated sample size, i.e. (198/4660)x 275, obtaining 12 B.Ed in Arts students (Figure 2).

Stage 3: A number of students to represent each year of study were then obtained by weight sampling, in which a total number of students in a particular year of study were divided by the total number of students in that particular degree program and then multiplied by the number of students obtained to represent that particular degree program. Referring to above B.Ed in Arts program, number of students chosen from 1st year was (93/198) times 12, a number obtained from stage 2 for that particular program, obtaining 6 students from first year(Figure 2).

Stage 4: After obtaining the required number of students from each year of study, a sampling interval was obtained for each year by total number of students in that particular year of study divided with sample size needed from that particular year of study. For 1st year B.Ed in Arts, sampling interval was 93/6= 15. So from a list of 93 B.Ed in Arts 1st year students, every 15th student was selected until the required 6 students were obtained. The first name from a list was picked randomly. The next names were picked by adding up the sampling interval from a serial number of a previous student.

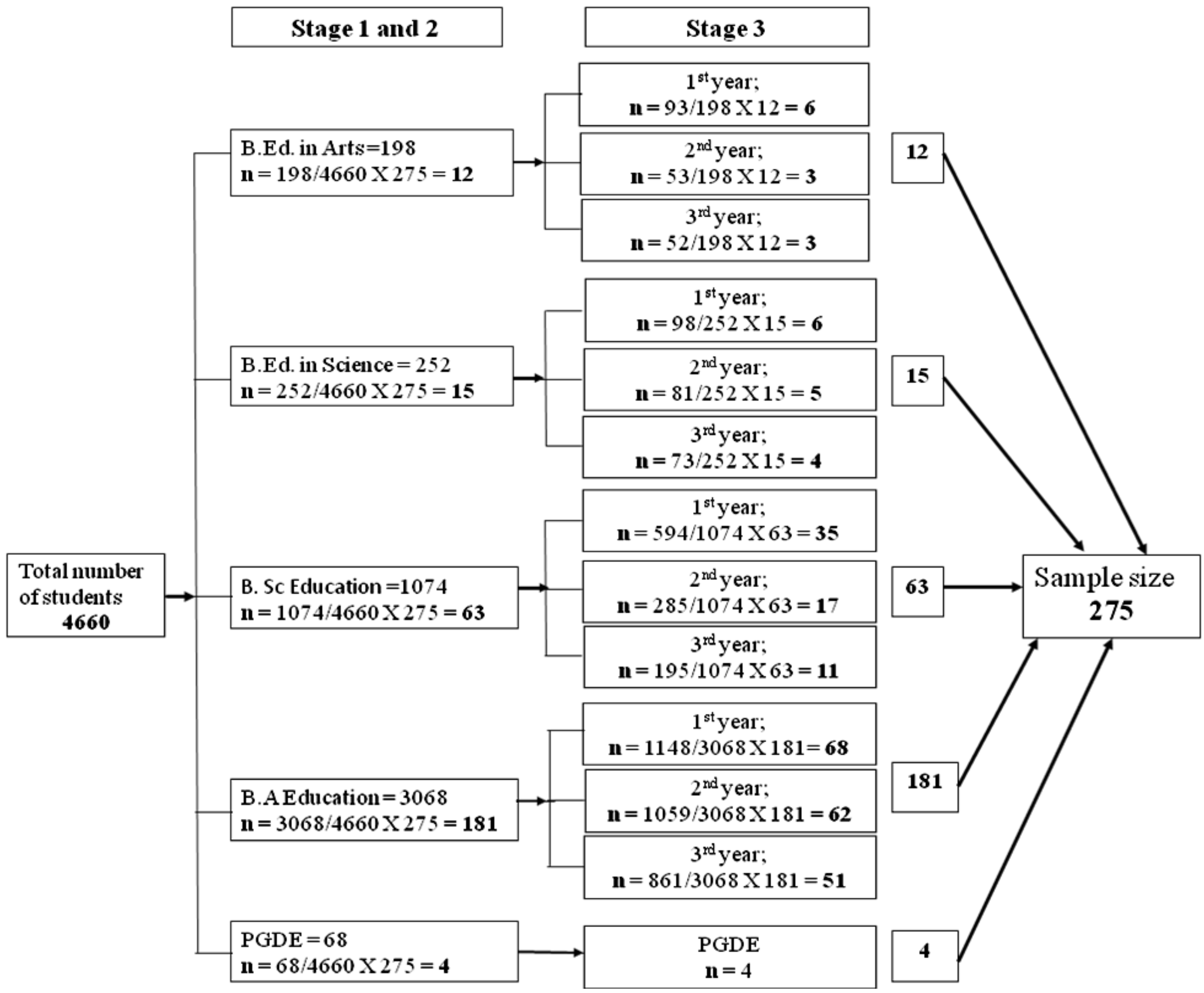


Figure 2: Schematic diagram for multistage sampling procedure

2.6 Study procedures

The first visit was for asking permission from DUCE administration to conduct the study and obtaining the necessary data for participant selections. The selected participants were visited and asked for their consent to participate in the study.

