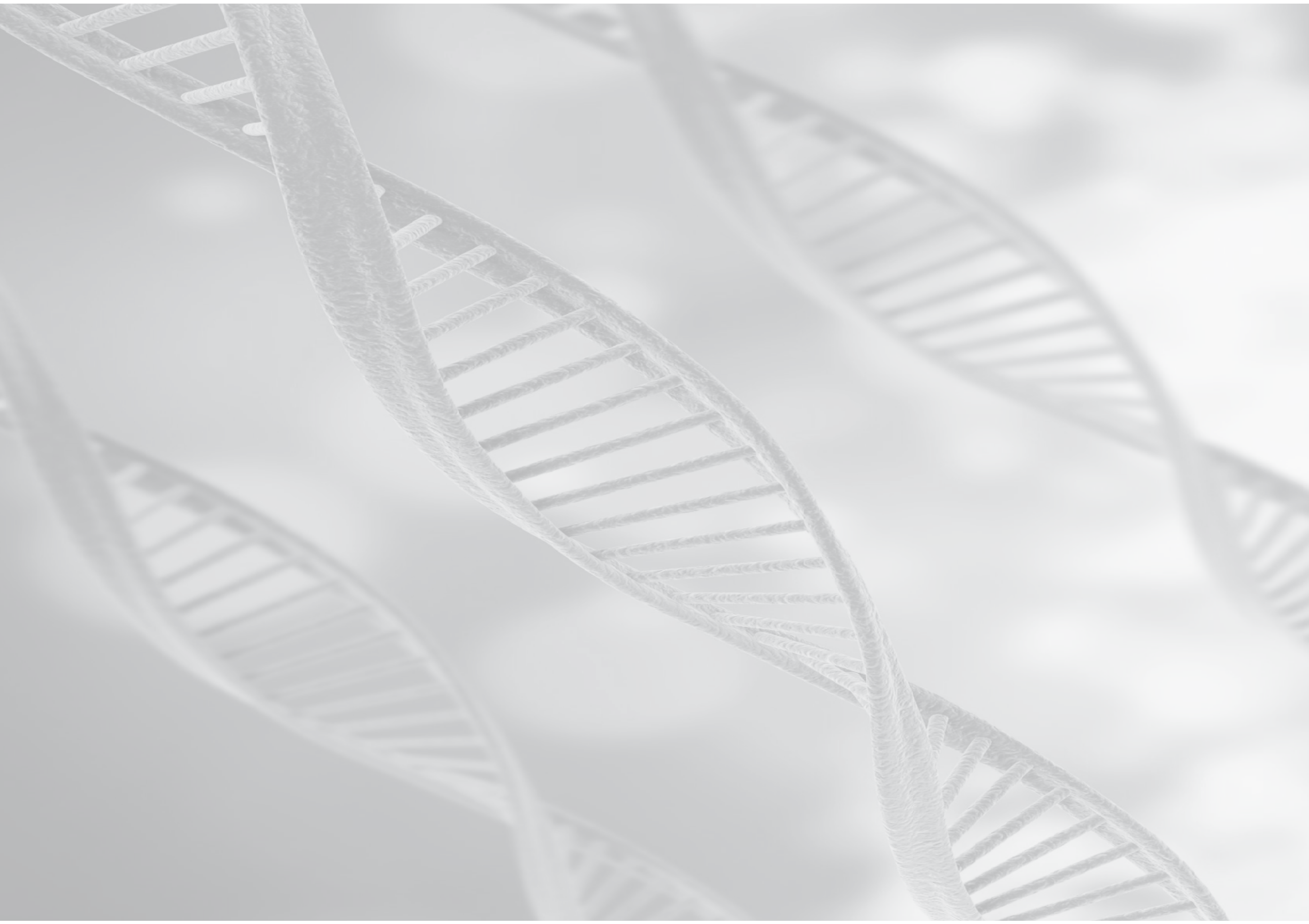
Correlation of Anthropometric Indices with Fasting Blood Glucose and Blood Pressure Among University Students in Kano, Nigeria

Number 2 Volume 17 July-December 2020

ISSN 0331-5340

NIGERIAN JOURNAL OF BASIC AND CLINICAL SCIENCES

Official Publication of College of Health Sciences, Bayero University Kano



Wolters Kluwer

www.njbcs.net

Medknow

Original Article

Correlation of Anthropometric Indices with Fasting Blood Glucose and Blood Pressure among University Students in Kano, Nigeria

