THE RELATIONSHIPS BETWEEN BODY MASS INDEX, TRUNCAL OBESITY INDICES WITH ESSENTIAL HYPERTENSION AND TYPE 2 DIABETES MELLITUS AMONG HAUSA ETHNIC GROUP, KANO, NIGERIA

BY

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DECLARATION

I hereby declare that that this work is the product of my research efforts undertaken under the supervision of Dr. M. S. SALEH and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that this research work and the subsequent write up of

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APPROVAL

This research work titled **"Relationships between Body Mass Index, Truncal Obesity Indices with Essential Hypertension and Type 2 Diabetes Mellitus among Hausa Ethnic Group, Kano, Nigeria"** has been examined and approved for the award of Masters Degree in Anatomy.

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ABSTRACT

The body mass index (BMI) is the anthropometric measurement most widely used by clinicians to estimate total body fat collection (generalized obesity) and thus risk estimation for metabolic and cardiovascular diseases such as essential hypertension and type 2 diabetes mellitus. Localized collection of excess fat around the abdomen and hip regions (Truncal obesity) measured by waist circumference (WC) and waist to hip ratio (WHR) have been shown to be strongly associated with essential hypertension and type 2 diabetes mellitus independent of total body fat measured by BMI in some populations. Even though some attempts have been made at estimating body fat content and risk of hypertension and diabetes using anthropometric studies in Nigeria, most attempts focused on using the BMI with little attempts on using Truncal obesity indices (WC and WHR). Also comparing the index of generalized obesity (BMI) with the indices of Truncal obesity (WC and WHR) with regards to their strength of association with hypertension and diabetes received less attention in the literature. In this case study of Murtala Muhammad Specialist hospital, Kano, 405 established cases of hypertension and/or diabetes mellitus were selected by systematic sampling method and studied. Generalized obesity was defined as BMI > 29.9 kg/m^2, Truncal obesity was defined for males as WC > 102cm or WHR > 1.0. Truncal obesity for females was defined as WC > 88cm and WHR > 0.85. The prevalence of the two forms of obesity and their strength of association with diseases were obtained. Values were compared between the hypertensive, diabetic and hypertensive- diabetic subgroups and among males and females. Conclusively WHR was the anthropometric index with the strongest association with essential hypertension and type 2 diabetes mellitus. Obesity was more common in the female subjects using all indices. BMI correlated strongly with WC but weakly with WHR.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The use of body mass index as an anthropometric indicator of generalized adiposity and in the prediction of essential hypertension and type 2 diabetes mellitus has been widely explored within the domain of physical anthropolology (WHO, 2000). The body mass index is one of the commonly used indicators of body fat composition and has been applied into public health and clinical practice (Keys *et al.,* 1972). The index is obtained by dividing a person's weight by the square of the height expressed in kg/m^2 (WHO, 2002). The clinical significance of BMI measurement is to classify adult individuals as underweight (<18.5kg/m^2), normal weight (18.5kg/m^2-24.9kg/m^2), overweight (25kg/m^2–29.9kg/m^2), obese (30kg/m^2-34.9kg/m2), severely obese (35kg/m^2-39.9kg/m^2), and morbidly obese (>40kg/m^2) (ASSO, 1995). In children and adolescents a healthy weight however varies with age and sex and is defined not as an absolute number but in relation to a historical normal group such that obesity is a BMI greater than 95^{th} percentile (Reilly, 2010). Blacks are known to have lower body fat for the same BMI than Caucasians. This has implications on the interrelationship between obesity and the other components of the metabolic syndrome (Deurenberg *et al.,* 1998). When the literature was reviewed, it was found that there is extensive literature on body fat composition using BMI which did not consider localized fat distribution and didn't put into account other possible causes of weight gain such as muscle hypertrophy in athletes, consequently an individual with a high BMI from large muscle mass rather than fat may be wrongly defined as obese using BMI (Gallagher *et al.,* 2000). For thousands of years obesity was rarely seen (Anon, 2005). It was not until the 20th century that it became common, so much so that in 1997, the World Health Organization (WHO) formally recognized obesity as a global epidemic (Caballero, 2007).

Table 1.1: Reference value of BMI among the Asian and European population (Tullocch *et al.,* 2003)

Category	Body mass index [c.b.]
Underweight	≤18.5
Normal weight	18.5-24.9
Overweight	25-29.9
Obesity class I	30-34.9
Obesity class II	≥35

Table 1.2: Reference value of truncal obesity indices among the Asian and European population (Tullocch *et al.,* 2003)

*Central obesity by abdominal circumference**	
Population	Cutoff
Euroamerican men	≥102 cm (40″)
Euroamerican women	≥88 cm (35″)
Asian men	≥90 cm (35″)
Asian women	≥80 cm (32″)
Central obesity by waist-to-hip ratio	
Men	>0.9
Women	>0.85

Although the BMI otherwise known as the Quetelet index (Gallagher *et al.,* 2000) is reliable in estimating the fat content of the body in > 90% of cases, in some individuals such as mesomorphic (muscular) persons in whom much of the body weight is constituted by muscles and in some races such as Asians who have disproportionately higher fat content even at normal BMI, the Quetlet index may not be reliable (Gallagher *et al.,* 2000). In such cases the fat content is estimated using the Duerenberg equation

(Tan *et al.,* 2004): Body fat percentage = 1.2(BMI) + 0.23(age) - 10.8(sex) - 5.4 with age being in years and sex being designated as 1 for males and 0 for females. This equation has a standard error of 4% and accounts for approximately 80% of the variation in body fat between individuals for whom the BMI is appropriate for estimating fat content and those for whom it is inappropriate. For men, a percentage of body fat greater than 25% defines obesity, with 21-25% being border line. For women, over 33% defines obesity, with 31-33% being border line (Tan *et al.,* 2004). Other indices used to estimate the degree and distribution of obesity include the 4 standard skin thicknesses (ie, subscapular, triceps, biceps, supra-iliac) and various anthropometric measures, of which waist and hip circumferences are the most important. Skin fold measurements are the least accurate means by which to assess obesity (Flegal *et al.,* 2012)

1. 2 SIGNIFICANCE OF THE STUDY

1. The study may add value to risk identification strategies employed by health managers in marking prototypes susceptible to essential hypertension and type 2 diabetes mellitus.

2. The result of the study may be helpful to clinicians and health educators in identifying people at risk of diabetes and hypertension.

3. The findings may serve as a basis for formulation of recommendations for achieving the health related millennium development goals (MDG)

1.3 STATEMENT OF RESEARCH PROBLEM

The study of cardiovascular risk estimation by measuring body fat composition in developing countries such as Nigeria had focused mainly on using weight and BMI and not so much on truncal obesity indices such as waist circumference, hip circumference, and waist-hip ratio which have also been proven to be useful cardiovascular risk predictors in many populations (Abidoye *et al.*, 2003).

Therefore there is limited data on the indices of truncal obesity, compared with BMI as they relate to hypertension and diabetes mellitus in our environment. Establishment of a correlation between truncal obesity indices and BMI and quantifying the relationship of each with essential hypertension and type 2 diabetes mellitus received less attention in the literature with very little of such attempt among the Nigerian population (Bakari and Onyemelukwe, 2005). This study is therefore designed to determine the relationships of the indices of Truncal obesity (WC and WHR) and the index of generalized obesity (BMI) with essential hypertension and type 2 diabetes mellitus among Hausa ethnic group of Kano metropolis.

1.4 JUSTIFICATION FOR THE STUDY

A study such as this, which critically estimates and compares the strength of relationship of generalized obesity and truncal obesity, with essential hypertension and type 2 diabetes mellitus is crucial in determining the type of obesity that is more relevant to our own population in terms of predicting the occurrence of these diseases which account for more than 25 percent of cardiovascular deaths in our environment (WHO, 1999). The study is therefore justified by;

1. The paucity of data for Kano metropolis on the indices of truncal obesity as risk factors for hypertension and diabetes.

2. The need to compliment with existing data established in some populations on hypertension and diabetes in relation to truncal obesity.

3. The need to establish a baseline data for Kano metropolis on the relationship between truncal obesity, generalized obesity, essential hypertension and type 2 diabetes mellitus in order to identify the risk significance of each obesity index for these diseases.

4. The need to compare and contrast the theory of relationships between BMI, truncal obesity indices with hypertension and diabetes with the practical situation of Kano metropolis.

1.5 AIM OF THE STUDY

To determine the relationships between the indices of truncal obesity (WC and WHR) and BMI with essential hypertension and type 2 diabetes mellitus in Kano metropolitan population.

1.5.1 **Objectives of the Study**

1. To determine the prevalence of generalized obesity using BMI (by measuring body weight and height) in hypertensive, diabetic and hypertensive- diabetic subjects who fulfill the inclusion criteria for the study in Kano metropolis

2. To determine the prevalence of truncal obesity (by measuring waist circumference, hip circumference and waist-hip ratio) in hypertensive and diabetic subjects recruited for the study.
3. To determine the pattern of obesity in male and female hypertensive and/or diabetic subjects who satisfy the requirement for the study.
4. To find the relationship between the indeces of generalized obesity (BMI), truncal obesity (WC and WHR) with essential hypertension and type 2 diabetes mellitus.
5. To find the correlation between truncal obesity indices and the BMI of hypertensive and or diabetic patients recruited for the study.
6. To make appropriate recommendation for risk identification in hypertension and diabetes.

1.6 TERMINOLOGIES USED IN THE STUDY

1. Adiposity -body fat content (Tan *et al.*, 2004)
2. Generalized obesity- excess fat which is distributed throughout the body. (Gallagher *et al.*, 2000)
3. Truncal obesity- excess fat which is localized to the abdominal and hip regions - (Chee-Eng, 2004)
4. Diabetes - metabolic disorder characterized by persistently elevated blood sugar (Kumar, 2005).
5. Fasting blood sugar- value of blood sugar obtained 6 to 8 hours after meal (Colledge *et al.*, 2003).

6. Random blood sugar- value of blood sugar obtained at any time regardless of meal in a non fasting person (Smyth, 2006).
7. Diastolic blood pressure – component of blood pressure measurement reflecting the pressure in the blood vessels (Parati *et al.,* 1998).
8. Systolic blood pressure- component of blood pressure measurement reflecting the pressure in the heart (Parati *et al.,* 1998).
9. Body weight- heaviness of the body showing the degree to which a body is drawn towards the earth by gravity (Donald, 2007)
10. Body height- vertical distance between the standing surface and the vertex of the head while the subject is standing erect (Price *et al.,* 2006).
11. Waist circumference- value of the measurement of the waist dimension (Lean *et al.*, 1995).
12. Hip circumference - value of the measurement of the hip dimension (Lean *et al.,* 1995).
13. Waist to hip ratio- a fraction obtained by dividing waist circumference by the hip circumference (Lean *et al.,* 1995).
14. Body mass index- a measurement obtained by dividing a person's weight by the square of the height expressed in kg/m^2 (WHO, 1995).

CHAPTER TWO

LITERATURE REVIEW

2.1 GENERAL OVERVIEW OF OBESITY, HYPERTENSION AND DIABETES

Obesity was once considered a problem only of high-income countries, but its current prevalence has rapidly spread to involve the developing countries especially the urban settlements (WHO, 2000). Traditionally in Nigeria and in many Africa communities obesity is regarded as a sign of affluence but scientifically it is described as a silent killer because it is similarly a strong risk factor for cardiovascular deaths as seen in other populations (Onwubere *et al.,* 2005). The modalities for treatment of obesity involve life style modification (Healthy diets, physical activities, and behavioral modification), specific pharmacologic therapies, and a surgical intervention called bariatric surgery which is reserved for severely and morbidly obese persons (Farmer *et al*., 2009).

