High Body Mass Index (BMI): A Marker for Cardiovascular Diseases

[1] Sulaiman A.L, *[1] Yunusa U.M, [1] Yunusa I,[2] Bello H.J and[3] Maryam A.I
[1] Department of Biochemistry, Kano University of Science and Technology, Wudil, PMB 3244, Kano, Nigeria.
[2] Department of Biochemistry and Molecular biology, COMSAT's Institute of Information Technology, Pakistan.
[3]Department of Microbiology, Ahmadu Bello University, Zaria, PMB 1045, Kaduna Nigeria.
*Correspondence author: umarmuazuyunusa@gmail.com

Abstract
High BMI is a global epidemic and is an important risk factor for developing cardiovascular diseases (CVD). Obesity is a biomarker for CVD such as musculoskeletal disorder, HTN, dyslipidemia, thromboembolic disorders, stroke, coronary artery disease, liver and gall bladder disease, sleep apnea etc. The most commonly used anthropometric tool to assess relative weight and classify obesity is the BMI, which is expressed as the ratio of total body weight over height squared (kg/m^2). High BMI are indeed linked with certain pregnancy complications such as miscarriages, caesarean section, and adverse outcomes such as hemorrhage and babies needing neonatal care. Women who are overweight are more likely to be infertile and however being overweight affects the reproduction outcomes of ovulation. The adverse health consequences associated with obesity are mostly related to an increased adiposity rather than increased weight and it is therefore important that any indicator of obesity reflects this increased adiposity. Obesity is highly associated with elevated blood glucose, blood lipids and changes in the body weight which are coincident with changes in the risk factor for adult onset diabetes. Several studies have established the connection between high BMI and CVD in populations. BMI should be used as a measure to track overweight status in populations and as a screening tool to identify potential weight problems. Further information is needed to better understand the correlation of BMI and CVD as well as to know exact mechanism linking obesity and breast cancer.

Keywords: CVD, Adult onset diabetes, miscarriages, cancer.

INTRODUCTION

High BMI, which is defined as obesity, is a global epidemic and is an important risk factor for developing cardiovascular diseases (CVD) (Sowers, 2003). It is also associated with the cardiovascular (CV) risk factors such as hypertension (HTN), dyslipidemia, insulin resistance, and diabetes mellitus (DM) leading to CV diseases (CVD), such as coronary heart disease (CHD) and ischemic stroke (Wilkins *et al.*, 2010; Wormser *et al.*, 2011). The World Health Organization (WHO) has declared overweight as one of the top 10 health risks in the world and one of the top five in developed nations (WHO, 2002). In developing countries, the rate of obesity has tripled, which has been attributed primarily to adopting a modern lifestyle with less physical activity and excessive consumption of energy dense foods (Hossain *et al.*, 2007). According to a recent estimate, the total numbers of overweight and obese adults in 2005 were 937 million and 396 million respectively, accounting for a third of the adult population in the world (Kelly *et al.*, 2008). Adjusting for secular trends, by 2030, the absolute numbers of overweight and obese are projected to increase to 2.16 billion and 1.12 billion, respectively (Mishra *et al.*, 2009). Several studies have documented that a high BMI is significantly associated, in both men and women, with manifestations of CVD such as angina, myocardial infarction (MI), heart failure (HF) and sudden death (Marjorie *et al.*, 2014).

The adverse health consequences associated with obesity are mostly related to an increased adiposity rather than increased weight and it is therefore important that any indicator of obesity reflects this increased adiposity (Taylor *et al.*, 2002). Given the costs of obesity as the factor contributing to weight gain which is critical in order to identify those at greatest risk and develop interventions to curb obesity earlier in life (Margaret *et al.*, 2007). Elevated BMI is associated with a variety of adverse health effects including inflammation of joints and bones and certain types of cancers (Magdalena *et al.*, 2007), type 2 diabetes mellitus (Singh *et al.*, 2013), chronic kidney disease (Jiang *et al.*, 2012), musculoskeletal disorder (Jiang *et al.* 2011), high blood pressure, high level of triglycerides (dyslipidemia) (Bhaskaran at al., 2014), thromboembolic disorders, miscarriage, and caesarian section in birth (Davies, 2013).