Those who were selected gave their consent and were interviewed to obtain their social demographic information and anthropometric measurements which were recorded in the respective interview questionnaire. Participants were then instructed and requested to come the following day while fasting for body fat percentage estimation by bioelectric impedance analysis and blood samples for lipid profiles and blood glucose estimation.

2.7 Data collection

Demographic data which was obtained included name, sex, age, marital status, program and year of study, risk factors for obesity and family history of hypertension, diabetes mellitus, and stroke.

Personal contacts were recorded for easy communication of results to each participant. For those identified with obesity, dyslipidemia, diabetes mellitus and hypertension they were counseled and then referred to their local physician at DUCE clinic for continued care and management.

The interviews and data collection were done by the principle investigator and a research assistant who was trained before starting collecting data.

2.7 Clinical Measurements

2.7. 1 Weight and height measurements

Weight of each participant was measured using calibrated adult weighing scale (ZT-150A)without shoes and in light clothing. Readings were recorded to the nearest 0.5 kilograms.

Height was measured using the stadiometer without shoes and recorded to nearest 0.5 centimeters.

BMI was then calculated using the formula of weight (in kilograms) divided to the square of the height (in meters). BMI of 30kg/m^2 and above were taken as obesity.

2.7.2 Blood pressure measurements

Blood pressure (BP) was taken from the forearm (brachial artery) of each participant by using OMRON digital sphygmomanometer. Blood pressure measurements were done in a sitting position with the arm supported at the level of the heart and repeated after 5 minutes; the average of the two measurements was taken as the individual's BP. Systolic pressures of above or equal to 140mmHg and/or diastolic pressure above or equal to 90mmHg were regarded as a high BP.

2.7.3 Body fat composition by bioelectrical impedance analysis (BIA)

Before the day of the study, selected students were instructed to rest for about 8 hours (not to be involved in vigorous exercise) and to refrain from alcohol intake for 12 hours prior to the study. On the day of analysis students were requested to remove shoes and socks and instructed to lie supine with the arms placed at 30 degrees from the body and legs not touching and remain still during the entire period of BIA. The selected area on the skin where the electrodes were placed was cleaned with spirit swabs. The electrodes were then placed on the right wrist on an imaginary line bisecting the ulna head and on the right ankle on an imaginary line bisecting the medial maleolus. The signal electrodes were placed on first joint of right finger and on the base of right second toe. The analyzer, BODYSTAT®1500, was turned on and the subject was insisted to refrains from moving (Figure 3).

(Source: Bodystat hardware user's guide)

Figure 3: Procedure for measuring body fat percentage using BIA

The BIA machine used has a built-in formula for calculation of BF%, in which calculated BF% is displayed on the screen. The body fat percentage >25% in men, and >32% in women, were used as cut off-points to define obesity (51).

2.8 Laboratory Tests

Fasting blood samples from participants for lipid profile and blood glucose levels were collected after an overnight fasting. Under aseptic technique, 5mls of venous blood were drawn from the antecubital fossa and placed in an empty sterile tube.

Blood samples collected for biochemical tests were transported to the MNH main biochemistry laboratory for immediate lipid analysis using the HumaStar 300 Chemistry analyzer.

Dyslipidemia was defined according to the WHO as the presence of at least one of the following; serum triglyceride (TG) >1.7mmol/l, total cholesterol (TC) >5.2 mmol/l, low density lipoprotein cholesterol (LDL-C) >3.5 mmol/l, and high density lipoprotein cholesterol (HDL-C) <0.9 mmol/l in men or <1.0 mmol/l in women(33).

The ACCU-CHEK® Glucometer was used to measure the fasting blood sugar level from a finger prick.

Calibration of all machines used in this study was done on daily basis.

2.9 Data Processing and Analysis

Data were entered, cleaned, and analyzed using EpiData version 3.1 and IBM Statistical Package for Social Sciences (SPSS) version 23. All numerical and categorical variables were analyzed using frequencies. Cross tabulations and Pearson’s Chi-square test were used to obtain the associations and strength of relationship between the independent and the dependent variables. Odds Ratios (OR) with 95% confidence intervals (CI) were reported. Relationship, association and difference between variables were considered statistically significant if $p < 0.05$. Pie and bar charts were used for pictorial presentation of the results.

2.10 Ethical Consideration

Ethical clearance was obtained from the Research and Publications Committee of Muhimbili University of Health and Allied Sciences.

Permission to conduct the study at DUCE was obtained from the responsible authority.

A written informed consent was obtained from each of the participant. Confidentiality was ensured/guaranteed to all participants of the study.

Participants identified with obesity,dyslipidemia, hypertension and diabetes mellitus were counseled by the researcher and then referred to the DUCE physician for further management.

CHAPTER THREE

4.0 RESULTS

Sociodemographic characteristics among study participants

A total of 275 students were enrolled to participate in the study. Out of the 275 students who participated, 177(64.4%) were male. The mean age (SD) was 24 ± 6 years, ranging between 19 and 45 years. Most of students, 238(86.5%), were aged between 20 to 30 years. Only 36(13.1%) students were married (Table 2).

Among all participants, 36(13.1%) had family history of diabetes mellitus, 63(22.9%) family history of hypertension, 16(5.8%) obesity and 14 (5.1%) family history of a stroke (Table 2).