2.2 PROBLEMS ASSOCIATED WITH OBESITY

The adverse effect of obesity is beyond the cardiovascular problems but has other grave co- morbidities associated with it as shown below (Wijga *et al.*, 2010);

- Respiratory - Obstructive sleep apnea, greater predisposition to respiratory infections, increased incidence of bronchial asthma, and Pickwickian syndrome (obesity hypoventilation syndrome).
- Malignant - Association with endometrial, prostate, colon, breast, gall bladder, and possibly lung cancer.
- Psychological - Social stigmatization and depression

- Cardiovascular - Coronary artery disease, essential hypertension, left ventricular hypertrophy, cor pulmonale, obesity-associated cardiomyopathy, accelerated atherosclerosis, and pulmonary hypertension of obesity.

- Central nervous system (CNS) - Stroke, idiopathic intracranial hypertension, and meralgia paresthetica.

- Obstetric and perinatal - Pregnancy-related hypertension, fetal macrosomia, and pelvic dystocia.

- Surgical - Increased surgical risk and postoperative complications, including wound infection, postoperative pneumonia, deep venous thrombosis, and pulmonary embolism.
- Pelvic - Stress incontinence.
- Gastrointestinal (GI) - Gall bladder disease (cholecystitis, cholelithiasis), nonalcoholic steatohepatitis (NASH), fatty liver infiltration, and reflux esophagitis.
- Orthopedic - Osteoarthritis, coxa vera, slipped capital femoral epiphyses, Blount disease and Legg-Calvé-Perthes disease, and chronic lumbago.
- Metabolic - Type 2 diabetes mellitus, prediabetes, metabolic syndrome, and dyslipidemia.
- Reproductive (in women) - Anovulation, early puberty, infertility, hyperandrogenism, and polycystic ovaries.
- Reproductive (in men) - Hypogonadotropic hypogonadism.

- Cutaneous - Intertrigo (bacterial and/or fungal), acanthosis nigricans, hirsutism, and increased risk for cellulitis and carbuncles.
- Extremity - Venous varicosities, lower extremity venous and/or lymphatic edema
- Miscellaneous - Reduced mobility and difficulty maintaining personal hygiene.

2.3 TRUNCAL OBESITY

Localized collection of fat in the trunk (truncal or central obesity) which is commonly assessed by waist circumference, hip circumference and waist-hip ratio independently predicts hypertension and diabetes mellitus to various extents in different population (Chee-Eng, 2004) . Various populations have proposed different cut off values to define truncal obesity. For example, the Asian and European populations have modified their reference value for truncal obesity, based on the related incidence of cardiovascular events peculiar to their own population as shown in table 1. One of the recently published definitions takes into account ethnic specific minimum value for central obesity; however, European normal values are still used in African populations where specific data are not yet available (Alberti *et al.*, 2005). Other synonyms for truncal obesity are central obesity, centripetal obesity and abdominal obesity but in the lay man language it is referred to as beer belly, beer gut or pot belly and it occurs when excessive fat around the hip and abdomen has built up to the extent that it is likely to have a negative impact on health producing an apple shaped body type (Carey *et al.*, 1998). Truncal obesity is also known to correlate strongly with intra abdominal visceral fat deposit which is a determinant of insulin resistance, a major step in the pathogenesis of type 2 diabetes mellitus (Elliot et *al.*, 2000). In addition to the co morbidities associated with obesity in general, persons with truncal obesity are at particular risk of Alzheimer and peripheral vascular diseases (Razay, 2006). Measurement of truncal dimension became popular in the early 1980s when scientist discovered some individuals with normal BMI, harboring excessive abdominal fat had relatively higher incidences of cardiovascular events and therefore declared that the key to obesity is body fat rather than body weight (Poehlman, 1998).

The precise mechanism by which fats accumulate in the trunk is not clear but some theories have been put forward. Some studies indicate that central adiposity, together with lipid dysregulation and decreased insulin sensitivity, is related to the excessive consumption of fructose (Stanhope *et al.*, 2010). Other environmental factors, such as maternal smoking, estrogenic compounds in the diet, and endocrine-disrupting chemicals may be involved (Perez *et al.*, 2009). Hypercortisolism, such as in Cushing's syndrome, also leads to central obesity as well as drugs, such as dexamethasone and other steroids, can also have side effects resulting in central obesity, especially in the presence of elevated insulin levels (Heindel, 2011).

It is shown that combining regular routine exercise which entails aerobic exercise and resistance training with consumption of healthy diets are the best ways of fighting abdominal obesity (Farmer *et al.*, 2009). Some drugs such as Thiazolidinediones may cause slight weight gain but decrease "pathologic" abdominal fat (visceral fat), and therefore may be prescribed for central obesity especially when it co-exist with diabetes (Fonseca, 2003).

The diagnosis of truncal obesity is based on simple anthropometric measurements such as waist circumferences and waist to hip ratio with normal reference values of <102 cm in men and <88 cm in women for the waist circumference and <0.9 in men and <0.85 in women for the waist to hip ratio (NCEP, 2002).

Men are considered to be at high risk from abdominal obesity if their waist measurements are 102 cm or higher, while on the other hand, women are considered to be at high risk if their waist measurements are 89 cm or higher (NCEP, 2002). Advanced radiological techniques, such as magnetic resonance imaging and computer tomographic scan are sometimes employed in measuring visceral fat as an indirect method of determining truncal obesity (Smith and Haslam, 2007).

The sex difference in the cut off value for defining truncal obesity is explainable by fat distribution effect of the sex hormones, in that while estrogen encourages fat deposition in the thigh and buttocks, testosterone enhances fat deposition in the abdomen (Lemieux, 1993)

2.4 ESSENTIAL HYPERTENSION

An individual is said to be hypertensive when there is persistent elevation in the systemic blood pressure with the systolic blood pressure (SBP) being greater or equal to 140mmHg and diastolic blood pressure (DBP) greater or equal to 90mmHg measured on at least two different occasions (Parati *et al.*,1998). It is described as essential or primary hypertension when there is no precise etiological factor in patients who are at least 40 years of age, while secondary hypertension is the case when it occurs before 40 years, and in many cases an etiology is identified; for example, renal artery stenosis, renal failure, pheochromocytoma and hyper aldosteronism (Mansia *et al.*, 2007). Although essential hypertension has no known etiology, certain risk factors are known. These include family history of hypertension, being overweight or obese, hyperlipidemia, diabetes, cigarette smoking, alcohol consumption, excessive salt intake, stress and sedentary life style (JNC, 1997). There is a new concept in the Aetio-pathogenesis, which identifies certain gene mutation in the pathogenesis of essential hypertension (Luft, 1998). This is seen in Liddle syndrome which is an autosomal dominant form of monogenic hypertension that results from mutations in the amiloride-sensitive epithelial sodium channel, leading to increased channel activity pathogenesis (Luft, 1998). Hypertension is described as a silent killer because it's largely asymptomatic presenting only in less than 20% of cases with symptoms such as head ache, dizziness, palpitations and in severe cases confusion and loss of consciousness (JNC, 1997). Essential hypertension remains a major modifiable risk factor for cardiovascular disease (CVD) despite our understanding of its pathophysiology and availability of effective treatment strategies. Globally it's a leading cause of sudden death from myocadial infarction (heart attack) and cerebrovascular accident (JNC, 1997), and a major etiology in the pathogenesis of congestive cardiac failure, chronic kidney disease, and blindness of hypertensive retinopathy (Cutler, 1996). There is a strong positive correlation between blood pressure and the risk of these cardiovascular diseases and this correlation is more robust with systolic than with diastolic BP (Sever and Poulter, 1989). Blood pressure (BP) is classified based on the readings of systolic and diastolic components as shown in table 2.

Table 2.1: Defination and classification of blood pressure level (Reisen *et al.*, 1978).

Category	Systolic, mm Hg		Diastolic, mm Hg
Optimal	<120	and	<80
Normal	<130	and	<85
High normal	130–139	or	85–89
Hypertension			
Stage 1 (mild)	140–159	or	90–99
Subgroup: borderline	140–149	or	90–94
Stage 2 (moderate)	160–179	or	100–109
Stage 3 (severe)	≥180	or	≥110
Isolated systolic hypertension	≥140	and	<90
Subgroup: borderline	140–149	and	<90

When patient's systolic and diastolic blood pressure fall into different categories, the higher categories should be applied (Reisen *et al.*, 1978).

The diagnosis of hypertension is made when the average of 2 or more diastolic BP measurements on at least 2 subsequent visits is 90 mm Hg, or when the average of multiple systolic BP readings on 2 or more subsequent visits is consistently 140 mm Hg (Beilen, 1998). Individuals with high normal BP tend to maintain pressures that are above average for the general population and are at greater risk for the development of definite hypertension and cardiovascular problems than the general population (Beilen, 1998). Using this classification, overall, approximately 20% of the world's adults are estimated to have hypertension, with the prevalence dramatically increasing in patients older than 60 years: In many countries, 50% of individuals in this age group have hypertension. Worldwide, approximately 1 billion people have hypertension, contributing to more than 7.1 million deaths per year (WHO, 2002). Studies have reported that about 24% of adults in the United States are hypertensive, prevalence of hypertension is 22% in Canada, of which 16% is controlled; it is 26.3% in Egypt, of which 8% is controlled; and it is 13.6% in China, of which 3% is controlled (WHO, 1999). Black individuals have a higher prevalence and incidence of hypertension than the Caucasians, with the prevalence of hypertension been reported to be increased by 50% in blacks (Brown, 2006). In Nigeria the prevalence is estimated to be about 42% with males being more affected than females in the ratio of 1.3: 1(Ifeoma *et al.,* 2011). A study conducted in Kano, north-western Nigeria reveals that hypertension is the commonest cardiovascular disease and has a prevalence estimate of 39.2% (Mukadas and Misbahu, 2009).

2.5 TYPE 2 DIABETES MELLITUS

Diabetes on the other hand is a metabolic disorder characterized by persistent hyperglycemia and its diagnosis is based on a fasting blood sugar of greater than 7mmol/l, random or 2 hours post prandal (after meal) glucose of greater than 11mmol/l (Colledge *et al.* 2003). Slight variation in the reference values however exists between clinics and laboratories (WHO, 1999). Type 2 or non insulin dependent diabetes typically occurs after 40 years and frequently results from a complex interplay between genetic and environmental factors, while type 1 or insulin dependent diabetes occurs at a much younger age and is essentially autoimmune mediated (Laron, 2002).Obesity is thought to be the primary cause of type 2 diabetes in people who are genetically predisposed to the disease and pathologically, it is due to insufficient insulin production from beta cells in the setting of insulin resistance (Kumar *et al.,* 2005). Insulin resistance, which is the inability of cells to respond adequately to normal levels of insulin, occurs primarily within the muscles, liver, and fat tissue (Kumar *et al.,* 2005). In the liver, insulin normally suppresses glucose release; however, in the setting of insulin resistance, the liver inappropriately releases glucose into the blood (Kumar *et al.,* 2005). The proportion of insulin resistance versus beta cell dysfunction differs among individuals, with some having primarily insulin resistance, and only a minor defect in insulin secretion, and others with slight insulin resistance and primarily a lack of insulin secretion (Kumar *et al.,* 2005). Other potentially important mechanisms associated with type 2 diabetes and insulin resistance include: increased breakdown of lipids within fat cells, resistance to and lack of incretin, high glucagon levels in the blood, increased retention of salt and water by the kidneys, and inappropriate regulation of metabolism by the central nervous system. However, not all people with insulin resistance develop diabetes, since an impairment of insulin secretion by pancreatic beta cells is also required (Shoback *et al.*, 2011).