WHO estimates that approximately 58% of diabetes mellitius, 21% of ischemic heart disease, and 8–42% of certain cancers can be attributed to BMI above 21 kg/m^2 (WHO, 2002). Risk estimates from population studies suggest that 75% of hypertension can be directly attributed to obesity. The risk of CVD varies by gender. Changes in HDL-C levels are usually more pronounced in women than in men (Poirier *et al.*, 2011). The association between obesity and LDL-C is more complex and its concentrations increase with BMI in men, but such an increase is not as pronounced in women. Furthermore, central obesity in women is associated with elevated LDL-C concentrations (Onat *et al.*, 2007). However, the effect of obesity on children is currently less well understood, in terms of the age at which risk parameters for cardiovascular disease begin to be affected and the magnitude of the effect (Claire, 2012). Nevertheless, a growing body of evidence suggests a similar association. In a 2009 study of children aged 1 to 17 years, being overweight increased the odds ratio for prehypertension by 50% and doubled or tripled the odds of hypertension, compared with normal weight children (Rosner *et al.*, 2009). This article reviews the metabolic consequences of high BMI as well as its pathological effects on cardiovascular diseases.

OBESITY MEASUREMENT AND GRADING

The most commonly used anthropometric tool to assess relative weight and classify obesity is the BMI, which is expressed as the ratio of total body weight over height squared (kg/m^2) (Lobstein *et al.,* 2004). Individuals with a BMI <18.5 kg/m^2 are considered as being underweight, whereas those with a BMI between 18.5 and 24.9 kg/m^2 are classified as having normal or acceptable weight. Individuals with a BMI ranging from 25 to 29.9 kg/m^2 are classified as overweight while obesity is present when BMI reaches ≥30 kg/m^2. Beyond that point, obesity is graded into 3 categories: grade 1 (BMI ranging from 30 to 34.9 kg/m^2), grade 2 (BMI ranging from 35.0 to 39.9 kg/m^2), and grade 3 (BMI ≥40 kg/m^2) (Poirier *et al.,* 2006). The American Heart Association has proposed additional obesity subgroups to take into consideration the rapidly expanding subgroup of patients with massive obesity and introduced grade 4 obesity corresponding to a BMI ≥50 kg/m^2 and grade 5 as a BMI ≥60 kg/m^2 (Poirier *et al.,* 2009; Poirier *et al.,* 2011).

OBESITY AND CARDIOVASCULAR DISEASES

Obesity is a biomarker for cardiovascular disease and other cardiovascular disease related disease such as type II diabetes (Lavie*et al.,* 2008), thrombolic disorders (Farquhar and Gillett, 2006), stroke, coronary artery disease, liver and gall bladder disease, sleep apnea, osteoarthritis cancer and cancer related mortality (CDC, 2011; Poirier *et al.,* 2006). Obesity has numerous consequences on the CV system (Marjorie *et al.,* 2014). Chronic accumulation of excess body fat leads to a variety of metabolic changes, not only increasing the prevalence of CVD risk factors but also affecting systems modulating inflammation (Poirier *et al.,* 2004). CVD risk factors, such as elevated blood pressure, elevated total cholesterol and low-density lipoprotein cholesterol (LDL-C), and low levels of high-density lipoprotein cholesterol (HDL-C) tend to increase with overweight and obesity (Bazzano *et al.,* 2003). In addition to its contribution as an independent CVD risk factor, obesity promotes alterations in other intermediate risk factors such as dyslipidemia, HTN, glucose intolerance, inflammatory state, obstructive sleep apnea/hypoventilation, and a prothrombotic state, as well as probably many additional unknown mechanisms (Wormser *et al.,* 2011). Obesity also induces a variety of structural adaptations/alterations in CV structure/function (Poirier *et al.,* 2004).