Nine students (3%) were cigarette smokers and 40(15%) students reported alcohol use.

Students reported to perform physical activities at different levels, 105(38.2%) performed light intensity physical activities, 108 (39.3%) moderate intensity activities and 62 (22.5%) vigorous intensity physical activities (Table 2).

Table 2:Socio-demographic features and their association with obesity among Students (N = 275).

Characteristic	Total N (%)	High BF% n (%)	p-value	High BMI n (%)	p-value
Sex					
Male	177(64.4)	7 (4.0)	<0.001	21(11.9)	< 0.001
Female	98(35.6)	16 (16.3)		22(22.4)	
Age groups					
mean age (SD) 24 ± 6 years					
< 20 years	6(2.2)	0 (0)		0 (0)	
20 – 30 years	238(86.5)	5 (2.1)		19(8.0)	
31 – 40 years	17(6.2)	9 (52.9)	<0.001	12(70.6)	< 0.001
≥ 41 years	14(5.1)	9 (64.3)		12(85.7)	
Marital status					
Single	239(86.9)	6 (2.5)	< 0.001	20(8.4)	
Married	36(13.1)	17(47.2)		23(63.9)	< 0.001
Family History of					
Diabetes Mellitus	36(13.1)	10 (27.8)	<0.001	14(38.9)	< 0.001
Hypertension	63 (22.9)	12 (19.0)	< 0.001	21(33.3)	< 0.001
Obesity	16(5.8)	4 (25.0)	0.01	6(37.5)	0.013
Stroke	14(5.1)	4 (28.6)	0.01	7(50.0)	0.001
Cigarette Smoking	9(3.3)	1 (11.1)	0.762	3(33.3)	0.137
Alcohol Use	40(14.5)	14 (35)	< 0.001	21(52.5)	< 0.001
Physical activity					
Light intensity	105(38.2)	12 (11.4)		20(19.0)	
Moderate intensity	108(39.3)	9 (8.3)	0.181	17(15.7)	0.273
Vigorous intensity	62(22.5)	2 (3.2)		6(9.7)	

Prevalence of obesity and relationship between BMI and BF%

The prevalence of obesity among DUCE students was 8.4% (95% CI; 5.1–11.7) by BF% and 5.1% (95% CI; 2.5–8.0) by BMI criteria.

Based on BF%, 5(1.8%) students had low body fat, whereas 31 (11.3%) were underweight by BMI. Among students with low body fat, only 1(20.0%) student was underweight and remaining 4(80.0%) were normal by BMI criteria. Among 31(11.3%) students categorized as underweight by BMI, 1 (3.2%) student had low body fat and 30(96.8%) had normal body fat by BF%, $p<0.001$, (Table 3).

Students categorized as having normal body fat by BF% were 247(89.8%), most of them had normal BMI, (79.8%), however (12.1%) were categorized as underweight and (8.1%) were overweight by BMI. Likewise students with normal BMI were 201(73.1%) and when categorized by BF% criteria 4(2.0%) had low body fat and 197(98%) were correctly categorized as normal body fat, $p<0.001$, (Table 3).

Students categorized as having high body fat by BF% criteria were 23 (8.4%), all of them had correctly categorized as high BMI whereby 9(39.1%) were overweight and 14 (60.9%) were obese, $p<0.001$, (Table 3)

And finally based on BMI, 29(10.5%) students were overweight, but when categorized by BF% criteria 20 (69%) students had normal body fat and 9 (31%) had high body fat. Students categorized as obese by BMI were 14(5.1%) and all of them had high body fat by BF% criteria, $p<0.001$, (Table 3).

All in all, the BF% categorization seem to significantly correlate well with BMI on measuring obesity ($r = 0.658$, $p < 0.001$).

Table 3: Relationship between BF% and BMI on body fat composition among students

	BMI				
BF%	underweight	normal	Overweight [b]	Obese [b]	**Total**
Low fat, n (%)	1 (20)	4(80)	0	0	5 (1.8)
Normal fat n (%)	30 (12.1)	197 (79.8)	20 (8.1)	0	247 (89.8)
[a]High fat, n (%)	0	0	9 (39.1)	14 (60.9)	23 (8.4)
Total (% within BF%) n (%)	31 (11.3)	201 (73.1)	29 (10.5)	14 (5.1)	275 (100)

p < 0.001, [a] High fat = obese by BF%, [b] High BMI = Overweight and obese

Association of socio-demographic features with obesity among students

Based on BF%, females were significantly more obese than male students (16.3% versus 4%, $p < 0.001$). Proportion of students with obesity was higher (64.3%) among older age group of equal or above 41 years than the proportion of obesity (2.1%) among younger age group of 20-30 years. Obesity differed significantly between the age groups, $p < 0.001$, (Table 2).

Furthermore the prevalence of obesity by BF% criteria was significantly higher among students with family history of diabetes mellitus (27.8% versus 5.4%, $p<0.001$), hypertension (19.0% versus 5.2%, $p<0.001$), obesity (25% versus 7.3%, $p=0.01$) and stroke (28.6% versus 7.3%, $p=0.01$) compared to those without family history of diabetes mellitus, hypertension, obesity and stroke respectively. (Table 2)

Based on BMI criteria, high BMI was also significantly more prevalent among female compared to male students, 22.4% versus 11.9%, $p < 0.001$, (Table 2).

