

# Bio-Electric Impedance Analysis and Anthropometric Obesity Indices as Predictors of Dyslipidaemia Among Adults at A Tertiary Institution in Lusaka, Zambia.

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## Research note

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# Abstract

**Objective** Dyslipidaemia and obesity have a synergistic effect on the development of cardiovascular diseases (CVDs). Anthropometric measurements have often been used as surrogate markers for obesity indices with diverse results. We evaluated the best obesity index for predicting dyslipidaemia among anthropometric measurements and body fat measurements with bio-electric impedance analysis (BIA).

**Results** Among 116 adults, 62 (53.4%) were female. The median age was 39 years (quartile (Q)1, Q3: 20.8, 65.4). Waist circumference (odds ratio (OR) 4.54; 95% CI 1.56, 13.19;  $p=0.005$ ) and total body fat percentage (OR 0.34; 95% CI 0.13, 0.91;  $p=0.031$ ) measurements of obesity indices were significantly associated with dyslipidaemia.

## Introduction

The global incidence of obesity is rising continuously with a mirrored rise of associated complications such as cardiovascular diseases (CVDs) (1, 2). Unfortunately, resource limited settings have not been spared (3, 4). If this rise is not addressed aggressively, there is a risk of further decline in health indicators especially in poor countries, like Zambia, which are already dealing with a heavy burden of infectious diseases and malnutrition.

Atherogenic dyslipidaemia, characterized by hypercholesterolaemia, hypertriglyceridaemia, high low-density-lipoprotein cholesterol (LDL-c), low high-density lipoprotein cholesterol (HDL-c) as well as an increase in other small density lipoproteins (5), is a major metabolic risk factor associated with obesity, particularly visceral adiposity (central obesity). Combination of atherogenic dyslipidaemia and visceral adiposity is a typical finding of metabolic syndrome (MS), which promotes insulin resistance and is a major cause of CVDs (6, 7). Therefore, accurate determination of visceral adiposity is cardinal for the diagnosis of MS and abating of the associated cardiometabolic complications.

Zambia has recorded a steady rise in the prevalence of obesity with statistics indicating that the prevalence has more than doubled in 8 years from 3.8% in 2008 to 8.1% in 2016, mostly due to sedentary lifestyle and consumption of high dense energy diets (8, 9). In most Zambian studies, anthropometric measurements such as body mass index (BMI) and waist-circumference (WC) have been used as adiposity indices (10). However, a meta-analysis involving 32 studies and 31,968 participants showed that BMI cutoff values used to diagnose obesity have high specificity (0.90) but low sensitivity (0.50) in identifying adiposity, as such they failed to identify half of the people with excess BF percentage (12). While others have explored the use of WC to other surrogates such as Waist-to-Height ratio (WHtR) and Waist-to-Hip ratio (WHR) in the prediction of obesity and associated cardiometabolic risks, results have been conflicting depending on the phenotype of the participants(13–16). These variations therefore indicate that more population specific studies are required to determine traditional methods of anthropometry needed to measure excess body fat, as a useful guide to assess the cardiometabolic risks associated with obesity, as well as optimise preventive or therapeutic remedies.

Since visceral adiposity is major contributor to atherogenic lipid abnormalities, its accurate determination is pertinent in assessing such cardiometabolic risks. However, determination of visceral adiposity requires sophisticated equipment such as Dual Energy X-ray Absorptiometry (DEXA) and Computer Tomography (CT) scan (17–19), which are expensive, time-consuming and not readily accessible in almost all Zambian public hospitals. Bio-electric Impedance Analysis (BIA) can be used as a cheaper, non-invasive and more sensitive method to provide information on visceral adiposity (11). While Beeson *et al* found it to be a valid test and comparable to DEXA (20), others have reported conflicting results with variations in fat estimation in the lean and obese (21, 22), and hence indicated that it was not reliable in assessing CVD risks.

