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Correlation between Body mass index, Waist Hip ratio, blood sugar levels and blood pressure in apparently healthy adult Nigerians

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Abstract:
Background: *Obesity is a global epidemic and is on the rise. Obesity is defined as a body mass index (BMI) which is equal to or more than 30kg/m^2. It is one of the modifiable risk factors of type 2 diabetes. This study was undertaken to assess the relationship between BMI, WHR, RBS and BP.* ***Method:*** *This cross-sectional study included 776 apparently healthy adult individuals who met the inclusion criteria. Random blood samples were collected to measure RBS using glucometers. Data on BMI, waist and hip circumference and blood pressure were collected from apparently healthy individuals.* ***Result:*** *The mean BMI was in the overweight range, 25.49±5.15 kg/m^2 and was higher in females. About two-thirds (62.8%) of the participants had abnormally elevated WHR. RBS, SBP and DBP increased significantly with increasing BMI status (p=0.000, p=0.000 and p=0.007 respectively) and were significantly higher with abnormally elevated WHR than in participants with normal WHR (p=0.000, p=0.000 and p=0.000 respectively). However, overweight individuals tended to have a higher RBS than the obese. There was a significant correlation between BMI and RBS (0.083, p=0.020), SBP (0.206, p=0.000) and DBP (0.152, p=0.000). There was a slightly stronger correlation between WHR and RBS (0.093, p=0.009), SBP (0.273, p=0.000) and DBP (0.217, p=0.000).* C***onclusion:*** *BMI and WHR are positively correlated with RBS and blood pressure in Nigeria. The Nigerian population is therefore at risk of Obesity and its related conditions (hyperglycemia and hypertension).*

Keywords: *Blood pressure, Body mass index, Obesity, Random blood sugar, Waist Hip ratio.*

I. Background

Body mass index (BMI) is a good measure of general adiposity [1]. A person can be categorized as underweight if his/her BMI is <18.5, as normal weight if his/her BMI is in the range of 18.5–24.9, as overweight if his/her BMI is between 25 to 29.9 and as obese if his/her BMI is ≥30[2]. An elevated BMI value is an established risk factor for ischemic heart disease, stroke and many cancers [3].
The global epidemic of Obesity is fast becoming a major public health problem and is worsening. In many populations, the average BMI has been rising by some percent per decade, thereby increasing concerns about the effects of increased adiposity on health [4].
The diagnosis of Obesity is usually based on BMI. However, Waist Hip ratio (WHR) is thought by some to be a more sensitive indicator of Obesity because of the inclusion of abdominal fat deposition in the Syndrome X [4]. Overweight or Obesity have been known to the medical profession for more than 2000 years [5]. Excessive body weight has become a major problem in industrialized and developed countries, where it has reached epidemic proportions [6, 7]. Individuals from the so called disadvantaged communities are not exempted from the epidemic. They are also at risk of obesity and its complications [8].

A number of large studies have proved that mortality increases with obesity [9-11]. Obese individuals are prone to many cardiovascular risk factors. Type 2 diabetes mellitus (T2DM) is strongly associated with overweight and obesity [12, 13]. Lipid metabolism is also adversely affected in obesity [7, 14]. The prevalence of these risk factors substantially increases with increasing BMI [15]. Overweight and obesity are also known to be independent risk factor for cardiovascular risk disease [14]. Increased body weight is a major risk factor for the metabolic syndrome which itself is a risk factor for coronary heart disease (CHD). Many studies have shown that individuals with metabolic syndrome are at high risk for the development of T2 DM [16-21]. Higher BMI in child hood is also associated with an increased risk for CHD later in life [22]. Impaired glucose tolerance is highly prevalent in children and adolescents with severe obesity [23]. Positive correlations between BMI and glucose levels (random and fasting), body lipids levels and blood pressure (BP) have been documented [24, 25].