The classic symptoms of diabetes are polyuria (frequent urination), polydipsia (increased thirst), polyphagia (increased eating), and weight loss. Other symptoms that are commonly present at diagnosis include a history of blurred vision, itchiness, peripheral neuropathy, recurrent vaginal infections, and fatigue (Kumar *et al.,* 2005). Many people, however, have no symptoms during the first few years and are diagnosed on routine testing (Smyth and Heron, 2006). People with type 2 diabetes mellitus may rarely present with hyperosmolar hyperglycemic state (a condition of very high blood sugar associated with a decreased level of consciousness and low blood pressure) (Kumar *et al* 2005). In very severe cases, diabetes is associated with a ten-year-shorter life expectancy due to a number of complications with which it is associated, including two to four times the risk of cardiovascular disease, ischemic heart disease, stroke, a 20-fold increase in lower limb amputations, and increased rates of hospitalizations (Smyth and

Heron, 2006). In the developed world, and increasingly elsewhere, type 2 diabetes is the largest cause of non traumatic blindness and kidney failure (Fasanmade *et al.,* 2008). Diabetes has also been associated with an increased risk of cognitive dysfunction and dementia through disease processes such as Alzheimer's disease and vascular dementia with other complications including acanthosis nigricans, sexual dysfunction, and frequent infections (Pasquier, 2010).

The development of type 2 diabetes is caused by a combination of lifestyle and genetic factors. A number of lifestyle factors are known to be important in the development of type 2 diabetes, including obesity and overweight, lack of physical activity, poor diet, (high sugar diet saturated fatty acids, alcohol) and stress (Shoback *et al.,* 2011). The genetic basis of diabetes is explained by the fact that if one identical twin has diabetes, the chance of the other developing diabetes within his lifetime is greater than 90%, while the rate for non identical siblings is 25–50% (Herder and Roden, 2011). Additionally, more than 36 genes were found to contribute to the risk of type 2 diabetes but theyl only account for 10% of the total heritable component of the disease (Vijan, 2010). Rarely, drugs such as glucocorticoids, thiazides, beta blockers, atypical antipsychotics and medical conditions such as acromegaly, Cushing's syndrome, hyperthyroidism, pheochromocytoma are also associated with type 2 diabetes (Abdullah *et al.,* 2010). Onset of type 2 diabetes can be delayed or prevented through healthy nutrition and regular exercise which may reduce the risk by over half (Raina and Kenealy, 2008). The benefit of exercise occurs regardless of the person's initial weight or subsequent weight loss but evidence for the benefit of dietary changes alone is however limited with some evidence for a diet high in green leafy vegetable and some for limiting the intake of sugary drinks (Orozco *et al.,* 2008). In those with impaired glucose tolerance, diet and exercise either alone or in combination with low dose of metformin may decrease the risk of developing diabetes (Lee *et al.,* 2012).

Management involves life style modification that addresses the risk factors, use of oral hypoglycemic drugs and insulin therapy in severe or complicated cases all of which aims at maintaining optimal glycemic control, preventing complication and increasing life expectancy (Kumar *et al.,* 2005). The world health organization proposed diabetes diagnostic criteria is shown in the table below (WHO, 2006).

Table 2.2: Diabetes Mellitus diagnostic criteria (WHO, 2006)

Condition	**2 hour glucose**	**Fasting glucose**	**HbA_{1c}**
Unit	mmol/l(mg/dl)	mmol/l(mg/dl)	%
Normal	<7.8 (<140)	<6.1 (<110)	<6.0
Impaired fasting glycaemia	<7.8 (<140)	≥ 6.1(≥110) & <7.0(<126)	6.0–6.4
Impaired glucose tolerance	≥7.8 (≥140)	<7.0 (<126)	6.0–6.4
Diabetes mellitus	≥11.1 (≥200)	≥7.0 (≥126)	≥6.5

Globally, it is estimated that there are 285 million people with type 2 diabetes making up about 90% of diabetes cases which is equivalent to about 6% of the world's adult population, with diabetes being common to both the developed and the developing world but remains uncommon however in the underdeveloped world (Meetoo et *al.,* 2007). Women seems to be at a greater risk for diabetes mellitus as do certain ethnic groups such as South Asians, Latinos, and Native Americans (Hawthorne *et al.,* 2008). This may be due to, the enhanced sensitivity to a western lifestyle in certain ethnic groups and probable diabetogenic effect of female sex hormones (Hawthorne *et al.*, 2008).

The prevalence of type 2 diabetes mellitus in Nigeria is estimated as 7.9% by a study in the southern part of the country, where the crude prevalence rates were 7.7 and 5.7% for males and females, respectively and the major risk factors identified were sedentary life style and unhealthy diets (Nyenwe, 2003)

Overall, There were 3,921,500 cases of diabetes in Nigeria in 2013 (Diabetes Association of Nigeria, DAN, 2O14). A study in Zaria northern Nigeria estimates the prevalence of individuals living with impaired blood glucose to be 4.5%, while only 2.5% were frankly diabetic with obesity and overweight being a major culprit (Dahiru *et al*., 2008). The conventional way of measuring the blood glucose is to use the glucose meter also called glucometer (Hafner, 2005).

2.6 PREVALENCE OF OBESITY USING THE VARIOUS INDICES

2.6.1 Body Mass Index (BMI)

A Lancet study estimated that using BMI, the number of obese adults in the world was 2.1 billion in 2013, compared with 857 million in 1980 (Ng *et al.*, 2014). The rate of obesity also increases with age at least up to 50 or 60 years old (Peter *et al.*, 2005). Obesity was once considered a problem only of high-income countries, but its current prevalence has rapidly spread to involve the developing countries especially the urban settlements (WHO, 2000). The highest global prevalence of obesity is in the United State of America where about 33% of men and 36% of women fall within the obesity range with African American women having a much higher prevalence of about 50% (Healy, 2011). The distribution of this statistics is such that the South America has a larger burden of the problem and consequently has been alternatively described as the stroke belt, the obesity belt, or diabetes belt to reflect the high incidence of these obesity complications in its populace (Bessesen, 2008). Using the universal criteria of obesity cut off point as BMI> 29.9, the Asians have the lowest rate of obesity of 3.2%, but because Asian populations are particularly susceptible to the health risks of excess adipose tissue, they have redefined obesity as any BMI greater than 25 (Bessesen, 2008). Using this cut off value, the prevalence of obesity in Asians would be 20%, a threefold increase from 1962 to 2002 (Anuurad *et al.,* 2003). Similarly, estimates made by the WHO also indicate that the problem of obesity extends globally. According to the most recent data published in 2011 from WHO, there is significant variation across the globe with the estimated overweight and obesity prevalence for women aged 15 years globally, ranging from a low prevalence of 3.7% in Ethiopia to a higher value of 93% in Nauru (WHO, 2014). In 2008, 1.5 billion adults, 20years and older, were overweight. Of those, over 200 million men and nearly 300 million women were obese (WHO, 2002). According to the global database on BMI compiled by WHO, the prevalence of obesity varied widely across countries. The obesity levels (BMI > 30 kg/m2) range from below 5% collectively in China, Japan, India, Indonesia and certain African nations to over 75% in Samoa and Nauru (WHO, 2012). But even in relatively low-prevalence countries like China and Japan, rates were almost 20% in some cities (Yoshike *et al.,* 2002). Recent available data reveal that the prevalence of obesity in adults in the United States is 33.9% compared to 23.1% in Canada, 22.7% in the United Kingdom, 16.9% in France and

16.4% in Australia (WHO, 2012). Obesity rates in West Africa are estimated to be 10% and rates of obesity among women are three times those found in men and in urban West Africa, rates of obesity have more than doubled in the last 15 years (Abubakari *et al.*, 2008). In Nigeria obesity prevalence is documented as 21% and like in other African communities, has a higher female predilection (Kolawole *et al.,* 2011*).* Evidence suggests that the health disadvantage of obesity in African women is less than that in white women, and would seem to have little influence on their proneness to hypertension, coronary heart disease and breast cancer (Abubakari *et al*., 2008). In another study on a rural Africa population the prevalence of obesity was ten times higher in women than in men, irrespective of the definition used (Abubakari *et al*., 2008). Apart from the genetic and hormonal differences, this can partly be explained by the high number of deliveries, as well as their lower level of physical activity (Sobngwi *et al.*, 2002). Meta-Analytical study indicates that obesity prevalence (body mass index > 30) among Nigerian adults was 8.8% (CI 7.0–10.6) in 2000, and in Ghanaian adults, it was 14.1% (CI 13.1–15.1%) in 1998 and that 25–57% of Nigerians were physically inactive (Abubakaria and Bhopalb, 2007).

2.6.2 Truncal Obesity Indices (Waist Circumference and Waist to Hip Ratio)

In 2011 an anthropometric study conducted in Kayseri, turkey revealed the prevalence of truncal obesity to be 29.9% using waist to hip ratio as the obesity indices, and 50.4% using waist circumference (Sahin *et al*.,2011). A cross sectional observational studies conducted among Indian students to determine the prevalence of obesity by various markers, showed a truncal obesity prevalence to be 16.4% using waist circumference (Pengpida and Peltzer, 2014). The prevalence of abdominal obesity in rural males and females from a study conducted in Polland showed prevalent rates of 11% and 9% respectively; however, statistically significant sex differences was observed in the older age group where prevalence of abdominal obesity was significantly greater in males, 12% when compared to females 8%. More thorough analysis of this prevalence of abdominal obesity shows its rising tendency with the males' age, from 7% among the youngest to 14% among the older ones whereas in the female group, the prevalence increases up to 13% until a critical age, then begins to decrease up to 7% in the older females (Sudera *et al.*, 2015). About 50% of men and 70% of women in the United States now exceed the waist circumference threshold for central obesity (Li *et al.*, 2007). A demographic health survey conducted in South Africa shows that about 10% of its populace have isolated central obesity, of which 9% were living with a metabolic problem attributable to hyperlipidemia (SADHS, 2003).

In Nigeria it is estimated that the prevalence of obesity using body mass index in the population is 11.12%. In men and women, obesity prevalence was 7.73%, and 14.37%, respectively. The prevalence of abdominal obesity in the same study was 21.75%. In men and women, it was 3.2% and 39.2% respectively (Chukuonye *et al.*, 2013).

2.7 RELATIONSHIP BETWEEN BMI, OBESITY, DIABETES AND HYPERTENSION

The use of body mass index as an anthropometric indicator of generalized adiposity and in the prediction of essential hypertension and type 2 diabetes mellitus has been widely explored within the domain of physical anthropolology (WHO, 2000). BMI gives a clue to the fat composition of the body and risk estimation for metabolic diseases related to excess body fat such as hypertension and diabetes mellitus (Chobanian *et al*., 2003). Obesity is considered one of the most serious public health problems of the 21st century, a well recognized risk factor for essential hypertension and type 2 diabetes mellitus which are the leading preventable cause of death worldwide (Haslam and James, 2005).