Information on the accuracy of anthropometric measurements and BIA as obesity indices in assessing cardiometabolic risks such as dyslipidaemia is limited in Zambia. This study aimed to identify the most appropriate obesity index for assessing abnormal lipid profiles among anthropometric parameters and body fat measures. We obtained the data from the control group (without any documented or known comorbidity) from an unpublished Master of Medicine in Internal Medicine dissertation (Mutengo *et al*, 2018) which looked at the clinical profile of dyslipidaemia among hypertensive adults in order to get a general picture of the obesity and dyslipidaemia status in the population not seeking health care.

## **Methods**

### ***Study design and population***

The data was from cross-sectional study of the control group with 116 participants who were enrolled from the Adult Outpatient Clinic (AOC) at the Lusaka Adult Hospital of the University Teaching Hospitals between January to June 2017.

### ***Data collection***

All participants were in an 8-12 hour overnight fasting state. Data included demographic information, blood pressure (BP) measurements taken after 5 minutes of rest, using an Omron M10-IT, anthropometry and BIA.

### ***Anthropometric Measurements***

Weight (in kilograms) was measured to the nearest 0.1 kg in light clothing and bare feet. Height (in metres) was measured to the nearest 0.1m using a stadiometer. Waist circumference (WC) was taken in an erect posture between the iliac crest and lower border of the last rib to the nearest centimetre while hip circumference was taken at the widest part of the buttocks using a dress-makers' tape measure.

### ***Visceral adiposity Measurement***

The 8-electrode (hand grips, anterior and posterior foot electrodes) TANITA BC-418 Segmental Body Composition Analyser, was utilised to assess fat tissue distribution. The height and age were entered on the control panel while the rest of the components such as the complete body composition profile (body weight, segmental and total BF percentage and mass, fat free mass, BMI, estimated muscle mass and total body water) were automatically calculated.

### ***Laboratory procedures***

Serum fasting blood glucose was measured with ACCUchek glucometer. A fasting blood glucose of  $\geq 7$  mmol/L was considered high. About 2mls of blood was drawn in heparinised bottles and analysed for serum plasma fasting lipid profile (TC, HDL-C, LDL-C and TG levels). Samples were analysed using standardised AU480 Beckman Coulter chemistry analyser.

### ***Case definition***

**Dyslipidaemia:** was defined as presence of one or more of the following in accordance with

the International Diabetes Federation (IDF) (7); Total Cholesterol of  $> 5.17$  mmol/L ( $>200$ mg/dl), Triglyceride  $> 1.7$ mmol/l ( $>150$ mg/dl), decreased HDL-C  $< 1.03$  mmol/L( $<40$ mg/dl) in males and  $< 1.3$  mmol/L ( $<50$ mg/dl) in females and elevated LDL-C  $> 3.36$ mmol/l ( $>130$ mg/dl).

**Obesity by BMI** – BMI was calculated by dividing weight with a squared height in metres (weight/height<sup>2</sup>). Obesity was considered as a BMI of  $\geq 30$  kg/m<sup>2</sup> according to the third report of the National Cholesterol Education Program Adult Treatment Panel-III (NCEP ATP III) (25).

**Central Obesity** - Waist circumference  $\geq 94$  cm for males and  $\geq 80$  cm for females and a waist-hip ratio of  $\geq 0.90$  for males and  $\geq 0.85$  for females by anthropometric measurements for the sub-Saharan population.

**Obesity by waist-to-height ratio (WHtR):** Defined as WHtR of greater than 0.5.

**Excess abdominal (visceral) fat:** This was central fat rating of 13 and above.

**Obesity by body fat percentage:** Defined as body fat greater than 25% for men and greater than 33% for women using BIA.

### ***Data analysis***

Data was entered in excel and thereafter exported to STATA version 16 for analysis. General characteristics and demographic information of study participants was presented using simple descriptive statistics. Means, medians, interquartile ranges (IQR), and standard deviations were calculated to describe the distribution of the variables. Continuous variables were tested for normality using the Shapiro Wilk test. Comparisons were made using Student t-test and Mann-Whitney U test. Chi-square was used to ascertain relationships between categorical variables. Two-sample-test of

proportions was used to determine the statistical difference between two proportions arising from independent samples. Logistic regression analysis (univariate and multivariate) was used to assess relationship between the dependent variable (dyslipidaemia) and various anthropometric and BIA obesity indices. Significant findings were reported taking into consideration a p-value of  $< 0.05$  for all the results.