The proportion of students with high BMI was also higher among the older age group of equal or above 41 years compared to students with high BMI in the younger age group of 20 to 30 years, (85.7% versus 8%, $p < 0.001$), (Table 2).

The prevalence of high BMI was significantly higher among students reported to use alcohol compared to non alcohol use students, (52.5% versus 9.4%, $p < 0.001$), (Table 2).

The prevalence of high body fat and high BMI was not significantly different among students who smoked cigarettes or with any levels of physical exercise, whether light, moderate or vigorous intensity physical activities (11.4%, 8.3% and 3.2% respectively by BF% p = 0.181 and 19.0%, 15.7% and 9.7% respectively by BMI, p = 0.273), (Table 2).

Association of obesity with dyslipidemia, hypertension, and diabetes mellitus

The overall prevalence of dyslipidemia among DUCE students was 27.3% (95% CI; 22.5–32.4), with 65(23.6%) having one type of dyslipidemia, 9(3.3%) two types and 1(0.4%) had three types of dyslipidemia.

Within the study population, prevalence of high serum TC was 12% (95% CI; 8.4–16.40), high serum triglyceride was 11.3% (95%CI; 7.6–14.9), low serum HDL-C was 7.3% (95%CI; 4.4–10.2) and high serum LDL-C was 0.7% (95%CI; 0.0–1.8). All the mean values of total serum cholesterol, serum triglycerides, HDL-C and LDL-C were within the normal reference ranges (Table 4)

Table 4: Prevalence of dyslipidemia among students (N= 275).

	Frequency, n	**Percentage, %**	**95%CI**
Any type of dyslipidemia	75	27.3	22.5 – 32.4
Elevated total serum Cholesterol	33	12	8.4 – 16.4
Mean (SD) 3.8±1.1 mmol/L			
Elevated serum Triglycerides	31	11.3	7.6–14.9
Mean (SD) 1.05±0.7 mmol/L			
Elevated serum HDL- Cholesterol	20	7.3	4.4–10.2
Mean (SD) 1.6±0.6 mmol/L			
Elevated serum LDL- Cholesterol	2	0.7	0.0 – 1.8
Mean (SD) 1.7±0.6 mmol/L			

***Normal values were: TC**< 5.2mmol/L; **TG** < 1.7mmol/L; **HDL-C**> 0.9 mmol/L in men; >1.0 mmol/L in women, and **LDL- Cholesterol**< 3.5 mmol/L*

The prevalence of dyslipidemia was not significantly different among obese and non obese students, 39.1% versus 26.2% (p = 0.182) by BF% and 37.2% versus 25.4%, (p = 0.111) by BMI criteria (Table 5).

The prevalence of hypertension among DUCE students was 11.6% (95% CI: 7.6–15.6).

Hypertension was significantly more prevalent among students with high body fat than those with normal or low body fat by BF% criteria (30.4% versus 9.9%, p=0.003), also was significantly higher among students with high BMI than among students with normal or low BMI, 27.9% versus 8.6%, p<0.00.1, (Table 5).

Prevalence of diabetes mellitus among students was 2.9% (95% CI; 1.1 – 5.1) and impaired fasting blood glucose was 15.6% (95% CI 11.3 – 19.6).

Diabetes mellitus was significantly more prevalent among students with high body fat compared to those with normal or low body fat by BF% criteria, 17.4% versus 1.6%, p<0.001. Also, the prevalence of diabetes mellitus was higher among students with above normal BMI than among students with normal and below normal BMI, 9.3% versus 1.7%, p=0.007, (Table 5).

Table 5: Association of obesity with dyslipidemia, hypertension, and diabetes mellitus among students(N = 275)

	Dyslipidemia		**Hypertension**		**Diabetes Mellitus**	
	n (%)	p-value	n (%)	p-value	n (%)	p-value
BF%:						
High body fat **(N = 23)**	9(39.1)		7(30.4)		4(17.4)	
Normal or below **(N =252)**	66(26.2)	0.182	25(9.9)	0.003	4(1.6)	<0.001
BMI:						
High BMI **(N = 43)**	16(37.2)		12(27.9)		4(9.3)	
Normal or below **(N = 232)**	59(25.4)	0.111	20(8.6)	<0.001	4(1.7)	0.007

In logistic regression analysis, students with high body fat, by BF% criteria, had 3.9 times greater odds of being hypertensive and 13 times greater odds of being diabetic than students with normal or low body fat. There was no significant association between high body fat and having dyslipidemia. Conversely, students with high BMI had 6.4 times greater odds of having dyslipidemia than students with normal or below normal BMI. There was no significant association between high BMI and having hypertension and diabetes mellitus (Table 6).