In addition obesity is strongly associated with hypertension and diabetes in Nigerians (Kadiri and Salako, 1997). Nigeria is facing an increasing prevalence of obesity, with a particularly strong occurrence in populations with hypertension and diabetes. A Nigerian study of these increases says that the rise of obesity rates can be attributed to rapid unplanned urbanization; change from local dietary pattern to western style diet which is driven by the proliferation of fast food outlets in major cities across the country and sedentary life style, with some genetic predisposition (Schelenberg *et al.*, 2013). Obesity is considered one of the most serious public health problems of the 21st century, a well recognized risk factor for essential hypertension and type 2 diabetes mellitus which are the leading preventable cause of death worldwide (Haslam and James, 2005). Truncal or central obesity independently predicts hypertension and diabetes mellitus to various extents in different populations (Chee-Eng *et al.*, 2004). Truncal obesity is also known to correlate strongly with intra abdominal visceral fat deposit which is a determinant of insulin resistance, a major step in the pathogenesis of type 2 diabetes (Elliot *et al.*, 2002). In a study conducted to assess the prevalence of obesity and systemic hypertension among diabetes mellitus patients attending an out-patient diabetes clinic in a Ghanaian Teaching Hospital, a high prevalence of overweight/obesity and systemic hypertension was found. Hyperglycemia was more prevalent among overweight/obese participants with higher values of BMI (Victor *et al.*, 2014).

2.8 THE RELATIONSHIP BETWEEN GENERALIZED OBESITY, TRUNCAL OBESITY WITH ESSENTIAL HYPERTENSION AND TYPE 2 DIABETES MELLITUS

Although the indices of truncal obesity were reported to strongly correlate with BMI, it is however not clear whether they can predict cardiovascular diseases better than BMI, suggesting that there are some controversial issues around the adiposity markers that better predict cardiovascular risk (Bergman *et al*., 2011). The relatively higher prevalence of diabetes or hypertension among Indian-Asians who had similar anthropometric dimension and common socio- demographic characteristics with other Indians was solely attributed to higher truncal obesity indices, there is thus a strong correlation between central obesity and cardiovascular disease (Shaw *et al.,* 2010). Recently a study assessed and compared the strength of association and discriminatory capability of measures of adiposity such as body mass index (BMI), waist circumference

(WC), hip circumference (HC), waist–hip-ratio (WHR), waist–height-ratio (WHtR) for prevalent screen detected diabetes (SDM) risk in a sub-Saharan African population, WC was the best predictors and to some extent WHtR of prevalent SDM in this population, while BMI and WHR were less effective (Mbanya *et al.*, 2015).

A comparative study to compare the impact of differences in waist circumference (WC) defined according to the International Diabetes Federation (IDF), and the Adult Treatment Panel III (ATP III), and body mass index (BMI) on cardiovascular disease risk factors in 402 apparently healthy volunteers of European ancestry showed that, prevalence of metabolic syndrome were essentially identical irrespective of the measure of WC used, as were metabolic characteristics of the subjects. Cardiovascular disease risk factor status therefore did not vary substantially when subjects were divided on the basis of WC or BMI and the results indicated that WC and BMI significantly correlated ($p < 0.05$, $r = 0.78$) (Marno *et al.,* 2008). In a study conducted to assess abdominal Adiposity and Clustering of multiple metabolic syndrome in White, Black and Hispanic Americans WC appears to be a marker for multiple metabolic syndromes in these ethnic groups. The results of this investigation lend support to the view that waist measurement should be considered as a clinical variable for assessing the risk of cardiovascular diseases (Ike *et al.*, 2000). A descriptive study of metabolic syndrome in a sub-Saharan African setting showed central obesity assessed by waist circumference to be more tightly associated with the other components of the metabolic syndrome (Leopold *et al.*, 2007). Although, waist-to-hip ratio (WHR) measures central fat deposition, it is imperfect, particularly among lean individuals (Wang *et al.,* 2005). Another study has also shown that WC may be a better anthropometric predictor of many components of metabolic syndrome than

BMI or WHR (Wang *et al.,* 2003). Indeed, since WC is more strongly associated with stroke and type 2 diabetes than either BMI or WHR, it may be measuring a different form of adiposity not totally accounted for by BMI or WHR (Molarius *et al.,* 1999).

In contrast, a study aimed at evaluating the associations between different measures of obesity and prevalent cardiovascular disorders in a large population-based cohort discovered that WHR was independently associated with prevalent of the diseases and provided better discrimination than either BMI or WC (Dagenais *et al.,* 2005). Other studies comparing obesity measures using mortality and cardiovascular problems as end points have shown WC and WHR to perform better than BMI. For example, more than 29,000 men were followed up during a period of 3 years in a study, and reported WHR as a stronger predictor of risk compared with BMI (Wang *et al*., 1995). Similarly, another study followed nearly 8,000 subjects over the course of 4.5 years and reported that although the upper percentiles of BMI, WC, and WHR were all associated with increased relative risk for cardiovascular problems, the magnitude of the association was greater for WC and WHR (Dagenais *et al.,* 2005). Some Studies of clinical relevance have however contested the superiority of waist circumference over BMI (Wang *et al.,* 2003; Ford *et al.,* 2003). This is seen in a study demonstrating the relation between increased abdominal obesity and adverse clinical consequences, which used measurements of WC made at 14 different anatomic sites and showed that measurements made at the 4 most commonly used sites yielded quite different absolute values for WC. On the basis of this observation, it was deduced that there is no significant difference in the predictive strengths of BMI and waist indices and it does not seem that knowledge of the WC provides any unique clinical insight and that either the BMI or WC can be used by clinicians (Wang *et al.,* 2003). Also a study has observed that the emphasis on the importance of assessment of abdominal obesity by waist circumference to help identify apparently healthy subjects who are more likely to develop cardiovascular disease (CVD) risk is somewhat paradoxical, given the evidence from the National Health and Nutrition Examination Survey showing that measurements of body mass index (BMI) and waist circumference (WC) correlated highly ($r = 0.9$), regardless of age, gender, or ethnicity, stressing that if the 2 measures of excess adiposity are so closely related, it is not immediately apparent why one should be more indicative of cardiovascular risk than the other (Ford *et al.,* 2003).

The evidence obtained from some other studies either equates BMI to Truncal obesity indices or upholds BMI (Haffner *et al.*, 1990; Gautier *et al.,* 1999; Tulloch *et al.*, 2003; Wang *et al;* 2005). For example a study among Indian population shows that increases in visceral obesity did not correlate with decreases in insulin-mediated glucose disposal in Pima Indians (Gautier *et al.,* 1999). In a similar study, BMI was the estimate of adiposity with the highest hazard ratio in the prediction of type 2 diabetes (Tulloch *et al.,* 2003). Similarly, a prospective study of Mexican-Americans reported that those patients with the highest baseline plasma glucose and insulin values were most likely to develop type 2 diabetes independent of differences in age, BMI, or central obesity (Haffner *et al.,* 1990).

In addition, prospective study in predominantly white population concluded that generalized and abdominal adiposity strongly and independently predicts risk of type 2 diabetes mellitus (Wang, 2005). Furthermore, study of obesity trend in a multi ethnic group has shown that BMI is more strongly associated with blood pressure than abdominal obesity (Seidell, *et al.,* 1991).The clustering of dyslipidemia, hyperuricemia, diabetes, and hypertension described in Whites and Africans was most strongly related to BMI, although the magnitude decreased when adjusted for differences in BMI and abdominal obesity (Schmidt *et al*., 1996). A cross sectional study conducted in Zaria, northern Nigeria studied the waist circumference, body mass index and its correlation with the blood pressure of a sample of women showed that waist circumference was found to be a better measure in assessing obesity and thus cardiovascular risk among the subjects. In the same study, a significant positive correlation however exists between the waist indices and BMI (Achie *et al.,* 2012). Additionally an observational study on the natives of northern Ibadan, Nigeria, investigated the relationship between two anthropometric measurements for obesity – body mass index (BMI) and waist-hip ratio (WHR), and the blood pressure of Nigerians aged 15-85 years. Results showed that WHR and BMI had a similar linear relationship with the blood pressure of the participants (Sanya *et al.,* 2009).

CHAPTER THREE

MATERIALS AND METHODS

3.1 THE STUDY AREA

The research was conducted in the metropolis of Kano state. Kano state is located on latitude 12^o02^1N, longitude 08^o30^1E in the north-western region of Nigeria (Ki – Zerbo, 1998). Kano is the most populous state in Nigeria with a state population of over 9 million, a metropolis of 137 km^2 area and consisting of 6 local government areas with a population of over 2 million (NPC,2006). The state is considered as the commercial and political centre of northern Nigeria (Kano encyclopedia, 2009). The major inhabitants of Kano are of Hausa and Fulani ethnic groups with minority representing virtually all tribes in Nigeria and a minute fraction of foreigners (Danasabe, 2000).

3.1.1 The study site

The research site was Murtala Muhammad Specialist Hospital (MMSH), specifically the diabetic / hypertensive clinic of the hospital. The hospital is a secondary health facility that serves the States, its neighboring States and even some neighboring countries such as Niger, Chad and Cameroon. About 150 patients patronize the hypertensive/diabetic clinic every working day of the week. This was obtained by dividing the weekly estimate of 750 Clients per week according the information obtained from Murtala Muhammed Specialist Hospital records department, by 5 working days of the week.

3.2 STUDY POPULATION

The study comprised of clients who satisfied the following selection criteria;

3.2.1 Selection Criteria

Inclusion Criteria

1. Any Hausa client who was registered as hypertensive, diabetic or hypertensive-diabetic in Murtala Muhammad Specialist Hospital Kano.

2. Any case of hypertension, diabetes or hypertension-diabetes, whose diagnosis was established on at least 2 different occasions in Murtala Muhammad Specialist Hospital and falls between 40 – 69 years

3. Any Clients who gave his/her voluntary consent to participate in the study

Exclusion criteria

1. Any client who did not satisfy the inclusion criteria

2. Any client with pregnancy, pelvic or abdominal tumor or other metabolic disorders apart from hypertension and diabetes

3.2.2 Sample Size Determination

The sample size for study was determined using the formula: (Lwanga and Lemeshow, 1991);

$$n = \frac{Z^2Pq}{d^2}$$

Where;

n= minimum sample size

Z= standard normal deviation with confidence interval of 95% (±1.96)

P= proportion in the target population (50%) 0.5

Q= 1-p, 1-0.5= 0.5

d = sampling error which is 5% (0.05)

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384$$

384 was therefore the minimum number of subjects needed for the study to allow a meaningful statistical analysis. However the research considered a sample size of 405.

3.2.3 Sampling Technique

The research was a cross sectional observational study. Systematic random technique was employed in selecting the subjects for this study. A sampling interval of 15 was used to select 10 patients per day. This interval was obtained by using the formula which states that sampling interval is equal to sample frame divide by sample size**.** Sample interval = sample_frame /sample size (Kothari, 2004)**.** Hence the sample interval of 15 is obtained by dividing 150 (sample frame) by 10 (daily sample size). However the starting point was randomly selected by tossing a coin assuming that the head represents the right side while the tail represents the left side (Kothari, 2004).

3.3 ETHICAL CONSIDERATION

Ethical approval and clearance was obtained from the ethical committee of Kano State Health Management Board through the management of Murtala Muhammad Specialist Hospital, Kano. The procedure, aims and objectives of the study was explained to the clients and a written consent was obtained

3.4 EQUIPMENTS AND INSTRUMENT

1. Digital weighing scale (Seca 769 Digital weighing scale, calibrated in kilograms,USA).
2. In-elastic measuring tape (Butterfly model, made in china, graduated in cm, 0-150cm).
3. Stadiometer (Seca 206IN, Body Meter stadiometer, calibrated in meters, USA).
4. A semi structured questionnaire was used to collect biodata, data on sociodemographic characteristics and medical history.