## Results

### *Baseline characteristics of study participants*

Data from 116 participants was analysed. Of these, 62 (53.4%) were female. The median age of the study participants was 39 years old [Interquartile range (IQR) 30, 48]. There was no significant difference between the median age for males (40.6 years) and females (37.2 years) ( $p=0.71$ ). Demographic, clinical and biochemical parameters are as shown in Table 1. The male participants had a significantly higher WHR and TC than the females (0.86 vs 0.81,  $p<0.001$  and 4.28 vs 3.96,  $p=0.042$ , respectively). Only two respondents confirmed history of smoking and therefore smoking variable was not included for analysis.

### **Table 1: Demographics characteristics of study participants**

Variable	All participants N= 116	Male N=54	Female N= 62	P value
Age (years), median (Q1, Q3)	39 (30, 48)	40.6 (28.7, 48.3)	37.2 (31.5, 47.6)	0.71
BMI, mean (95% CI)	26.6(25.4,27.7)	26.8 (25.2, 28.4)	26.4 (24.7,28.0)	0.73
WC (cm), mean (95% CI)	83.6 (81.1,86.1)	84.8 (81.4, 88.2)	82.5 (78.9, 86.0)	0.36
WHR, mean (95% CI)	0.84 (0.82,0.85)	0.86 (0.84, 0.88)	0.81 (0.80, 0.83)	<b>&lt;0.001*</b>
WHtR, mean (95% CI)	0.50 (0.49,0.52)	0.50 (0.48, 0.52)	0.50 (0.49, 0.53)	0.77
Central fat rating, median (Q1, Q3)	8.9 (4.7, 14.4)	9.4 (4.4, 15.2)	8.4 (5.0, 13.3)	0.67
Total BF (%) <sup>a</sup> , median (Q1, Q3)	24 (14.1, 37.1)	21.2 (13.8, 38.5)	24.5 (14.5, 36.2)	0.80
SBP (mmHg), mean (95% CI)	116 (113,119)	115 (110, 120)	116 (113, 120)	0.66
DBP (mmHg), median (Q1, Q3)	76 (68, 83)	77 (66, 84)	74 (69, 82)	0.54
TC (mmol/L), median (Q1, Q3)	4.14(3.41,4.78)	4.28 (3.66, 4.87)	3.96 (3.29, 4.28)	<b>0.042*</b>
LDL-c (mmol/L), median (Q1, Q3)	2.65(2.05,3.02)	2.72 (2.27, 3.04)	2.39 (1.92, 3.00)	0.11
HDL-c (mmol/L), median (Q1, Q3)	1.38(1.20,1.61)	1.38 (1.16, 1.59)	1.38 (1.24, 1.62)	0.68
TG (mmol/L), median (Q1, Q3)	0.76(0.56,1.07)	0.81 (0.59, 1.12)	0.74 (0.52, 0.99)	0.28
FBG <sup>a</sup> (mmol/L), median (Q1, Q3)	5.2(4.9,6.0)	5.60 (5.20, 5.71)	5.4 (5.14, 5.67)	0.70
Alcohol (Yes), n (%)	76 (65.5)	32 (59.3)	44 (71.8)	0.19
**Exercise n (%)	76 (65.5)	32 (59.3)	44 (71.8)	0.19
Education level, n (%)				
No education	12 (10.3)	5 (9.3)	7 (11.2)	
Primary	41 (35.3)	22 (40.7)	19 (30.7)	

Secondary	50 (43.1)	21 (38.9)	29 (46.8)	0.71
Tertiary	13 (11.2)	6 (11.1)	7 (11.3)	