Table 6: Logistic regression showing prediction of Obesity to dyslipidemia, hypertension and diabetes mellitus among DUCE students (N=275)

	Dyslipidemia		**Hypertension**		**Diabetes**	
	n (%)	OR (95%CI)	n (%)	OR (95%CI)	n (%)	OR(95%CI)
BF% above normal						
Yes	9(39.1)	1.81(0.75 – 4.4)	7(30.4)	**3.9(1.5 – 10.6)**	4 (17.4)	**13(3.0 – 56.3)**
No	66(26.2)	1	25(9.9)	1	4 (1.6)	1
BMI above normal						
Yes	16(37.2)	**6.4(4.2 – 9.6)**	12(27.9)	1.7(0.8 – 3.4)	4 (9.3)	1 (0.2 – 3.9)
No	59(25.4)	1	20(8.6)	1	4 (1.7)	1

CHAPTER FOUR

4.0 DISCUSSION

The current study demonstrated the high prevalence of obesity and dyslipidemia among relatively young adults at DUCE.Therewas a comparable prevalence of obesity when using two different methods to measure obesity, i.e. 8.4% by BF% and 5.1% by BMI.

The BF% correlated significantly with BMI on measuring obesity among students ($r=0.658$, $p<0.001$). Several studies had revealed similar results.For instance a study done in Japan among participants aged 25 to 59 years revealed significant correlation of obesity prevalene measured by BMI and that measured by BF% by BIA method, ($r=0.755$–0.810), (68). Another study done in Nigeria among 18 years and above subjects also revealed more or less comparable prevalence of obesity of 18.5% by BF% and 17.3% by BMI criteria, with a strong and significant correlation between BF% and BMI, ($r = 0.81$, $p<0.01$) (27).

The correlation between BMI and BF% varies according to the body content of lean and fat mass in that a given BMI may not correspond to the degree of body fat composition among the different population(41). The current study revealed slight variation of body fat composition among students categorized as normal body fat by BF% and normal BMI, (89.8% versus 73.1%). Only 8.1% of students with normal BF% were overweight by BMI criteria. All students with high body fat by BF% were found to have high BMI. This signifies a strong correlation between BF% and BMI on measuring obesity. However several previous studies comparing BMI with other techniques known to accurately measure body fat composition revealed that the standard BMI cut off point for obesity may not reflect true extent of body adiposity(65,66,67).

Another key finding from the present study is the significant gender association with obesity. Female were obese than male students demonstrated by both methods, whereby prevalence of obesity by BF% among females was 16.3% against 4.0% in males. Based on BMI criteria, the prevalence of obesity was 22.4% and 11.9% among female and male respectively. This finding of significant gender association with obesity is similar to other previous studies. The prevalence of obesity by BMI among general population in Tanzania have been reported to be higher among females than males, 9.5% versus 2.5%, (72). The same finding were also reported among adolescents in Dar es Salaam, 7.5% versus 0.7% (18), among young adults in Uganda reported 2.9% versus 1.8%(73), and in Australia 29.5% versus 24.7% by BF% and 28.2% versus 19.7% by BMI (74).

The difference or similarities of obesity prevalence among these studies can be explained by differences in population characteristics and different methods used to diagnose obesity. The sex differences in obesity is partly due to a relative sedentary life style among female compared to male students who reported to be engaged more in moderate to vigorous physical activities.

Other speculated explanation of sex differences in obesity could bethe consequence of the sex-specific hormones, oestrogen and progesterone in female and androgens in male (75). Oestogen hormone promotes subcutaneous fat accumulation (76).

Body fat fluctuates with the differences between energy intake and energy expenditure over time. As expected, low levels of physical activity are a major predictor of fat mass accumulation during overfeeding in humans, pointing to a substantial role of spontaneous physical activity in the control of energy balance (77). Prevalence of obesity was higher among students who reported low level of physical activity, but this was not statistically significant. Speculated explanation for this observation is that the crude and possibly subjective method used for assessing and quantifying the level of physical activities could have been affected by recall bias.

Obesity, especially visceral obesity, causes insulin resistance and is associated with dyslipidemia, hypertension and impaired glucose metabolism all of which exacerbate atherosclerosis (4). The current study revealed that high body fat by BF% was significantly associated with presence of hypertension and diabetes mellitus whereas high BMI was significantly associated with the occurrence of dyslipidemia.

The prevalence of dyslipidemia among DUCE students was high, 27.3%, and high BMI was significantly associated with occurrence of dyslipidemia among students. The hallmark of dyslipidemia in obesity was elevated fasting triglycerides, a major cause of other lipid abnormalities such as elevated LDL-C and low levels of HDL-C due to delayed clearance of the TG-rich lipoproteins and formation of small dense LDL (78). The current study revealed higher prevalence of hypercholesterolemia (12%) andhypertriglyceridemia (11.3%) among DUCE students, although less than reported prevalence of hypertriglyceridemia (84%), among adults in Temeke, Dar es Salaam (79). The difference could be explained by demographic differences between the two studies.

Prevalence of hypertension among students was 11.6%, being higher among obese than non obese students, 30.4% versus 9.9% by BF% and 27.9% versus 8.6% by BMI criteria. Previous studies have reported similar association between obesity and hypertension. In Dar es Salaam, the prevalence of either systolic hypertension alone, diastolic alone or combined hypertension was found to be significantly higher among obese adolescents (39.1%, 13% and 13% respectively) compared to adolescents with normal BMI, (17.5%, 5,5% and 4.0% respectively) (18).