Isyaku Mukhtar Gwarzo, Mabaruka Nasir Adam, Nafisa Yusuf Wali, Salisu Ahmed Ibrahim

Department of Human Physiology, Faculty of Basic Medical Sciences, Bayero University, Kano, Nigeria

Abstract

Context: Studies have suggested superiority of measures of central obesity over body mass index (BMI) in predicting cardiovascular risk. This multiplicity of anthropometric indices has led to inconsistency in their correlation with fasting blood glucose (FBG) and blood pressure. **Aim:** The aim of this study was to determine the prevalence of obesity using different anthropometric indices and their correlation with FBG and blood pressure among university students in Kano, Nigeria. **Materials and Methods:** One hundred and forty-eight participants were randomly selected for the study. Anthropometric indices, FBG and blood pressure were measured following standard protocols. Data were analysed using IBM SPSS version 23.0. Pearson's correlation coefficient was used to determine the relationship between quantitative variables. $P \leq 0.05$ was considered statistically significant. **Results:** The mean age of the participants was 22.09 years ± 4.03. The prevalence of obesity was: BMI – 4.8%, waist circumference (WC) – 23.1%, waist–hip ratio (WHR) – 31.76% and waist–height ratio (WHtR) – 31.76%. BMI was positively correlated with diastolic blood pressure (DBP) and mean arterial pressure (MAP). WC was positively correlated with systolic blood pressure (SBP), DBP and MAP. WHtR was positively correlated with SBP, DBP and MAP among female participants only. WHR was negatively correlated with DBP and MAP in male participants only. WC, WHtR and WHR were positively correlated with FBG among female participants only. **Conclusion:** The prevalence of obesity among undergraduate students in Kano is high. There was a wide variation in the correlation between anthropometric indices and FBG and blood pressure.

Keywords: Anthropometry, correlation, fasting blood glucose, Kano, undergraduates

Introduction

Obesity is a nutritional disorder characterised by excessive or abnormal fat accumulation and distribution that poses a significant risk to the health and life of an individual.[1] Globally, the prevalence of obesity was reported to have nearly tripled from 1975 to 2016, with about 1.9 billion people older than 18 years being overweight.[1] Nigeria and other countries in sub-Saharan Africa, who previously had lower prevalence rates, are now experiencing a trend similar to that of developed nations.[2] An earlier systematic review reported a prevalence of obesity of 8.8% in Nigeria and 14.4% in Ghana.[3] However, a more recent review in West Africa reported an overall prevalence ranging from 65.7% to 90% in West Africa, 4%–49% in Nigeria and 20%–60% in Ghana[4] using different anthropometric indices. Obesity is now regarded as a major risk factor for cardiovascular diseases (CVDs).[5]

Access this article online

Quick Response Code:

Website: www.njbcs.net

DOI: 10.4103/njbcs.njbcs_38_19

One effective way of reducing the impact of obesity is by active screening and identification of people at risk. To achieve this, various anthropometric indices have been used to assess body mass, composition and size with the aim of determining their relationship with cardiometabolic parameters. Traditionally, BMI has been used as a screening tool for obesity and risk stratification with some degree of success.[2] However, emerging evidences suggest that BMI may not be the ideal anthropometric index in assessing CVD risk because, abdominal obesity, not

Address for correspondence: Dr. Isyaku Mukhtar Gwarzo, Department of Human Physiology, Bayero University, Kano, Nigeria. E-mail: mukhtargwarzo@gmail.com

Submitted: 08-Dec-2019 **Revised:** 08-Jul-2020
Accepted: 27-Jul-2020 **Published:** 09-Oct-2020

How to cite this article: Gwarzo IM, Adam MN, Wali NY, Ibrahim SA. Correlation of anthropometric indices with fasting blood glucose and blood pressure among university students in Kano, Nigeria. Niger J Basic Clin Sci 2020;17:128-34.

general obesity that is measured by BMI, is associated with increased risk of CVDs.[6] This observation has led to emergence of many anthropometric indices for assessment of obesity which include waist circumference (WC), waist–hip ratio (WHR), waist–height ratio (WHtR) and others. The multiplicity of these anthropometric indices has, however, resulted in variations in prevalence of obesity; their correlation with FBG and blood pressure has also remained inconsistent depending on which index is used.[7-11] The aim of this study was to determine the prevalence of obesity using different anthropometric indices and their correlation with FBG and blood pressure among university students in Kano, Nigeria.