Abbreviations: BMI, Body Mass Index, WC, Waist Circumference, WHR, Waist-to-Hip ratio, WHtR, Waist-to-Height ratio, TBF, Total body fat, SBP, systolic blood pressure, DBP, diastolic blood pressure, BMI, Body Mass Index, HDL-c, high-density lipoprotein, LDL-c, low-density lipoprotein cholesterol, TG, triglyceride, FBG, fasting blood glucose, cm, Centimetres, BF, body fat \*Statistically significant. \*\*at least 150 minutes of moderate activities per week or 75 minutes of intense activities per week. <sup>a</sup> Missing values

### ***Dyslipidaemia according to anthropometry and BIA***

Figure 1 demonstrates box plots comparing the mean and median values of anthropometric and BIA measurement of participants who were dyslipidaemic. The mean WC was significantly higher among participants who were dyslipidaemic than those who were not (87.5 vs 81.0 cm,  $p=0.011$ ). The mean BMI, WHR and median total body fat percentage was higher in the dyslipidaemic participants (27 vs 25, 27 vs 25, and 24% vs 23%) than the non-dyslipidaemic. However, the differences in the two groups was not statistically significant.

### ***Predictors of dyslipidaemia among various anthropometric measurements and BIA***

Table 2 demonstrates factors associated with dyslipidaemia using anthropometric and BIA obesity indices. It has been projected in Table 2 that obesity indices as measured by WC (OR 2.24; 95% CI 1.04, 4.81;  $p=0.039$ ), central fat rating (OR 0.42; 95% CI 0.18, 0.95;  $p=0.038$ ) and total body fat (OR 0.36; 95% CI 0.16, 0.82;  $p=0.014$ ) were independently associated with dyslipidaemia. However, in the multivariate model, WC (OR 4.54; 95% CI 1.56, 13.19;  $p=0.005$ ) and total body fat percentage (OR 0.34; 95% CI 0.13, 0.91;  $p=0.031$ ) were significantly associated with dyslipidaemia among the study participants.

### **Table 2. Univariate and multivariate logistic regression model between various obesity indices and dyslipidaemia.**

Obesity indices/Dyslipidaemia regression	Univariate		Multivariate <sup>as</sup>	
	OR [95% CI]	P-value	OR [95% CI]	P-value
BMI	1.23 [0.56 - 2.71]	0.61		
WC	2.24 [1.04 - 4.81]	<b>0.039*</b>	4.54 [1.56 - 13.19]	<b>0.005*</b>
WHR	1.79 [0.80 - 4.00]	0.16	1.11 [0.42 - 2.90]	0.84
WHtR	1.08 [0.47 - 2.50]	0.86		
Central fat rating	0.42 [0.18 - 0.95]	<b>0.038*</b>	0.52 [0.21 - 1.30]	0.16
Total body fat	0.36 [0.16 - 0.82]	<b>0.014*</b>	0.34 [0.13 - 0.91]	<b>0.031*</b>

Abbreviations: BMI, Body Mass Index, WC, Waist Circumference, WHR, Waist-to-Hip ratio, WHtR, Waist-to-Height ratio, <sup>as</sup>age and sex included in the model, \*Statistically significant

## Discussion

The results from this study showed that the prevalence of obesity was high in the study population with both WC and total body fat being factors influencing dyslipidaemia among the adults in the study population.

Our study showed that male participants generally had higher anthropometric measurements and lipoproteins, with the exception of total body fat which was higher in women. The male population showed a significantly higher WHR and total cholesterol compared to females. The higher WHR in males can be partially explained by the anatomical make-up; females in the study population had more weight distributed around their hip and buttocks hence resulting in lower values of WHR compared to their male counterparts whose weight was distributed more centrally. In contrast, Njelekela et al in Tanzania found that women had higher WHR and lipoprotein abnormalities compared to the males (26). Additionally, population studies in Lusaka, Zambia, where all our participants came from also indicated higher anthropometry and lipoprotein abnormalities in women than men (9). But this was noted in older age groups (45 years and above) which contrasted which the younger age group in our study with a median age of 39 years.