Obesity is one of the most important modifiable risk factors in the pathogenesis of type 2 diabetes [26, 27]. The mechanism by which obesity induces insulin resistance is poorly understood. Adipocytes secrete a number of biological products (leptin, TNF-alfa, free fatty acids, resistin, and adiponectin) that modulate insulin secretion, insulin action and body weight and may contribute to insulin resistance [28]. The insulin resistant state that should enhance the regulation of calorie and fat metabolism during famine and prolonged periods of fasting can be deleterious. A positive correlation is assumed to exist between BMI and blood sugar levels. The prevalence of Diabetes Mellitus (DM) in adult Nigerian population is about 3.9% [29]. This is similar to other evolving populations in sub-Saharan Africa but is much lower than for Saudi Arabia and United Arab Emirates [29]. Population based preventive measures for the control of the DM epidemic must therefore include avoidance of adiposity through physical activity and regulated caloric intake [30, 31].
A positive correlation is thought to exist between random blood glucose and obesity. However, racial factors seem to be important in the relationship between body mass index and glucose intolerance because large studies such as the Scottish study did not demonstrate a correlation between casual blood sugar and BMI [32]. There are no previous studies in this region that sought to define the relationships between these variables. This study was undertaken to determine the correlation between random blood sugar (RBS), BMI and BP in a healthy adult Nigerian population.

II. Materials And Methods

A cross sectional study carried out in a semi-urban Local government Area (LGA) in Nigeria. Sagamu LGA is one of the 20 LGAs in Ogun state, Nigeria. The natives constitute part of the Remo ethnic division of Ogun state. It has an estimated population of about 269,890 and occupies an area of 640 square kilometers with an average density of 421 persons per square kilometer. The local Government has 15 political/administrative wards, 11 of which are located within the Sagamu metropolis. It is a major transit region between the southwest, southeast south- south and northern parts of Nigeria.

This household survey employed the multistage sampling technique to recruit 800 apparently healthy adults aged 18 years and above. Eight of the 15 wards were selected using simple random sampling by balloting. House numbering was done in each of the eight wards and 100 houses each were selected by stratified random sampling method. One eligible participant was recruited per house by simple random method via balloting. Data collection was done with a pretested and corrected questionnaire; Anthropometric, Laboratory and physiologic measurements were also done by duly trained final year medical students.

The questions included Age and sex while the anthropometric measurements included the height, Weight, Waist and Hip circumference.

Height was measured with stadiometer with the participants standing on and horizontal plane, heels together and stretching upwards to fullest with their hands loosely hanging down. Weight was measured with a properly calibrated portable weighting scale with participants standing erect, barefooted and wearing minimal clothes. The BMI was calculated. The individuals were classified on the basis of their BMI into Underweight (BMI<18.5), Normal (BMI of 18.5 to <25), overweight (BMI of 25 to <30) and Obese (BMI≥30).

The Waist circumference was measured as the abdominal girth at the midpoint between the costal margins and the anterior-superior iliac spine. The Hip circumference was measured at the level of the greater trochanters. Patients were classified as normal or abnormal based on the Waist Hip ratio (WHR). WHR>0.95 for males and >0.8 for females were considered to be abnormal. Males with WHR≤0.95 and females with WHR≤0.8 were considered to be normal.

Blood pressure was measured with aneroid sphygmomanometer as described by Rose et al [33]. Individuals were classified using the JNC7 report on the prevention, detection, evaluation and treatment of High Blood Pressure into Normal (<120/80mmHg), Pre-hypertensive (120-139/80-89mmHg) and Hypertensive (≥ 140/90mmHg) [34].

Random capillary blood samples were collected to measure RBS using Glucometers. Random capillary blood sugar level of 140mg/dl (7.7mmol/l) was used as cut off. This value gives the highest sensitivity and specificity for diagnosis of DM using the two hour postprandial plasma glucose of 200mg/dl or more (≥11.1 mmol/l) criterion [35].

The Data were entered into a computer and Statistical analysis was done using the SPSS 16.0 and WHO Anthro. Continuous variables were reported ad Means ± Standard deviation. Prevalence rates were expressed as percentages. Associations were tested using the student t-test, one way ANOVA and chi square test. The extent of association was measured using the Pearson correlation coefficient. Alpha level was set at 0.05.