Materials and Methods

Study area and population

The study was conducted between September and November, 2019, at the Faculty of Basic Medical Sciences (FBMS), Bayero University, Kano, Nigeria. The study population was made up of all students in the faculty. The faculty has three departments, run four undergraduate programs and serves all undergraduate programs of College of Health Sciences.

Ethical clearance

Ethical approval for the study was obtained from the Ethics and Research Committee of Kano state ministry of health with reference number MOH/off/797/T.I/1650.

Study design and sampling technique

The study was a cross-sectional descriptive study. Cluster sampling technique was used to select FBMS out of all the faculties in the university. Simple random sampling was then used to recruit participants from various departments and programs in the faculty.

Sample size determination

Minimum sample size was determined using the formula for calculating sample size for health studies by Lwanga and Lemeshow:[12]

$n = Z^2pq/d^2$

where

n = minimum sample size

Z = standard normal deviate corresponding to 95% confidence interval = 1.96

p = proportion of obesity from a previous study = 8.9% = 0.089[13]

q = complimentary probability = (1− p) = 1–0.089 = 0.911

d = degree of precision = 0.05.

Therefore, $n = (1.96)^2 (0.089)(0.911)/(0.05)^2 = 124$.

Inclusion and exclusion criteria

All students of FBMS and those serves by the faculty were included in the study. However, students with history of hypertension and diabetes were excluded from the study.

Data collection

Data capture form was used to obtain sociodemographic information of the participants. Blood pressure was measured on the left arm with the participant seated calmly using mercury sphygmomanometer (Accoson™ Ltd., Ayrshire, UK) and Littmann stethoscope (3M Littmann®, Minnesota, USA). Systolic blood pressure (SBP) was taken as the first appearance of Korotkoff sound while its disappearance was considered diastolic. Fasting blood glucose (FBG) was measured after an overnight fast using an on-site Accu-Chek® glucometer (Roche Diabetes Care, Inc., Indianapolis, USA).

Anthropometric measurements

Weight was measured using Omron HN286 digital weighing scale (Kyoto, Japan) to the nearest 100 g with the participant wearing light clothing. Height was measured using stadiometer with the participant without shoes or cup and standing erect facing upward.[14] Waist and hip circumferences were measured following the WHO STEPwise protocol.[15] Participants were made to stand erect with their arms by the side, feet close together and weight evenly distributed. Hip circumference was measured at the widest point of the buttocks while WC was measured at a point midway between the lower margin of the last palpable rib and the top of iliac crest.

BMI was calculated as weight in kg divided by height in meter squared (kg/m^2). WHR was calculated as WC divided by HC and WHtR as WC (cm) divided by height (cm).

Definitions

BMI was classified according to WHO classification into underweight (<18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2) and obese (30 kg/m^2 and above).[16] WC and WHR were defined according to IDF's consensus worldwide definition of metabolic syndrome.[17] WC of <94 cm in males and <80 cm in females were considered normal while ≥94 cm in males or ≥80 cm in females were considered obesity. WHRs of ≥0.90 in males and ≥0.85 in females were considered obesity. A WHtR of ≥0.5 in both sexes was considered obesity.[18]

Hypertension was defined as SBP ≥130 mmHg and/or diastolic blood pressure (DBP) ≥85 mmHg.[17] While fasting blood sugar of <100 mg/dl, 100–125 mg/dl and ≥126 mg/dl were considered normal, prediabetes and diabetes, respectively.[17]

Statistical analysis

Data were analysed using the Statistical Package for Social Sciences (IBM SPSS) version 23.0 (IBM, Armonk, New York, USA). Independent t-test was used to compare the mean values of quantitative variables between male and female participants while Chi-square test of association was used to determine the association between categorical variables and sex. Pearson's correlation coefficient was used to determine the relationship between all quantitative variables. $P \leq 0.05$ was considered statistically significant, and results were presented as frequencies, percentages and mean ± SD.

Results

Sociodemographic characteristics of the participants

The mean age of the participants was 22.09 ± 4.03 years (16–42 years). There was no statistically significant difference in age between male and female participants (21.81 ± 2.86 and 22.21 ± 4.43; t = −0.54, P = 0.590). Majority of the participants (83.1%) had no family history of diabetes, and only 14.9% of the participants have had their blood glucose tested in the past and 42.6% were aware of a disease called diabetes [Tables 1 and 2].