3.5. ANTHROPOMETRIC STUDIES

3.5.1 Safety Measures (Colledge *et al.*, 2003).

Each patient was examined separately while ensuring adequate confidentiality and privacy using a mobile hospital screen cover. In order to prevent the chances of contacting infection, myself and my research assistants disinfected the examining hands by washing with an antiseptic soap up to the elbow joint and thereafter wore a disposable latex glove after each examination. Where the measuring instruments accidentally came in contact with body secretion such as sweat and saliva, it was immediately disinfected using solution of metholated spirit. A protective ward coat was also worn throughout the data collection exercise. For clients who manifested the symptoms of respiratory tract infections such as cough and nasal discharge, protective face mask was offered to them. Also comfortable waiting chairs were offered to all participants to avoid undue fatigue.

3.5.2 Technique for measuring height (Price *et al.*, 2006):

For all the anthropometric measurements, two research assistant including a male and a female were trained and engaged. Height was measured to the nearest 0.1cm as the vertical distance between the standing surface and the vertex of the head while the subject was standing erect without shoes using a stadiometer.

The subjects were asked to remove their shoes and any headwear or hair ornaments. The thickness of any irremovable braids/corn rows was then measured with a small plastic ruler and deducted from the total height at the end. The head was then raised far enough up so that the subject can stand under the head board comfortably. For subjects much taller than me, I stood on a chair or stool to correctly position the subject. The subject were then asked to stand with their back against the measuring rod, with feet slightly apart, the trunk balanced over the waist, knees straight, arms and shoulders relaxed. The head stop was then slided down until it touched the top of the head. And the subject asked to take a deep breath so as to straighten the spine and gives a consistent measurement. The measurement was read from the display and then recorded on the appropriate part of the proforma as it appears on the display to the nearest 0.1cm

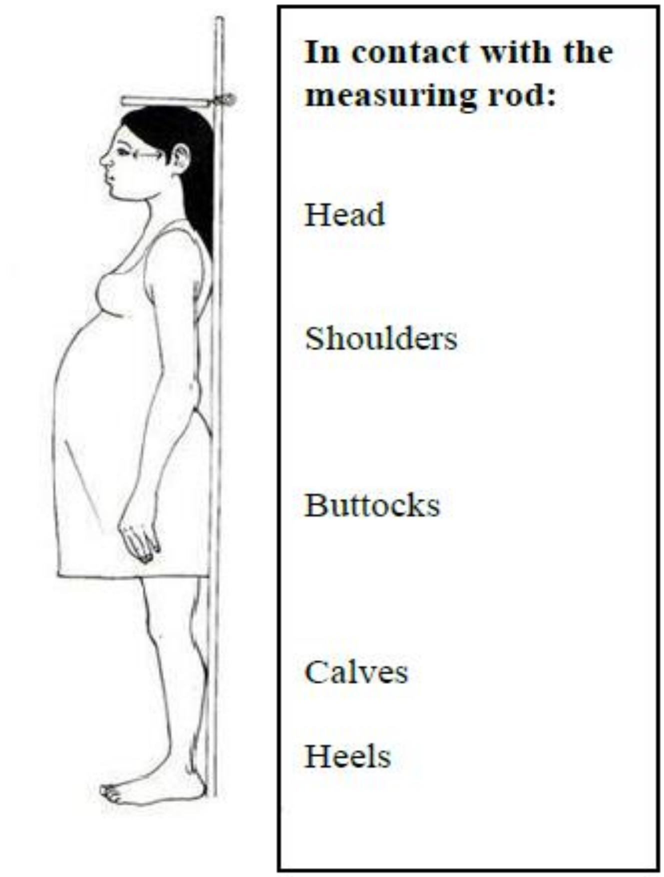

Figure 3.1: Illustration of the technique for measuring height (Price *et al.,* 2006)

3.5.3 Technique for measuring weight (Price *et al.*, 2006):

The weight was measured in kilograms using a digital weighing scale while the subject is in light clothes. The client was asked to remove any heavy objects and take off his or her shoes and all accessories and the scale was then put on a perfectly flat surface with no obstructions. The participant was then asked to stand on the scale, placing his/ her feet on the footmarks pasted on the scale, and remain still until the readings appears. The weight in kilogram was then read to the nearest decimal place and recorded in the appropriate section of the proforma. The weight measurement was taken twice and the average recorded.

3.5.4 Technique for calculating BMI (Mueler *et al*., 1991)**:**

The body mass index was be calculated by dividing the weight in kilograms by the square of the height in meters, using a digital calculator and the result expressed in kg/m^2 (WHO, 1995). Generalized obesity was defined as BMI greater than 29.9 kg/m^2.

3.5.5 Technique for measuring waist circumference (Lean *et al.*, 1995)**:**

Waist circumference was measured in centimeter with a non- stretchable plastic tape horizontally placed over the unclothed abdomen at the narrowest point between the lowest rib and the iliac crest. The participant was instructed to gather his or her gown shirt above the waist, cross the arms, and place the hands on opposite shoulders. The desired position of the arms was demonstrated to the clients. When necessary, the pants and under clothing was lowered slightly below the waist but the subject was informed before performing each step of the procedure. I then stood on the participant's right side to palpate the hip area and locate the right Ilium of the pelvis. With the cosmetic pencil I then drew a horizontal line just above the uppermost lateral border of the right ilium. This mark was then being crossed at the midaxillary line. The measuring tape was extended around the waist ensuring that the tape is positioned in a horizontal plane at the level of the measurement mark. While still on the participant's right side, the assistant came around to the subject's left side to check the placement of the tape and ensure that the tape sits parallel to the floor and lies snug but does not compress the skin. The measurement to the nearest 0.1 cm was taken at the end of the client's normal expiration.

3.5.6 Technique for measuring hip circumference (Lean *et al.,* 1995; Heish *et al.,* 1999)**:**

The hip circumference was measured while the subject was standing erect with the feet fairly close together; pockets emptied and the tape passed around the point with the maximum circumference over the bottom. Each client stood erect with feet together and weight evenly distributed on both feet while holding up the examination gown. The study assistant then stood at the back of the client and gathered the side seams of the exam pants together above the hips and placed the thumb in the fabric to make a fold then held the folded sides of the pants snugly while I squatted on the right side of the client to place the measuring tape around the buttocks. The tape was placed at the maximum extension of the buttocks while the study assistant adjusts the sides of the tape and checked the front and sides so that the plane of the tape is horizontal. The zero end of the tape was held under the measurement value and the tape held snug but not tight. The measurement was taken from the right side and called to the assistant who then recorded it (Heish *et al.*, 1999).

3.6 LIMITATIONS

1) Sociocultural background – A few of the clients, especially females were quite shy to expose their trunk for measurements. This affected the clients' cooperation.

2) Difficulty recruiting subjects – part of the inclusion criteria is that patient must be from Kano metropolis. This reduced the ease of recruiting subjects

3) Poor Clinical records – part of the patients information needed was to establish the medical condition of the subjects and the number of follow ups. Sometimes due to poor record this could not be established.

3.7 STATISTICAL METHODS

The data were expressed as mean ± standard deviations and simple percentage was used to determine the prevalence and common pattern of obesity. Chi-square was used to test the association between the occurrence of the diseases (hypertension, diabetes or their co morbidity) and obesity indices (BMI, WC and W/H ratio). Multivariate analyses of variance (using R software) were further used to test the relationships between the occurrences of the disease with the obesity indices. Pearson's correlation was used to find the correlation between the obesity indices (BMI, WC and W/H ratio). SPSS version 20 was used for statistical analysis and $P < 0.05$ was set as level of significance.

CHAPTER FOUR

RESULTS

4.1 DESCRIPTIVE STATISTICS

Out of the 405 subjects recruited for the study (table 4.1), 215(53%) were females while 190 (47%) were males. The subjects had a mean age of 53.39 years. The minimum age was 36years while the maximum was 69 years with standard error of 0.36. The mean height was 163.36cm, the minimum and maximum height of the subjects were 189.1cm and 141.8cm respectively with standard error of 0.44. The mean for the subjects weight was 69.44 kg, with a minimum of 41.3kg , a maximum of 112kg and standard error of 0.65. The body mass index calculated for the subjects had a mean of 26.06, minimum of 17.21, maximum of 43.7 and standard error of 0.24.The waist circumference and waist-to- hip ratio had mean values of 91.88cm and 0.96 respectively. The maximum waist circumference was 118.7cm and minimum was 65.9 with a standard error of 0.58. Waist to hip ratio had maximum of 1.14, a minimum of 0.10 and a standard error of 0.00.

Table 4.1: Descriptive statistics of the general study population (n= 405)

Variables	Mean	Minimum	Maximum	Range	SEM
Age (years)	53.39	36.00	69.00	33.00	0.36
Weight (kg)	69.44	41.30	112.00	70.70	0.65
Height (cm)	163.36	141.80	189.10	47.30	0.44
BMI (kg/m^2)	26.06	17.21	43.70	26.49	0.24
WC (cm)	91.88	65.90	118.70	52.80	0.58
W/H ratio	0.96	0.10	1.14	1.04	0.00

BMI: body mass index, WC; waist circumference, W/H waist to hip ratio, SEM; standard error of mean

Table 4.2: Descriptive statistics of the male participants (n= 190)

Variables	Mean	Range	Minimum	Maximum	SEM
Age (years)	56.89	33.00	36.00	69.00	0.47
Weight (kg)	68.13	59.20	46.60	105.80	0.82
Height (cm)	167.13	47.30	141.80	189.10	0.62
BMI (kg/m^2)	24.41	18.06	17.21	35.27	0.27
WC (cm)	90.60	47.10	65.90	113.00	0.83
W/H ratio	0.99	1.03	0.10	1.13	0.00

BMI: body mass index, WC; waist circumference, W/H waist to hip ratio, SEM; standard error of mean

Table 4.3: Descriptive statistic of the female participants (n= 215)

Variables	Mean	Minimum	Maximum	Range	SEM
Age (years)	50.29	36.00	69.00	28.00	0.43
Weight (kg)	70.57	46.60	105.80	71.00	0.98
Height (cm)	159.99	141.80	189.10	42.00	0.52
BMI (kg/m^2)	27.52	17.21	35.27	27.00	0.34
WC (cm)	92.97	65.90	113.00	48.00	0.81
W/H ratio	0.94	0.10	1.13	0.38	0.00

BMI: body mass index, WC; waist circumference, W/H waist to hip ratio, SEM; standard error of mean

4.2 PREVALENCE OF OBESITY USING BMI, WC AND WHR IN THE STUDY POPULATION

Table 4.4 Prevalence of obesity using BMI, WC AND WHR

	Prevalence of obesity					
	Male			Female		
Diseases sub group	BMI	WC	W/R	BMI	WC	W/R
Hypertensive	16%	28%	56%	18.7%	37%	44.3%
Diabetic	0%	33.3%	66.6%	17.9%	34.3%	47.8%
Hypertensive-Diabetic	12%	29.3%	58.6%	15.9%	40.2%	43.9%

In female hypertensive, the prevalence of generalized obesity using BMI was 18.7% while in male hypertensive it was 16%. The BMI of the female diabetes showed a generalized obesity prevalence of 17.9% while for male diabetics generalized obesity was 0%. Prevalence of generalized obesity in female subject with co-existence of hypertension and diabetes was 15.9% while in co morbid male clients generalized obesity was 12%. For hypertensive male and female clients truncal obesity prevalence was 28% and 37% respectively using waist circumference. In the diabetic clients truncal obesity prevalence using waist circumference was 34.3% and 33.3% in females and males respectively. Truncal obesity prevalence using WC in co morbid females was 40.2% while in co morbid males it was 29.3%. Truncal obesity prevalence by W/H ratio in female with co morbidity was 43.9%. The prevalence of truncal obesity using waist to hip ratio in hypertensive clients was 44.3% in females and 56% in males. Truncal obesity using W/H ratio was 66.6% in diabetic male clients while in diabetic female clients it was 47.8%. For clients with hypertension-diabetes co morbidity, the prevalence of truncal obesity using waist to hip ratio was 58.6% and 43.9% in males and females respectively.