III. Results And Discussion

Results

Seven hundred and seven six well filled data set were available at the end of the study.

A total of 776 individuals, 200 (25.8%) males and 576 (74.2%) females were examined. The mean age of the participants was 42.61±14.33 years. Among them, 232 (29.9%) were overweight and 136 (17.5%) were obese while, 28 (3.6%) were underweight. The mean BMI was 25.49±5.15 Kg/m^2. The mean WHR was 0.87±0.08. Among the participants 487 (62.8%) had abnormally high WHR (>0.95 in males and > 0.80 in females). Mean RBS was 98.22±17.92 mg/dl (Table-1).

Comparison of these parameters between males and females showed that BMI was significantly higher in females, whereas men had significantly higher WHR as expected. However, while men tended to have WHR within what is normally expected for their sex, women were shown to have abnormally high WHR than expected for their sex (Table-2).

Diastolic and Systolic blood pressures increased significantly with increasing BMI status and were significantly higher with abnormally elevated WHR than in participants with normal WHR. RBS was also significantly higher in those with elevated WHR than in those with normal WHR. RBS tended to increase significantly with increase in BMI status but overweight individuals tended to have a higher RBS than the obese (Tables -3 and 4).

Bivariate correlation analysis showed that SBP, DBP, RBS and WHR had positive correlation with BMI. They also had a positive correlation with WHR. The variables also showed a positive correlation among themselves except that the blood pressure (systolic and diastolic) was not correlated with RBS (Table 5).

After controlling for effects of age and sex the correlation of RBS, SBP and DBP with WHR decreased to 0.078 (p=0.029), 0.184 (p=0.000) and 0.166 (p=0.000) respectively. The correlation of SBP and DBP with BMI also decreased to 0.178 (p=0.000) and 0.123 (p=0.000) respectively whereas the correlation between RBS and BMI slightly increased to 0.084 (p=0.000). RBS still had no correlation with SBP (-0016, p=0.649) and DBP (0.009, p=0.806).

Discussion

There is a significant difference in the proportion of males and females that participated in the study. The males were often unavailable because they went out to make income for the sustenance of the family.

Overweight and obesity are some of the factors implicated in disease conditions including diabetes mellitus, and hypertension. Majority of the notable investigations about them have been carried out among western populations [7, 9-11, 14]. A few have also been done in Asian populations [36-38].

The frequency and severity of the related disease conditions are thought to increase with the increase BMI and or WHR (above normal). Our study demonstrated statistically significant differences between BMI groups (underweight, normal, overweight, Obese) and WHR groups (normal and abnormally elevated) for all the parameters that were tested (RBS, SBP and DBP). The overweight, obese and those with elevated WHR had higher values. These findings corroborate other studies, which showed that overweight and obesity are consistent parameters associated with cardiovascular risk in most populations [39-42].

The mean BMI found in our study was in the overweight range and is higher in females. This is similar to findings of another study in Nigeria [43]. High average BMI was also demonstrated in many studies in Asian [44-48]. Close to two-thirds of our study participants had abnormally elevated WHR.

In a country where majority of the population lives below poverty line and lacks proper nutrition food, the finding of an average BMI that is in the overweight and a majority with WHR values above normal values is surprising. The finding suggests that there are other factors other than food that are associated with being overweight and having abnormal fat deposition. There could be a possible interplay of genetic factors, sedentary lifestyle and lack of exercise.

Our study revealed that mean SBP, DBP, and RBS level showed a positive correlation with BMI and WHR. These findings are similar to majority of other findings in western populations [49, 50] and several Asian populations [25, 47, 48]. A few studies have however shown varied results. While a study in Zaria, Nigeria showed a positive correlation of BMI with RBS among males but no correlation among females [43], Bakari and his colleagues showed positive correlation of BMI with RBS in females but no correlation in males [43].