In the present study the prevalence of diabetes mellitus was 2.9% and impaired fasting glucose was 15.6%. The prevalence of diabetes mellitus was slightly lower than that reported among general population in Tanzania of 4.3%, (72). This difference can be explained by the different sociodemographic characteristics of study population. Obesity increases the risk of diabetes; this is in keeping with our results in which the prevalence of diabetes was higher among obese students, 17.4% among obese by BF% and 9.3% by BMI, compared to non obese students by BF% and BMI, 1.6% and 1.7% respectively.

In the current study, high BMI was associated with the occurrence of dyslipidemia, whereas high BF% was associated with diabetes and hypertension and not dyslipidemia. Several other studies also indicates that BMI is a predictor of hypertension and dyslipidemia than BF% (60,69) .The study done among Singaporean Chinese population revealed BF% by BIA was not a useful predictor of lipid profile and insulin resistance(81).

The limitations of BF% by BIA as a predictor of cardiovascular diseases have been speculated to be due to the different contribution of subcutaneous and visceral adipose tissue to metabolic dysregulation. It is reported that BIA does not discriminate between subcutaneous and visceral adipose tissue contribution to the body fat composition (82). In comparing several methods for assessing visceral fat with CT scan, it was found that BIA correlates only with subcutaneous and not visceral fat (83). Further more in some cross-sectional studies, peripheral fat showed low contribution to health risks or even a protective effect (71,72, 73).

4.1 Study Limitations

Most of participants in this study were younger active students, aged between 20 – 30 years; hence the results might not be a true representative of the general population.

The subjective method used for assessing and quantifying the level of physical activity among students could have been affected by recall bias.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study demonstrated high prevalence of obesity and its cardiometabolic complications.There was a positive correlation between BF% and BMI on measuring obesity which implied that an increase in BMI corresponded also with an increase in BF%.
Even though both BF% and BMI were somehow comparable in obesity determination, they were different in predicting the associated cardiovascular risk factors in this relatively population of young adults. High BF% was associated with occurrence of hypertension and diabetes mellitus, while high BMI was significantly associated with occurrence of dyslipidemia.

5.2 Recommendation

In this population of relatively youg adults the use of BF% by BIA method as a measure of obesity were comparable however the prediction of cardiometabolic complications differed.
There is a need of more diverse population studies to describe more the variability of the BMI and BF% in obesity assessment.

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APPENDICES

Appendix 1: Questionnaire (English Version)

S/N………....

A. SOCIODEMOGRAPHIC CHARACTERISTICS:

Name of the respondent……..……………Age:…… Phone number…………

1. Participants cadre:
    1. 1st year student
    2. 2nd year student
    3. 3rd year student
    4. Post graduate student
2. Students course of study
    1. Bachelor of Education in Arts
    2. Bachelor of Education in Science
    3. Bachelor of Science with Education
    4. Bachelor of Arts with Education
3. Age…………………………
    1. < 20 years
    2. 20-30 years
    3. 31- 40 years
    4. ≥ 41 years
4. Gender
    1. Male
    2. Female
5. Marital Status
    1. Single
    2. Married
    3. Cohabiting
    4. Divorced
    5. Widow/widower

B. RISK FACTORS:

6. Do you have family history of anyof the following diseases?
    1. Diabetes Mellitus
    2. Hypertension
    3. Obesity
    4. Stroke
    5. Others (specify)………………………………………………..
7. Have you ever been diagnosed with any of the following diseases?
    1. Diabetes Mellitus
    2. Hypertension
    3. Dyslipidemia
    4. Others (specify)………………………………………………..
8. Cigarette smoking
    1. Never smoked
    2. Stopped smoking
    3. Current smoker
9. Alcohol use
    1. Never
    2. Stopped
    3. Current alcohol use

C. PHYSICAL ACTIVITIES ASSESSMENT:

In the past one month assess what kind of activities you have been involved and indicate your level of physical activity

Physical activity	Put √	Frequency per week	Hours spent		MET
			Per day	Per week	
LIGHT INTENSITY ACTIVITIES:					**< 3**
Sleeping					0.9
Watching television					1.0
Writing, desk work, typing					1.8
Walking, 1.7mph (2.7km/h) level ground, strolling, very slowly					2.3
Walking, 2.5mph (km/h)					2.9
MODERATE INTENSITY ACTIVITIES:					**3 to 6**
Bicycling, stationary, 50watts, very light effort					3.0
Walking 3.0mph (4.8km/h)					3.3
Home exercise, light or moderate effort, general					3.5
Walking 3.4 mph (5.5km/h)					3.6
Bicycling, < 10mph (16km/h), leisure, to work or for pleasure					4.0
Bicycling, stationary, 100watts, light effort					5.5
VIGOROUS INTENSITY ACTIVITIES:					**> 6**
Jogging, general					7.0
Push-ups, sit-ups, pill-ups, jumping jacks					8.0
Running jogging, in place					8.0
Rope jumping, football, Volleyball					10

Source: https://blog.dacadoo.com/blog/2013/03/22/whats-a-met/*(International Physical Activity Questionnaire)*