Table 4.5: prevalence of obesity among male participants using BMI, WC and W/H ratio

	Frequency (%) of Abnormal			
Metabolic disorder (n)	BMI	WC	W/H ratio	Total Frequency
Hypertensive (96)	8 (16%)	14 (28%)	28 (56%)	50
Diabetes (22)	None (0%)	4 (33.3%)	8 (66.6%)	12
Hypertensive-diabetes (72)	9 (12%)	22 (29.3%)	44 (58.6%)	75
Total (n) = 190	17	40	80	137

BMI: body mass index, WC; waist circumference, W/H; waist to hip ratio.

Table 4.6: Prevalence of Obesity among Female participants using BMI, WC and W/H ratio

	Frequency (%) of Abnormal			
Metabolic disorder (n)	BMI	WC	W/H ratio	Total Frequency
Hypertensive (137)	41 (18.7%)	81 (37%)	97 (44.3%)	219
Diabetics (36)	12 (17.9%)	23 (34.3%)	32 (47.8%)	67
Hypertensive-diabetic (42)	13 (15.9%)	33 (40.2%)	36 (43.9%)	82
Total (n) = 215	66	137	165	368

BMI: body mass index, WC; waist circumference, W/H; waist to hip ratio.

4.3 PATTERN OF OBESITY

Truncal obesity measured by waist- to- hip ratio was the commonest form of obesity among hypertensive subjects with frequency of 24.7%, followed by truncal obesity using waist circumference with frequency of 18.8%. Generalized obesity was least common with frequency of 9.6%.

Measurement of waist to hip ratio of the diabetic group of clients showed truncal obesity to be the commonest form of obesity with frequency of 7.9%, followed by truncal obesity using waist circumference with frequency of 5.3%. Generalized obesity using BMI showed a frequency of 2.3%

Truncal obesity using waist-to-hip ratio was the most common among subjects with hypertension-diabetes co-morbidity, having a frequency 15.2%, while truncal obesity by waist circumference measurement had a frequency of 10.9% and generalized obesity had 4.3%.

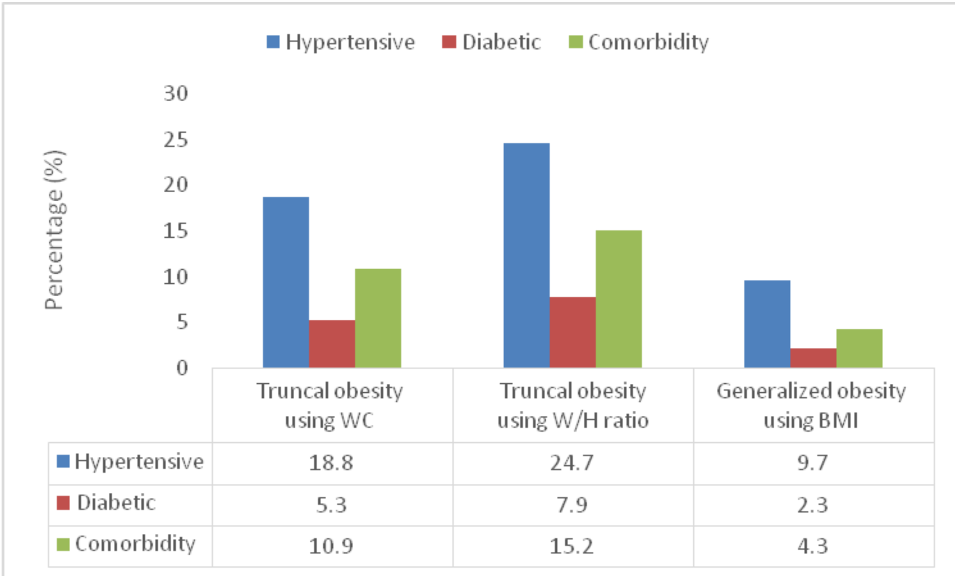

Figure 4.1: Pattern of obesity among hypertensive, diabetic and hypertension-diabetes co morbidity clients

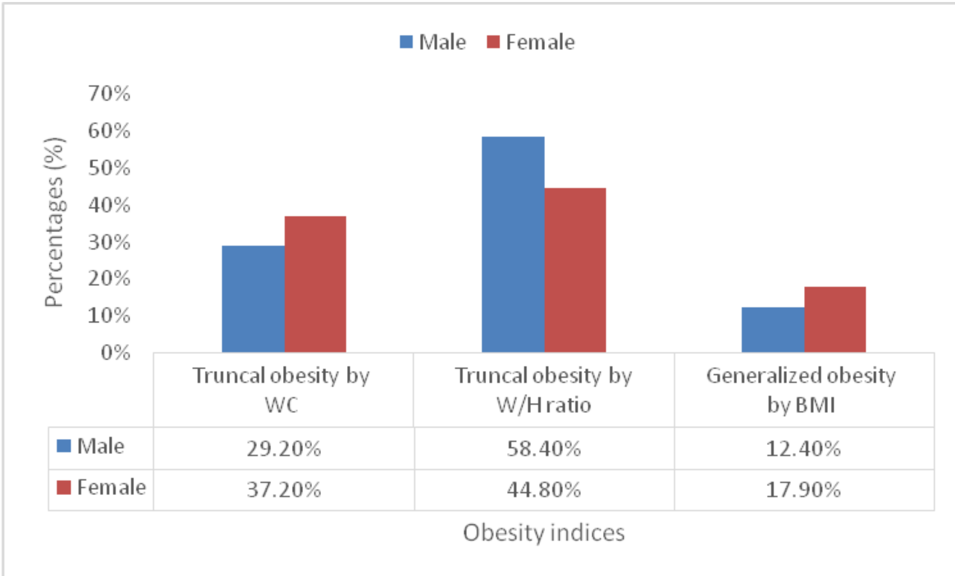

Figure 4.2: Pattern of obesity among male and female clients

4.4 ASSOCIATION BETWEEN OBESITY INDICES (BMI, WC AND W/H RATIO) AND THE DISEASES (HYPERTENSION, DIABETES OR THEIR CO MORBIDITY) USING CHI- SQUARE TEST.

For males, there is no statistically significant association between the BMI and medical history of hypertension and diabetes, but there was statistically significant association between waist circumference and the medical history ($p < 0.04$, $x^2 = 6.43$). Also there is statistically significant association between waist- to- hip ratio and medical history in male subjects ($p<0.0001$, $x^2 = 17.56$) (Table 4.8)

For females, there is no statistically significant association between the BMI and the medical history of hypertension and diabetes. There is also no statistically significant association between the waist circumference of the female subjects and the medical history. However there is statistically significant association between the waist- to- hip ratio and medical history of the female subjects ($p <0.02$, $x^2 =7.57$) (Table 4.9)

Table 4.7: Chi square association between BMI and the metabolic diseases in male participants

Variables			Categories of BMI				Total
			Underweight	Normal	Overweight	Obese	
Medical history	Hypertensive	Count	7	48	33	8	96
		Expected Count	3.5	53.6	30.3	8.6	96.0
		Residual	3.5	-5.6	2.7	-0.6	
		Std. Residual	1.8	-0.8	0.5	-0.2	
	Diabetes	Count	0	14	8	0	22
		Expected Count	0.8	12.3	6.9	2.0	22.0
		Residual	-0.8	1.7	1.1	-2.0	
		Std. Residual	-0.9	0.5	0.4	-1.4	
	Co-morbidity	Count	0	44	19	9	72
		Expected Count	2.7	40.2	22.7	6.4	72.0
		Residual	-2.7	3.8	-3.7	2.6	
		Std. Residual	-1.6	0.6	-0.8	1.0	
Total		Count	7	106	60	17	190
Pearson Chi-Square= 12.075, P = 0.06							

Table 4.8: Chi square association between waist circumferences (WC) and the metabolic diseases in male participants using Chi square.

Variables			Categories of WC		Total
			Normal	Abnormal	
Medical history	Hypertensive	Count	82	14	96
		Expected Count	75.8	20.2	96.0
		Residual	6.2	-6.2	
		Std. Residual	0.7	-1.4	
	Diabetes	Count	18	4	22
		Expected Count	17.4	4.6	22.0
		Residual	0.6	-0.6	
		Std. Residual	.2	-.3	
	co morbidity	Count	50	22	72
		Expected Count	56.8	15.2	72.0
		Residual	-6.8	6.8	
		Std. Residual	-0.9	1.8	
Total		Count	150	40	190
Pearson Chi-Square= 6.438, P= 0.040					

Table 4.9: Association between waist to hip (W/H) ratio and metabolic diseases in male participants using Chi square

Variables			Categories of W/H ratio		Total
			Normal	Abnormal	
Medical history	Hypertensive	Count	68	28	96
		Expected Count	55.6	40.4	96.0
		Residual	12.4	-12.4	
		Std. Residual	1.7	-2.0	
	Diabetes	Count	14	8	22
		Expected Count	12.7	9.3	22.0
		Residual	1.3	-1.3	
		Std. Residual	.4	-.4	
	Co morbidity	Count	28	44	72
		Expected Count	41.7	30.3	72.0
		Residual	-13.7	13.7	
		Std. Residual	-2.1	2.5	
Total		Count	110	80	190
Pearson Chi-Square=17.560, P < 0.0001					

Table 4.10: Chi square association between BMI and the metabolic diseases in female participants

Variables			Categories of BMI				Total
			Underweight	Normal	Overweight	Obese	
Medical history	Hypertensive	Count	2	47	47	41	137
		Expected Count	1.3	48.4	45.2	42.1	137.0
		Residual	0.7	-1.4	1.8	-1.1	
		Std. Residual	0.6	-0.2	.3	-0.2	
	Diabetes	Count	0	16	8	12	36
		Expected Count	0.3	12.7	11.9	11.1	36.0
		Residual	-0.3	3.3	-3.9	0.9	
		Std. Residual	-0.6	0.9	-1.1	0.3	
	comorbidity	Count	0	13	16	13	42
		Expected Count	0.4	14.8	13.9	12.9	42.0
		Residual	-0.4	-1.8	2.1	0.1	
		Std. Residual	-0.6	-0.5	0.6	0.0	
Total		Count	2	76	71	66	215
Pearson Chi-Square=4.029, P=0.673							

Table 4.11: Association between waist circumferences (WC) and the metabolic diseases in female participants using Chi square.

Variables			Categories of WC		Total
			Normal	Abnormal	
Medical history	Hypertensive	Count	56	81	137
		Expected Count	49.7	87.3	137.0
		Residual	6.3	-6.3	
		Std. Residual	0.9	-0.7	
	Diabetes	Count	13	23	36
		Expected Count	13.1	22.9	36.0
		Residual	-0.1	0.1	
		Std. Residual	0.0	0.0	
	Co-morbidity	Count	9	33	42
		Expected Count	15.2	26.8	42.0
		Residual	-6.2	6.2	
		Std. Residual	-1.6	1.2	
Total		Count	78	137	215
Pearson Chi-Square = 5.259, P = 0.072					

Table 4.12: Association between waist to hip (W/H) ratio and the metabolic diseases in female participants using Chi square.