Generally, most anthropometric indices were higher in the dyslipidaemic group than the non-dyslipidaemic group, reflecting findings from other studies (13, 28–30). Our study showed a mean WC to be significantly higher among participants who were dyslipidaemic than those who were not and generally in agreement with most studies which favour use of central obesity indices as surrogates in assessing cardiometabolic risk factors across various ethnic, regional and age groups (31–34). BIA methods of analysis did not show any significance association with dyslipidaemia in our study. This also concurs with the studies by Lee K *et al* in Korean men and Bosy-Westphal *et al* in the Dutch population which favoured the usefulness of anthropometry over direct body fat measurements for assessment of metabolic risks (24, 35). However, our study did not look at other metabolic indicators used in these studies such as insulin resistance by homeostasis model assessment (HOMA-IR), but it still provides useful baseline information on which obesity indicators can be utilized in our setting.

Various studies have indicated that anthropometric measurements and their associations with cardiometabolic risk factors such as dyslipidaemia, differ depending on demographic characteristics of study participants (13–15, 28, 31). In our study, WC was significantly associated with dyslipidaemia while WHR had the least association. The findings were similar to those in a large population survey in the United States among the Caucasians (36), the Tehranian men (37) and among the Mediterranean population (38) but in contrast with other studies, including a meta-analysis, which favoured WHtR as the best predictor of dyslipidaemia (28, 30, 32). Additionally, our study findings also contradicted some African studies that have favoured BMI as the best predictor for dyslipidaemia such as studies among the Sudanese and Ugandans which indicated BMI to be a strong predictor of dyslipidaemia (39, 40). However, these studies did not utilise the methods looking at body fat distribution.

We further noted that a unit increase in total body fat was significantly associated with reduced chance of dyslipidaemia, which in part may a contribution from women whose weight was generally distributed around the buttocks and hips, shown to be protective than the centrally distributed weights. Total body fat measurement by BIA is a reflection of overall fat distribution and does not give information on visceral fat distribution, which can vary at any given total body fat. A similar effect found with BMI which cannot differentiate between body fat distribution and fat mass (11, 24, 38).

Obesity indices from our study and other studies worldwide have shown variations based on population and demographic distribution. There is need for more Zambian studies on obesity indices that would predict dyslipidaemia in our population.

## **Conclusion**

Both WC and total body fat were important contributors to the understanding of dyslipidaemia risk factors among the adults in the study population. However, there is need for more robust epidemiological designs and consensus on the best age and sex dependent anthropometric and direct fat measurements indices useful in assessing cardiometabolic risks in the Zambian population.

### ***Study limitation***

This was a cross-sectional study and therefore the study did not determine the temporal sequence between dyslipidaemia and anthropometric indices. Additionally, the study population was small. We were unable to assess visceral fat levels using DEXA, or MRI due budget limitations. However, our study does highlight some of the parameters to look out for when assessing cardiometabolic risks.

## List Of Abbreviations

BIA: Bio-electric impedance analysis, BF: Body fat, BMI: Body mass index, CVD: Cardiovascular disease, HDL-c: High-density lipoprotein cholesterol, LDL-c: Low-density lipoprotein cholesterol, MS: Metabolic syndrome, WC: Waist-circumference, WHR: Waist-to-hip ratio, WHtR: Waist-to-height ratio.

## Declarations

### *Ethics approval and consent to participate*

Written informed consent was obtained from all study participants. Ethics approval from the parent study was obtained from the University of Zambia- Bio-medical Research Ethics Committee (UNZA-BREC), REF. No. 024-06-16.

### *Consent for publication*

Not applicable.

### *Data availability and material*

Data is available on reasonable request through the corresponding author.

### *Competing interests*

Authors declare no competing interests.

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Not applicable.

### *Author contributions*

KHM, SM and BCK conceived and designed the study and drafted the manuscript. PJC, DMC and BMH coordinated the study and drafted the manuscript. All authors critically reviewed the manuscript for its scholarly content and approved the final submission.