Overweight/obesity has become a serious health problem accompanying changes in dietary and physical activities and is increasing to epidemic proportion in most countries (Kumaniya *et al.,* 2008). Many studies have proved cardiovascular disease as main cause of mortality in both elderly population including women approaching menopause and children at adolescent age (Wu *et al.,* 2014). Obesity is among the leading cause of elevated cardiovascular disease (CVD) mortality and morbidity (Akil and Ahmad 2011). Obesity being a pandemic health concern with over 500 million adults worldwide estimated to be obese and 958 million were overweight as of 2008 (Doris *et al.,* 2014). Factors leading to the earlier stated problem include family situation, eating disorders, low socio economics status, malnutrition, stress, and lack of exercise (Dragano *et al.,* 2009; Siegrist and Marmot, 2004).

Obesity and heart diseases

Association between high BMI and overall risk for developing coronary heart disease (CHD) has increase 20% in overweight and 50% in obese individual, both overweight and obesity are associated with increased risk for developing atrial fibrillation (Lenz *et al.,* 2009). Stroke was also analyzed from obese people history of mild stroke, high level data were ascertained from those set of obese people in South American men and women. CHD were significantly higher in older men than women (Martha *et al.,* 2013). In a systematic evaluation of health effects of BMI, Global Burden of Disease found that excess body weight accounted for high

death mortality, nearly 70% of death that related to high BMI were due to cardiovascular disease and 60% of those death occurred in obese people, this estimated the relative risk for ischemic heart disease, ischemic stroke, hemorrhagic stroke and hypertensive heart disease (GBD, 2017).

Obesity and hypertension

CVD mortality and morbidity has shown to be elevated in people with high BMI, particularly with central deposition of fat tissues (Artherioscelerosis) (Van-Gaal *et al.,* 2006). Obesity is linked to high blood pressure. Persistent hypertension is one of the risks for stroke, myorcadial infarction, heart failure and arterial aneurysm, moderate elevation of arterial blood pressure lead to shortened life expectancy which will also increase the risk of heart disease (Akil and Ahmad, 2011). In another study, overweight men were at 1.5 times higher increase risk for developing hypertension over men with normal BMI baseline at 25. Men who were obese at baseline have > 4- fold increased risk for developing hypertension (Sibah *et al.,* 2012).

Obesity and Cancer

Obesity being a pandemic health concern is one of the established risk factor for breast cancer development in post-menopausal women (AICR, 2007). The biological mechanism linking obesity and breast cancer is not well established, but could involve interacting mediators of hormone, adipocytokines and inflammatory cytokines which link to cell survival or apoptosis, migration and proliferation of cell (Hursting and Berger, 2010). High BMI is consistently associated with very low survival of breast cancer base on analysis of individuals of 12 months before cancer diagnosis and 12 months after. Women who have higher BMI have increased risk of breast cancer mortality (Doris *et al.,* 2014).

Pancreatic cancer has higher number of fatality case, with an average of only 6% of individuals diagnosed with pancreatic cancer past 5 years (CFF, 2011). Pancreatic cancer incidence and mortality have shown positive association with BMI, 10% to 14% increased risk factor for each 5kg/m2 increment in body mass (Aune *et al.,* 2012; Genkinger *et al.,* 2011). Also positive linkage of pancreatic cancer mortality for both male and female in overweight and obese individuals were observed in measure of central obesity, waist circumference and waist to hip ratio (Genkinger *et al.,* 2015).

Obesity and diabetes mellitus

Diabetes is an important metabolic disorder which is characterized by hyperglycemia with variable degree of insulin resistance, impaired insulin secretion & increased glucose levels for Type-I (insulin-dependent) and Type-II (non-insulin-dependent) diabetes mellitus (Prakash *et al.,* 2015; Yadav *et al.,* 2016). Excessive body weight and lack of exercise are predominantly the most common causes of Type II DM (RSSDI, 2012). The prevalence of type 2 diabetes mellitus (T2DM) has significantly increased worldwide, which has resulted in an increased burden on individuals and health care systems (Eggers, 2011).

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality in those with diabetes. Multiple studies have shown that diabetes independently increases the risk for CVD up to 1.4-fold (Gandaglia *et al.,* 2013). The primary risk factors for heart disease associated with diabetes include dyslipidemia, elevated BMI, poor glycemic control, hypertension, insulin resistance, and history of smoking (Böhm *et al.,* 2007). Many factors such as obesity, physical inactivity, poor dietary habit, genetic and environment, oxidative stress with

increasing body mass index (BMI) are attribute to the pathogenesis of the disease (Gwarzo*et al.,* 2010).