10. What kind of physical activities you have been involved in the past one month?
    1. Light intensity physical activities
    2. Moderate intensity physical activities
    3. Vigorous intensity physical activities

D. MEASUREMENTS:

11. Height……………………….meters
12. Weight……………………….Kg
13. BMI…………………………Kg/m^2
14. Body Fat Percentage………..%
15. BP: **SBP** **DBP**

	SBP	DBP
1st reading	…….	……..mmHg
2nd reading	…….	……..mmHg
Average BP	…….	……..mmHg

E. BIOCHEMISTRY

16. Fasting blood glucose…………………..mmol/L
17. Serum triglyceride……………………...mmol/L
18. Serum HDL………………..………..mmol/L
19. Serum LDL……………………….….mmol/L
20. Serum Cholesterol-total (TC)………….mmol/L

Appendix 2: Questionnaire (Swahili version)

SEHEMU A: TAARIFA YA KIJAMII **Namba……......**

Jina la mshiriki………………………………. Namba ya simu…………….

1. Kada ya mshiriki:
    1. Mwanafunzi mwaka wa kwanza
    2. Mwanafunzi mwaka wa pili
    3. Mwanafunzi mwaka wa tatu
    4. Mwanafunzi wa Stashahada
2. Kozi ya mwanafunzi :
    1. Shahada ya Elimu katika Sanaa
    2. Shahada ya Elimu katika Sayansi
    3. Shahada ya Sayansi na Elimu
    4. Shahada ya Sanaa na Elimu
3. Umri…………………………
    1. Chini ya miaka 20
    2. Kati ya miaka 20-29
    3. Kati ya miaka 30-39
    4. Kati ya miaka 40 – 49
    5. Zaidi ya miaka 50
4. Jinsia
    1. Kiume
    2. Kike
5. Hali ya ndoa
    1. Sijaoa/sijaolewa
    2. nimeoa/nimeolewa
    3. Ninaishi na mwanamke/mwanaume
    4. Tumetalikiana
    5. Mgane/mjane

SEHEMU B: HISTORIA YA KIAFYA

6. Je katika familia yenu kuna historia ya ugonjwa wowote kati ya haya yafuatayo?
    1. Kisukari
    2. Shinikizo la damu
    3. Kunona/kitambi
    4. Kiharusi
    5. Mengineyo (taja)……………………………………………..
7. Je ulishawahi kuambiwa kuwa na magonjwa yafuatayo?
    1. Kisukari
    2. Shinikizo la damu
    3. Mafuta mengi mwilini
    4. Mengineyo (taja)……………………………………………..
8. Je unavuta sigara?
    1. Sijawahi kuvuta
    2. Nimeacha kuvuta
    3. Ninavuta mpaka sasa
9. Je unakunywa pombe?
    1. Sijawahi kunywa
    2. Nimeacha kunywa
    3. Ninakunywa hadi sasa

SEHEMU C: UPIMAJI WA KIWANGO CHA MAZOEZI

Aina ya shughuli ulizozifanya kwa kipindi cha mwezi mmoja uliopita kuonyesha kiwango mazoezi ya mwili kama sehemu ya afya yako

Aina ya Mazoezi ya mwili	**MET**	**Weka √**
kiwango cha chini:	**< 3**	
Kulala	0.9	
Kuangalia televisheni	1.0	
Kuandika, kuchapa au kazi nyinginezo za mezani	1.8	
Kutemebea kwa kasi ya wastani wa umbali wa maili 1.7 kwa saa sehemu iliyo tambarare na taratibu	2.3	
Kutembea kwa kasi ya wastani wa umbali wa maili 2.5 kwa saa	2.9	
kiwango cha kati:	**3 to 6**	
Kuendesha baisikeli ya mazoezi nyumbani kwa muda mfupi	3.0	
Kutembea kwa kasi ya wastani wa umbali wa maili 3 kwa saa	3.3	
Kufanya mazoezi ya wastani nyumbani	3.5	
Kutembea kwa kasi ya wastani wa umbali wa maili 3.4 kwa saa	3.6	
kuendesha baiskeli kwenda kazini/kutembea	4.0	
Kufanya mazoezi ya kuendesha baiskeli nyumbani	5.5	
Kiwango cha juu:	**> 6**	
Mazoezi ya kukimbia ukiwa maeneo ya nyumbani	7.0	
Mazoezi ya nguvu kama kukimbia umbali mrefu	8.0	
Mazoezi ya kuruka kamba	10	

Source: https://blog.dacadoo.com/blog/2013/03/22/whats-a-met/*(International Physical Activity Questionnaire)*

10. Ni kwa kiwango gani umefanya mazoezi ya mwili kipindi cha mwezi mmoja uliopita?
    1. Kiwango cha chini
    2. Kiwango cha kati
    3. Kiwango cha juu

SEHEMU D: UCHUNGUZI NA UPIMAJI WA MWILI

11. Urefu……………………………….mita
12. Uzito………………………………..Kg
13. Uwiano wa uzito na urefu………….Kg/m^2
14. Asilimia ya mafuta mwilini………..%
15. Kiwango cha Shinikizo la damu: **SBP** **DBP**
    a. Kipimo cha awali ……. ……..mmHg
    b. Kipimo cha marudio ……. ……..mmHg
    c. Wastani ……. ……..mmHg