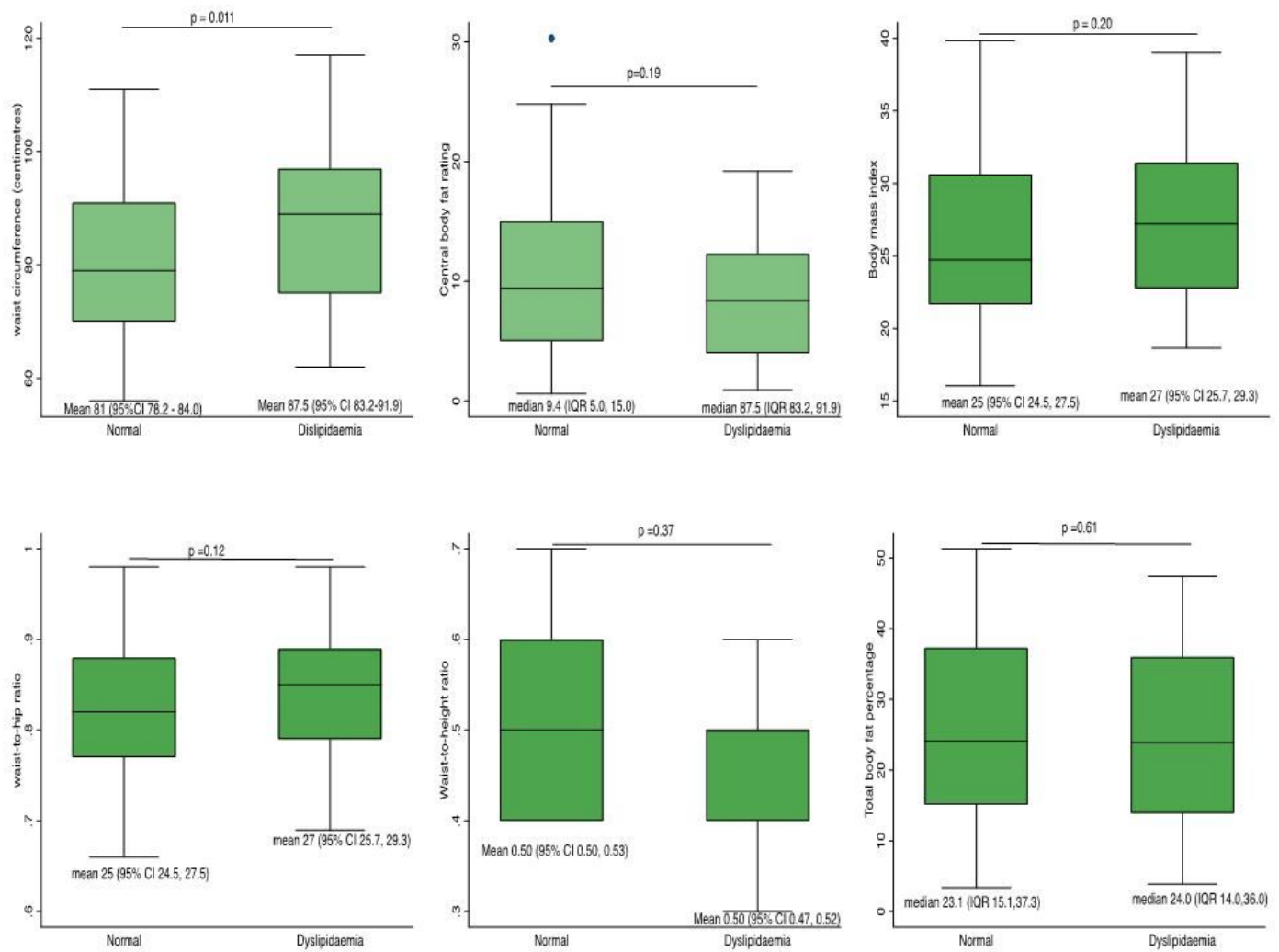
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## Figures



**Figure 1**

Dyslipidemia according to anthropometry and BIA among study participants (IQR- interquartile range; CI- Confidence Interval)