Obesity is highly associated with elevated blood glucose, blood lipids and changes in the body weight which are coincident with changes in the risk factor for the disease (Din-Dzietham *et al.,* 2007). Increased body mass is one of the investigated factor for the disease (Waki, 2005). However, recent study shows the risk for developing type 2- diabetes which shows increase of about 20% for each $1kg/m^2$ rise in BMI, compared to individual with normal weight (Lenz *et al.,* 2009).

According to the overflow hypothesis, glucose and lipids are initially stored in the expanding subcutaneous adipose tissue compartment (Blauw *et al.,* 2017), but when the storage capacity of adipose tissue is exceeded, lipids can accumulate in organs (steatosis) including the muscles, liver, heart, and skeletal muscle, resulting in insulin resistance of those organs (Tchernof and Despres, 2013). Adult on-set diabetes can also develop when the pancreatic capacity to generate insulin cannot maintain the increased demand induced by insulin resistance (Philips *et al.,* 2007). Rapid absorbed carbohydrates which cause sudden increase in concentration of blood glucose place extra demand on the pancreases (Willett *et al.,* 2002). However, insulin resistance is not affected only by weight but rather by also increase in dietary fat (Vessby *et al.,* 2001). Visceral in the adipose tissue secretes cytokines such as interleukin -6 (IL-6) and tumour necrosis factor (TNF) which are important inducer of insulin resistance, circulating adinopectin, an adipocyte derived hormone which improves insulin sensitivity is reduced as the fat cell expand with body weight gain (Nishizawa *et al.,* 2002).

Obesity and joint pains

BMI is a useful indicator for obesity in association with Rheumatoid arthritis (Bhole *et al.,* 2012), Rheumatoid arthritis is among the common autoimmune disease, characterized by diffuse synovial inflammation and destruction (Baodong *et al.,* 2015). A combination of genetic background and environmental factor has considered to be associated with this complex disorder (Choy and Panayi, 2001). Foot joint pain are also associated with overweight and obese in either of the ways, foot join pain first developed and result in decrease of inactivity leading to weight gain (Anita *et al.,* 2014) or high BMI pain could cause increased load that is placed on the joints and structure of the feet with increasing body weight (Frey and Zamora, 2007; Irving, 2007).

Heel pain (Plantar fasciopathy PF), is a condition among athletic, community, occupational and military and is common in citing running injuries (Van Leeuwen et *et al.,* 2015). PF is described by pain or localized tenderness at the insertion of plantar fascia on the calcaneus, which become worse on bearing of weight in the morning or after periods of inactivity or with prolonged walking (Butterworth *et al.,* 2012)

Obesity and maternal complications

High BMI are indeed linked with certain pregnancy complications such as miscarriages, caesarean section, and adverse outcomes such as hemorrhage and babies needing neonatal care (Davies, 2013). Women who are overweight are more likely to be infertile and however being overweight affects the reproduction outcomes of ovulation (Farquhar and Gillett, 2006). Maternal obesity is associated with an increased risk for both maternal and neonatal complications (Callaway *et al.,* 2006). Obesity is associated with increased risk for gestational diabetes, caesarian section, hypertension and thrombeombolic disorders (Galtier *et al.,* 2000). Birth defects, macrosomia, admission to neonatal intensive care stillbirth and

prenatal death are all increase in infants of women who are obese (Ehrenberg *et al.,* 2004). However, menopausal women have higher BMI compared to premenopausal women (Magdalena *et al.,* 2007).

CONCLUSION

BMI is a reasonable indicator of obesity and cardio vascular complications for both adults and children. Several studies have established the connection between high body mass index and CVD in populations. BMI should be used as a measure to track overweight status in populations and as a screening tool to identify potential weight problems such as diabetes, HTN, joint pains, dyslipidemia, heart diseases, and maternal complications, in individuals.

RECOMMENDATIONS

Further information is needed to better understand the correlation of BMI and CVD as well as to know exact mechanism linking obesity and cancer most especially breast cancer.

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