Variables			Categories of W/H ratio		Total
			Normal	Abnormal	
Medical history	Hypertensive	Count	40	97	137
		Expected Count	31.9	105.1	137.0
		Residual	8.1	-8.1	
		Std. Residual	1.4	-0.8	
	Diabetes	Count	4	32	36
		Expected Count	8.4	27.6	36.0
		Residual	-4.4	4.4	
		Std. Residual	-1.5	0.8	
	Co-morbidity	Count	6	36	42
		Expected Count	9.8	32.2	42.0
		Residual	-3.8	3.8	
		Std. Residual	-1.2	0.7	
Total		Count	50	165	215
Pearson Chi-Square= 7.578, P= 0.023					

4.5 ASSOCIATION BETWEEN THE OBESITY INDICES (BMI, WC AND W/H RATIO) AND THE DISEASES BY MULTIVARIATE ANALYSIS USING R SOFTWARE (R CORE TEAM, 2014).

In Table 4.13 multivariate analysis of the obesity indices(BMI, WC, WHR) and the metabolic diseases (hypertension, diabetes and co-morbidity) of the general study population showed that all the obesity indices are significant in predicting the metabolic diseases with adjusted R-squared value of 0.1131 (F-statistic: 4.426 on 15 and 388 DF, p-value: 1.011e-07) . However, multivariate analyses of the male and female subgroups showed that the obesity indices are significant in predicting the metabolic diseases only in male subjects with an adjusted R-squared value of 0.1621 (F-statistic: 3.437 on 15 and 174 DF, p-value: 3.977e-05) (Table 4.13). Further analysis using Akaike information criterion (AIC) to identify the most important variables responsible for the relationship between the obesity indices and the metabolic diseases in males showed that BMI, WHR and BMI: WHR interactions were responsible, however WHR (t= 3.774, P=0.000216) had the strongest contribution compared to BMI (t=3.499, P=0.000585) and WHR: BMI (t= -3.454, P= 0.000684) interactions respectively.

Table 4.13: Multivariate analysis for association between obesity indices and the diseases in the general population

	Estimate	Std.Error	t-value	Pr(>|t|)
(Intercept)	-6.127e+01	1.961e+02	-0.312	0.755
WC	3.612e-01	2.208e+00	0.164	0.870
WHR	1.146e+02	2.038e+02	0.562	0.574
BMI	1.698e+00	8.159e+00	0.208	0.835
AGE	1.094e+00	3.653e+00	0.299	0.765
WC:WHR	-7.752e-01	2.266e+00	-0.342	0.732
WC:BMI	-1.663e-03	8.402e-02	-0.020	0.984
WHR:BMI	-4.243e+00	8.493e+00	-0.500	0.618
WC:AGE	-7.358e-03	4.115e-02	-0.179	0.858
WHR:AGE	-2.064e+00	3.797e+00	-0.544	0.587
BMI:AGE	-3.252e-02	1.536e-01	-0.212	0.832
WC:WHR:BMI	2.312e-02	8.655e-02	0.267	0.790
WC:WHR:AGE	1.549e-02	4.225e-02	0.367	0.714
WC:BMI:AGE	8.551e-05	1.585e-03	0.054	0.957
WHR:BMI:AGE	7.917e-02	1.598e-01	0.495	0.621
WC:WHR:BMI:AGE	-4.884e-04	1.633e-03	-0.299	0.765

Multiple R-squared: 0.1461, Adjusted R-squared: 0.1131, F-statistic: 4.426 on 15 and 388 DF, p-value: 1.011e-07

Table 4.14: Multivariate analysis for association between obesity indices and the diseases of male subjects

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.422e+03	9.844e+02	1.444	0.1505
WC	-1.644e+01	1.081e+01	-1.521	0.1300
WHR	-1.346e+03	9.852e+02	-1.366	0.1737
BMI	-6.614e+01	4.321e+01	-1.531	0.1276
AGE	-2.537e+01	1.702e+01	-1.491	0.1378
WC:WHR	1.575e+01	1.074e+01	1.467	0.1443
WC:BMI	7.593e-01	4.644e-01	1.635	0.1039
WHR:BMI	6.234e+01	4.312e+01	1.446	0.1500
WC:AGE	2.882e-01	1.859e-01	1.550	0.1229
WHR:AGE	2.398e+01	1.704e+01	1.407	0.1611
BMI:AGE	1.189e+00	7.505e-01	1.584	0.1150
WC:WHR:BMI	-7.228e-01	4.603e-01	-1.570	0.1182
WC:WHR:AGE	-2.751e-01	1.849e-01	-1.488	0.1386
WC: BMI: AGE	-1.344e-02	8.015e-03	-1.677	0.0953
WHR:BMI:AGE	-1.119e+00	7.493e-01	-1.493	0.1372
WC:WHR:BMI:AGE	1.276e-02	7.949e-03	1.606	0.1101

Multiple R-squared: 0.2286, Adjusted R-squared: 0.1621, F-statistic: 3.437 on 15 and 174 DF, p-value: 3.977e-05

Table 4.15: Multivariate analysis for association between obesity indices and the diseases of female subjects

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-1.222e+01	2.276e+02	-0.054	0.957
WC	1.435e-01	2.649e+00	0.054	0.957
WHR	4.213e+01	2.497e+02	0.169	0.866
BMI	-4.775e-01	8.973e+00	-0.053	0.958
AGE	-1.613e-01	4.451e+00	-0.036	0.971
WC:WHR	-3.902e-01	2.818e+00	-0.138	0.890
WC:BMI	7.377e-03	9.183e-02	0.080	0.936
WHR:BMI	-8.310e-01	9.840e+00	-0.084	0.933
WC:AGE	2.244e-03	5.198e-02	0.043	0.966
WHR:AGE	-3.100e-01	4.886e+00	-0.063	0.949
BMI:AGE	1.477e-02	1.767e-01	0.084	0.933
WC:WHR:BMI	4.258e-03	9.823e-02	0.043	0.965
WC:WHR:AGE	2.051e-03	5.537e-02	0.037	0.970
WC:BMI:AGE	-2.146e-04	1.811e-03	-0.118	0.906
WHR:BMI:AGE	6.307e-03	1.941e-01	0.032	0.974
WC:WHR:BMI:AGE	2.227e-05	1.941e-03	0.011	0.991

Multiple R-squared: 0.1083, Adjusted R-squared: 0.04114, F-statistic: 1.612 on 15 and 199 DF, p-value: 0.07306

Table 4.16: Multivariate analysis for association between obesity indices and the diseases using AIC

Call Formula = MH ~ WHR + BMI + WHR: BMI

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-32.4478	8.9813	-3.613	0.000390	***
WHR	34.5824	9.1634	3.774	0.000216	***
BMI	1.2334	0.3525	3.499	0.000585	***
WHR:BMI	-1.2383	0.3585	-3.454	0.000684	***

Multiple R-squared: 0.138, Adjusted R-squared: 0.1241, F-statistic: 9.926 on 3 and 186 DF, p-value: 4.207e-06.

4.6 CORRELATION BETWEEN TRUNCAL OBESITY INDICES (WC AND WHR) AND BMI

4.6.1 Among Hypertensive group of Clients

In both male and female hypertensive clients, BMI correlated strongly with the waist circumference. In male hypertensive the Pearson's coefficient of correlation (r) was 0.776 while in females it was 0.778. However BMI had weak correlation with waist hip ratio in both sexes with r values of 0.181 and 0.365 in male and female hypertensive respectively.

4.6.2 Among Diabetic Clients

In the diabetic group of clients BMI and WC correlated strongly with r values of 0.70 and 0.70 in males and females respectively. A weak correlation was however observed between WHR and BMI in both male and female diabetics. In females r was 0.257 while in males r was 0.428

4.6.3 Among co-morbidity Clients

BMI correlated strongly with WC (r= 0.796) in female clients with both essential hypertension and type 2 diabetes mellitus. In the male subjects, there was however a weak correlation between BMI and WC (r 0.488). In both male and female clients with co-morbidity there was a weak correlation between BMI and WHR with Pearson's coefficient r = 0.099 for females and 0.152 for males.

Table 4.17: Correlation between Truncal Obesity Indices and BMI

Disease Condition	Sex	Variables	WC	W/H Ratio
Hypertensive	Female (n=137)	BMI (kg/m^2)	0.778**	0.365**
		WC		0.688**
	Male (n=96)	BMI (kg/m^2)	0.776**	0.181
		WC		0.266**
Diabetes	Female (n=36)	BMI (kg/m^2)	0.700**	0.257
		WC		0.630**
	Male (n=22)	BMI (kg/m^2)	0.707**	0.428*
		WC		0.692**
Co-morbidity	Female (n=42)	BMI (kg/m^2)	0.796**	0.099
		WC		0.313*
	Male (n=72)	BMI (kg/m^2)	0.488**	0.152
		WC		0.563**

4.7 DISCUSSION

The values of generalized obesity prevalence in this study are slightly higher than those obtained by Taiwo *et al.* (2015) who conducted a study to determine the prevalence of obesity as well as its predictors in a rural south western Nigeria and estimated obesity prevalence to be 10%. The finding of this study is also higher than a reported prevalence of 2% for obesity in a southern Nigerian community (Oladapo *et al.,* 2010). It is also higher than a reported prevalence of 4.3% from rural northern Nigeria by (Adediran *et al.,* 2012). It is however similar to the findings of (Ahaneku *et al.,* 2011) who reported generalized obesity prevalence of between 11.7% and 13.3% in a rural community in south eastern Nigeria. Even though the result of this study shows obesity rates to be higher than many studies in Nigeria, it is closer to the findings of Kolawole *et al.*(2011) which showed a prevalence of 21% for generalized obesity in a northern Nigerian community, but much lower than reported prevalence from some other parts of the world. For example the obesity levels (BMI > 30 kg/m2) range from below 5% collectively in China, Japan, India, Indonesia and certain African nations to over 75% in Samoa and Nauru (WHO, 2012). The wide variation in the global and local prevalence may be explained by genetic, environmental and socio cultural differences. And this may further explain the relative similarity in the obesity prevalence obtained from this study and that of Kolawole *et al.* (2011) conducted in northern Nigeria. However contrary to the findings of some researchers which show a high prevalence of generalized obesity in diabetics (WHO, 1995; Haslam and James, 2005; Victor *et al.,* 2014) its prevalence in male diabetics according to this study is 0%. This may either be due to relatively fewer number of male diabetics (only 22 subjects) recruited for this study or a pointer to the metabolic insignificance of generalized adiposity in the pathogenesis of type 2 diabetes mellitus in the male diabetics of Kano metropolis. Also the close values of the prevalence of generalized obesity using BMI in this study with those obtained from by the same index in many populations including Nigeria (Kolawole *et al.*, 2011) may suggest that BMI alone either plays minimal role in the risk of occurrence of these diseases or at least needs other factors with which it must interplay. However, the observation that among the female diabetics (36 subjects), a generalized obesity prevalence of 17.9% was obtained supports the reason of low sample size proportion for the unusually low prevalence of generalized obesity in male diabetics.