Our study showed that the correlation of mean SBP, DBP and RBS with WHR is consistently stronger than with BMI though both seem to be on the weak side. There are better ways of measuring obesity and body fat. Computed tomography (CT) scan and (Magnetic resonance imaging) MRI are the gold standard methods used to evaluate body fat distribution [51], but the WHR is a better and hence more commonly used to predict visceral fat accumulation in epidemiological studies [52, 53].

The correlation of BMI and WHR with RBS and Blood pressure were generally weakened after controlling for age and gender although they were still significant. Faheem et al had similar findings [36] while

Turcato et al showed that in both men and women, BMI-cardiovascular risk factors correlation was no longer significant after age adjustment [25].

IV. Conclusion

BMI and WHR are positively correlated with RBS and blood pressure in Nigeria. The Nigerian population is therefore at risk of Obesity and its related conditions (hyperglycemia and hypertension) like many western and Asian countries.

BMI or preferably WHR should be routinely checked in clinical practice and epidemiological surveys. There is a need for promotion of a healthy life style, regular exercise and proper nutrition.

V. Limitation Of The Study

The fasting blood sugar is the ideal measure of blood sugar level. However, its measurement was not quite feasible in this household based study. Hence (capillary) random blood sugar was used as an indicator of the blood sugar level. It is the most convenient of reaching large number of apparently healthy people.

VI. Conflict Of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

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Table 1: Frequency distribution of Respondents' parameters

Parameters	Frequency	Percentage
Age (in years)		
Less than 25	73	9.4
25-34	167	21.5
35-44	204	26.3
45-54	164	21.2
55-64	104	13.4
≥65	64	8.2
Sex		
Male	200	25.8
Female	576	74.2
BMI Classification		
Underweight	28	3.6
Normal weight	380	49.0
Overweight	232	29.9
Obese	136	17.5
Waist-Hip ratio		

Normal	289	37.2
Abnormal (elevated)	487	62.8
Blood pressure classification		
Normal	234	30.2
Pre-hypertension	273	35.2
Hypertension	269	34.7
Random blood sugar		
Normal	708	91.2
Hyperglycemia	56	7.2
Hypoglycemia	12	1.5

Table 2: Sex distribution of mean values of risk factors

Parameters	Male (n=200)	Female (n=576)	P value
BMI	23.26±3.33	26.26±5.45	0.000
WHR	0.90±0.08	0.86±0.07	0.000
RBS	98.88±18.92	97.99±17.57	0.544
Systolic BP	135.30±23.19	132.63±25.65	0.194
Diastolic BP	79.94±15.65	80.13±16.13	0.884

Independent sample *t*-test used for comparing means

Table 3: Distribution of mean values risk factors according to BMI groups

Parameters	BMI Groups				P value
	Underweight (n=28)	Normal weight (n=380)	Overweight (n=232)	Obese (n=136)	
RBS	91.86±14.02	96.81±16.17	101.14±20.64	98.47±17.67	0.000
Systolic BP	115.57±20.37	129.51±22.60	137.95±24.21	139.71±30.02	0.000
Diastolic BP	68.57±12.83	78.87±16.06	81.53±14.68	83.35±17.22	0.007

Differences between BMI groups compared using one way ANOVA

Table 4: Distribution of mean values risk factors according to WHR groups

Parameters	WHR Groups		P value
	Abnormal/elevated (n=487)	Normal (n=289)	
RBS	101.02±19.46	95.18±14.49	0.000
Systolic BP	137.07±26.74	126.99±20.46	0.000
Diastolic BP	82.19±16.75	76.53±13.95	0.000

Differences between WHR groups compared using one way ANOVA

Table 5: Correlation between BMI, RBS and BP {correlation coefficient (p-value)}

	BMI	WHR	RBS	Systolic BP	Diastolic BP
BMI	1				
WHR	0.148 (0.000)	1			
RBS	0.083 (0.020)	0.093 (0.009)	1		
Systolic BP	0.206 (0.000)	0.273 (0.000)	0.012 (0.737)	1	
Diastolic BP	0.157 (0.000)	0.217 (0.000)	0.025 (0.483)	0.750 (0.000)	1