SEHEMU E: VIPIMO VYA MAABARA

16. Kiwango cha sukari kwenye damu………………………………mmol/L
17. Kiwango cha mafuta aina ya triglyceride kwenye damu……….. mmol/L
18. Kiwango cha mafuta aina ya HDL kwenye damu …………….. mmol/L
19. Kiwango cha mafuta aina ya LDL kwenye damu ……………… mmol/L
20. Kiwango cha mafuta kwenye damu Cholesterol (TC)………….. mmol/L

Appendix 3: Informed Consent Form (English Version)

Greetings, I am Dr Johannes Ngemera, a postgraduate resident in the department of Internal Medicine at MUHAS, conducting a study on **"body fat composition and dyslipidemia among adults at the Dar es Salaam University College of Education"**as a part of my Masters degree.

What is the aim of this research?

The study is aiming at examining whether the use of body fat composition to define obesity is more effective in detecting individuals at greater risk for dyslipidemia.

What participation involves: Should you agree to participate in this study; an interview on social demographic and clinical history regarding your health using questionnaire and also some clinical measurements will be taken.

Confidentiality: All information collected on questionnaires will be entered into a computer with special identification number. The questionnaires will be handled with greater secrecy in order to maintain your confidentiality.

Risk: we expect no harm to happen to you during the course of this study.

Right to withdraw and alternatives Participating in this study is completely a voluntary choice and refusal to participate or withdrawal will not involve penalty or loss of any benefits to which you are entitled.

Benefits: Participating in this study allows you to know your health status with respect to body fat composition and dyslipidemia.

Whom to contact:

If you have any question about this study you may contact Dr. Johannes Ngemera, mobile number 0713214950; or the Supervisor Prof. Lutale, mobile number 0754292485.

If you have questions about your rights as a participant you may contact The Chairman of MUHAS Research and Publications Committee. P.O.BOX 65001 Dar es Salaam. Tel 2150302-6

Participant's Signature:

I ……………………………………….....have read and understood the content of this form. My questions have been answered and I voluntarily **agreed / disagree** to participate in this study.

Signature of participant………………………. Signature of witness……............……
Date of signed consent……………………….

Appendix 4: Informed Consent Form (Swahili version)

Fomu Ya Ridhaa Kushiriki Kwenye Utafiti

Salaaam. Mimi ni Dk. Johannes Ngemera, mwanafunzi wa udhamili Chuo Kikuu cha Sayansi za Afya Muhimbili. Nafanya utafiti kuhusu **Magonjwa yatokanayo na ongezeko la mafuta mwilini kwa wanafunzi wa Chuo kikuu kishiriki cha elimu Dar es salaam**

Lengo la utafiti

Ni kuangalia njia sahihi zaidi ya kubaini walio katika hatari zaidi ya kupata magonjwa yatokanayo na ongezeko la mafuta mwilini

Je, ushiriki wangu ni nini?

Kushiriki kwako ni pamoja na kujibu maswali ya dodoso utakayoulizwa na pia kufanya upimaji wa uzito, urefu, shinikizo la damu na kiwango cha mafuta mwilini kwa kutumia mashine maalum. Pia utachukuliwa damu kwa ajili ya kupima kiwango cha sukari na mafuta.

Madhara/usiri

Hakuna madhara yoyote yanayotegemewa kutokana na utafiti huu.Taarifa za ugonjwa wako

zitatunzwa kwa kutumia herufi maalum ili kuwa na usiri.

Uhuru wa kushiriki

Kushiriki kwenye utafiti ni hiari yako. Unaweza kujitoa wakati wowote. Kama utaamua kutoshiriki, utaendelea kupata huduma zako kama kawaida hapa chuoni bila bugudha yoyote ile.

Faida ya ushiriki

Ukishiriki kwenye utafiti huu , utachunguzwa kama una kiashiriria chochote cha magonjwa yatokanayo na mafuta mengi mwilini na kupata ushauri.

Kwa taarifa zaidi:

Ukiwa na maswali yeyote kuhusu utafiti huu tafadhali wasiliana na Dk. Johannes Ngemera, kwa simu ya mkononi 0713214950, au Msimamizi wangu Prof. Janet Lutale simu ya mkononi 0754292485

Ukiwa na swali lolote kuhusu haki zako kama mshiriki wa utafiti huu tafadhali wasiliana na Mwenyekiti wa Kamati ya Utafiti na Uchapishaji, Chuo Kikuu cha Tiba na Sayansi za Afya Muhimbili, S.L.P. 65001, Dar-es-Salaam. Simu ya ofisini: 022 2152489.

Idhini ya ushiriki:

Mimi …………………………………………………nimeelezwa/nimesoma na kuyaelewa maelezo yote yanayohusiana na utafiti huu. Maswali yangu yamejibiwa. Kwa hiari yangu, bila kushurutishwa nimekubali/sikubali kushiriki kwenye utafti huu.

Sahihi ya mshiriki.. Tarehe…………………….

Sahihi ya mtafiti.. Tarehe………………...……