Overall the prevalence rates for Truncal obesity obtained in this study using both indices is higher than obtained from the general populace (community prevalence) according to literature. For example in 2011 an anthropometric study conducted in Kayseri, Turkey revealed the prevalence of truncal obesity to be 29.9% using waist to hip ratio as the obesity indicex and 50.4% using waist circumference (Sahin *et al*.,2011). A cross sectional observational study conducted among Indians to determine the prevalence of obesity by various markers showed a truncal obesity prevalence to be 16.4% using waist circumference (Pengpida and Peltzer, 2014). About 50% of men and 70% of women in the United States now exceed the waist circumference threshold for central obesity (Li *et al.*, 2007). A demographic health survey conducted in South Africa shows that about 10% of its population have isolated central obesity of which 9% were living with a metabolic problem attributable to hyperlipidemia (SADHS, 2003). Prevalence of abdominal obesity in southern Nigerian population was 21.75% by WHR. In men and women, it was 3.2% and 39.2% respectively (Chukuonye *et al.*, 2013). The higher prevalence of truncal obesity indices in this study and in other similar studies (Molarius *et al.,* 1999) may not be unconnected with the close relationship of truncal obesity with the metabolic diseases (Leopold *et al*., 2007). However worthy of mention is the lower prevalence of these indices in this study group compared to the results obtained from the general population in the United State and some European countries (Li *et al.*, 2007). The explanation for this may not be far from the same genetic, environmental and socio cultural factors that explain the difference in the generalized obesity prevalence between the two environments.

Generally, the commonest form of obesity observed in both sexes and in all the disease groups was truncal obesity using waist to hip ratio followed by truncal obesity using waist circumference and generalized obesity using BMI. Specifically in the hypertensive group of clients, truncal obesity using WHR had a relatively higher frequency of occurrence when compared to the diabetic group of clients, or clients with co morbidity. The pattern distribution of the obesity indices among the male and female subgroups shows that obesity is more common in the females when compared to males using two indices (waist circumference and BMI) out of the three. Only Truncal obesity defined by waist to hip ratio was fairly more common in male subjects (58.4% against 44.8%) This result is in keeping with the findings of some studies (Oladapo *et al.*, 2010; Adediran *et al*., 2012). A similar trend was reported by World Health Organisation in 2000. Also the study of obesity trend in northern Nigeria by Kolawole *et al.,* (2011) had a higher female predilection. In another study on a rural Africa population the prevalence of obesity was ten times higher in women than in men, irrespective of the definition used (Abubakari *et al*., 2008). Apart from genetic and hormonal differences, this can partly be explained by the high number of deliveries, as well as their lower level of physical activity (Sobngwi, Mbanya and Unwin, 2002). However a clear difference between the finding of this study and that of similar studies as cited above, is that one of the obesity indices (waist to hip ratio) is fairly more common among the male subjects with hypertension, diabetes or both as opposed to the above studies in which obesity is more common in females using all the indices of obesity. The reason for this may be because in this study the mean age (tables 2 and 3) of the male (56.89years) subjects was higher than the females (50.29years), and truncal obesity has been shown to increase with age (Sudera *et al*., 2015), this may partly explain why truncal obesity by waist to hip ratio is more common in the male subjects of this study.

In this study, BMI was not significantly associated with the diseases which are similar to the finding of Shaw *et al.,* 2010 which showed that diabetes or hypertension among Indians and Asians who had similar BMI was associated with truncal indices only. Contrarily, Kadiri *et al.,* 1997 in his study on obesity and associated factors in Nigerians showed BMI to be strongly associated with hypertension and diabetes. In another study to assess the discriminatory and cardiovascular predictive strengths of various obesity indices, BMI was the estimate of adiposity with the highest hazard ratio in the prediction of type 2 diabetes (Tulloch, *et al*., 2003). Furthermore, the results of studies in a multi ethnic group study has shown that BMI is more strongly associated with blood pressure than abdominal obesity (Seidell, *et al.,* 1991). The reason why BMI did not have a statistically significant association with hypertension and diabetes in this study like some other studies as cited above, is not very clear. But going by the pathological basis, the relationship between BMI and these diseases is closely linked to its ability to estimate total body fat (Chobanian *et al.,* 2003) and since blacks are known to have a lower body fat for the same BMI than Caucasians, this has implications on the inter-relationship between obesity and the other components of the metabolic syndrome (Deurenberg *et al.,* 1998). So it could be that the body fat contents of hypertensive and diabetics of Kano metropolis was low for their BMI and therefore was not significantly associated with the occurrence of these diseases. Also Abubakari *et al.,* (2008) in a study to determine the association between obesity and metabolic diseases in Africans revealed that the health disadvantage of obesity in African women is less than that in white women, and obesity would seem to have little influence on their proneness to hypertension, coronary heart disease and breast cancer. So it could also be that this reduced health disadvantage of obesity noticed among the female subjects of their study in an African population is found in both sexes of some other African community exemplified by Kano metropolis. Also, most of the subjects recruited for this study live a sedentary life style, in that while most of the males are stationary traders and business men, most women are full time house wives.

The statistically significant association between waist circumferences of male clients, waist-hip-ratio of the male clients, and waist-hip-ratio of the female clients to the metabolic diseases is in keeping with the findings of many studies. For example, Dagenais *et al., (*2005) followed nearly 8,000 subjects over the course of 4.5 years and reported that although the upper percentiles of BMI, WC, and WHR were all associated with increased relative risk for cardiovascular events, the magnitude of the association was greater for WC and WHR. Also Zhang *et al*., (2003) followed more than 29,000 men during a period of 3 years and reported WHR as a stronger predictor of risk of hypertension and diabetes compared with BMI. Similarly, a cross sectional study conducted in Zaria, northern Nigeria studied the waist circumference, body mass index and its correlation with the blood pressure of a sample of women and waist circumference was found to be a better measure in assessing obesity and thus cardiovascular risk among the subjects. In the same study, a significant positive correlation was found to exist between the waist indices and BMI (Achie *et al.*, 2012).

Contrary to the findings of the above cited studies, in this study there was no statistically significant association between the waist circumference of the female subjects and the occurrence of hypertension and diabetes. Possible explanation for this is that truncal obesity is known to correlate strongly with intra-abdominal visceral fat deposit which is a determinant of insulin resistance, a major step in the pathogenesis of the metabolic diseases (Elliot et *al.*, 2000). In this study it could be that the high values of truncal dimension obtained for the females may be due to laxity of the anterior abdominal wall muscles rather than intra-abdominal fat and therefore waist circumference did not have significant association with the metabolic diseases in question. The laxity of the anterior abdominal wall muscles may be expected in this age group of the females recruited for the study (> 40years) due to multiple deliveries.

In both male and female subjects of all the disease subgroup BMI strongly correlated with waist circumference but it correlated weakly with the waist to hip ratio in all the groups. A comparative study to compare the impact of differences in waist circumference (WC) defined according to the International Diabetes Federation (IDF) and the Adult Treatment Panel III (ATP III) and body mass index (BMI) on cardiovascular disease risk factors in 402 apparently healthy volunteers of European ancestry showed that WC and BMI significantly correlated ($p < 0.001$) (Marno *et al.*, 2008). Also (Ford *et al.*, 2003) in their study on anthropometric indices of obesity showed that measurements of body mass index (BMI) and waist circumference (WC) correlated highly ($r = 0.9$), regardless of age, gender, or ethnicity.

Similarly Achie and colleagues, 2012 in their study conducted in Zaria, a significant positive correlation was found between the waist circumference and BMI of the subjects. This may probably be due to the similarity between BMI and WC in their relationships with hypertension and diabetes mellitus.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The study aimed at quantifying the relationships between generalized obesity and Truncal obesity with essential hypertension and type 2 diabetes mellitus by finding the prevalence of the two forms of obesity, association between the various indices for the obesities and the occurrence of the diseases, and the correlation between the obesity indices in hypertensive and diabetic clients of Murtalal Muhammed specialist hospital Kano. Values were compared between the male and female subgroups.

Truncal obesity by waist- to- hip ratio was the most prevalent form in both males and females with hypertension, diabetes or both. It was highest in male diabetics (66.7%) and its highest value in females was also in female diabetic (47.8%). These values are much higher than those obtained from most community based prevalence. Generalized obesity was the least prevalent across all the subgroups of both sexes and was even 0% in the male diabetics. Truncal obesity was the most common type of obesity among the study subjects. Using all the indices, obesity was generally more common in the female subjects. Only obesity by waist hip ratio was fairly more common in males.

BMI did not have statistically significant association with the occurrence of the hypertension, diabetes or both but waist circumference and waist to hip ratio were significantly associated with the occurrence of hypertension and diabetes with the strength of association being stronger for waist hip ratio. But in female clients waist circumference did not have significant association with the hypertension or diabetes.

Among the obesity indices BMI correlated strongly with waist circumference but weakly with waist hip ratio in both sexes and in all the disease subgroups

5.2 CONCLUSION

Conclusively, waist–hip-ratio is the anthropometric index with the strongest association with essential hypertension and type 2 diabetes mellitus in this study. BMI had no significant association with the diseases, however waist circumference was significantly associated with the diseases only in male subjects. Generally obesity was more common in the female subjects.

5.3 RECOMMENDATION

1. There is the need to conduct similar study with a larger sample size of each disease subgroup in order to establish more detail relationship between these anthropometric indices and each of the diseases.

2. Measurement of waist-to-hip ratio and waist circumference should be employed by health care providers as an initial screening tool for individuals susceptible to these diseases.

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APPENDIX I

Proforma for data collection (Appendix 1)

Biodata

1. Code……….. 2. Sex ……………… 3.Age ……………………………

4. Occupation ……………………………………………………………..

5. Level of Education

Primary	Secondary	Tertiary	None

6. Medical history

Hypertensive	Diabetic	Hypertensive - diabetics
Number of follow up=		

7. Anthropometry

Variable	Measurement
Weight (kg)	
Height(meter)	
BMI(kg/m^2)	
Waist circumference(cm)	
Hip circumference(cm)	
Waist to hip ratio	

Consent form (Appendix 2)

Consent to Participate in this Research

1. Research Topic: The role of body mass index and truncal obesity as independent risk factors in the development of essential hypertension and type 2 diabetis mellitus

You are cordially invited to participate in this Msc. (Anatomy) academic research study to be conducted by ABDULLAHI ASUKU YUSUF from the Department of Anatomy, Faculty of Basic medical Sciences, BUK, Kano.

If you have any question or concerns about the research, please feel free to contact ABDULLAHI ASUKU YUSUF from the Department of Anatomy, Faculty of Basic medical Sciences, BUK, Kano.

Phone no: 08032878100

Email address: abdullahiyusif43@yahoo.com

1. **Purpose of the Study**

To determine if generalized obesity and truncal obesity are risk factors for essential hypertension and type 2 diabetes mellitus in our population.

2. **Procedures**

The data collection will involve collecting information with regards to bio-data, here the participant will be asked to provide some information relevant to his/her bio-data.

In the second phase of the study the medical history of the participant will be recorded followed by body variables; height, weight, hip and waist circumferences.

3. **Potential Risk and Discomfort**

There is no associated risk with this procedure and the only discomfort may be the time you will sacrifice and inconvenience while taking the measurements.

4. **Potential Benefits to Participant and/or to society**

This research will be of benefit to the participant and/or society in the following ways;

- The study may add value to risk identification strategies developed for sipping prototypes susceptible to essential hypertension and type 2 diabetes mellitus.
- The result of the study may be helpful to clinicians and health educators in the management of diabetes and hypertension.
- The findings may serve as a basis for formulation of recommendations for achieving the millennium development goals (MDG)

5. **Potential incentives for Participation**

Incentive in the form of free anti-diabetic and anti-hypertensive drugs or refreshment may be offered to the participant after participation

6. **Confidentiality**

Every effort shall be made to ensure confidentiality of identity for the information that is obtained in connection with this study. The variables and information collected shall be used in line with the aims and objectives of the study as well as scientific publications. I assure you that the information collected shall be kept in strict confidence.

7. **Participation and Withdrawal**

You may choose whether to participate in this study or otherwise. If you voluntarily accept to participate in this study without any legal recourse, you may withdraw at will and this shall not in any way affect the services being rendered to you.

You may also refuse to answer any questions you don't want to and still remain in the study.