Prevalence of prediabetes, diabetes, overweight, obesity and hypertension among the participants

Only 0.7% of the participants had prediabetes. Using BMI, the prevalence of overweight and obesity was 16.2% and 4.8%, respectively (males: 20.9% and 2.3%; females: 14.3% and 5.8%). Furthermore, 10.1% of the participants were underweight (males – 4.7% vs. females – 12.4%). The prevalence of truncal obesity using WC was 23.1% (males – 2.33% vs. females – 32.38%; χ^2 = 15.262, P = 0.001). Using WHR, the prevalence of obesity was 31.76% (37.21% vs. 34.29%; χ^2 = 0.114, P = 0.735). Similarly, using WHtR, the prevalence was 31.76% (males – 18.60% vs. females – 36.19%; χ^2 = 4.404, P = 0.036).

Table 1: Sociodemographic characteristics of the participants

Variable	*n* (%)
Department	
Anatomy	36 (24.3)
Physiology	46 (31.1)
Biochemistry	39 (26.4)
Others	27 (18.2)
Ethnicity	
Hausa	89 (60.1)
Yoruba	19 (12.8)
Others	40 (27.0)
Sex	
Male	43 (29.1)
Female	105 (70.9)
Level	
100	16 (10.8)
200	53 (35.8)
300	16 (10.8)
400	61 (41.2)
Spill over	2 (1.4)
Family history of DM	
Yes	25 (16.9)
No	123 (83.1)
DM test status	
Tested for DM before	22 (14.9)
Never tested for DM before	126 (85.1)
Awareness of DM	
Aware of DM	63 (42.6)
Not aware of DM	85 (57.4)
Smoking	
Known smoker	7 (4.7)
Not a known smoker	141 (95.3)
Alcohol	
Known alcoholic	0 (0)
Not a known alcoholic	148 (100)

DM: Diabetes mellitus

The prevalence of hypertension using SBP only was 11.5% (males – 25.58% vs. females – 5.71%; χ^2 = 11.843, P = 0.001). However, using DBP only, the prevalence was 15.5% (males – 32.56% vs. females – 8.57%; χ^2 = 13.373, P = 0.001). The results of prevalence of prediabetes, diabetes, overweight, obesity and hypertension among the participants are presented in Table 3.

Mean clinical and anthropometric parameters of the participants

The mean FBG of the participants was 95.51 ± 13.36 mg/dl (males – 100.51 ± 12.89 vs. females – 93.47 ± 13.06 mg/dl; t = 2.99, P = 0.003). The mean SBP, DBP and mean arterial pressure (MAP) of the participants were 118.36 ± 16.26 mmHg, 80.11 ± 12.86 mmHg and 92.73 ± 12.62 mmHg, respectively. Male participants had statistically significant higher mean SBP (124.19 ± 21.07 and 115.98 ± 13.21 mmHg, t = 2.86, P = 0.005), mean DBP (85.12 ± 12.61 and 78.06 ± 12.49 mmHg, t = 3.11, P = 0.002) and MAP (98.01 ± 14.20 and 90.57 ± 11.29 mmHg, t = 3.37, P = 0.001) than their female counterparts even though both had normal values.

The mean weight, height and BMI of the participants were 60.54 ± 12.16 kg, 1.63 ± 0.07 m and 22.77 ± 3.95 kg/m^2, respectively. The mean HC, WC, WHR and WHtR of the participants were 93.12 ± 10.49 cm, 77.91 ± 9.35 cm, 0.84 ± 0.06 and 0.48 ± 0.058, respectively. Female participants had statistically significant higher HC compared with their male counterparts (94.61 ± 10.67 and 89.44 ± 9.15 cm, t = −2.78, P = 0.006). WC, even though higher in females than males, was not statistically significant (78.26 ± 9.66 and 77.07 ± 8.58 cm, t = −0.70, P = 0.485). However, male participants had statistically significant higher WHR than their female counterparts (0.87 ± 0.09 and 0.83 ± 0.06, t = 3.03, P = 0.003) while female participants had statistically significant higher WHtR than their male counterparts (0.456 ± 0.048 and 0.489 ± 0.059, t = −3.19, P = 0.002). The result of mean clinical and anthropometric parameters of the participants is presented in Table 2.

Correlation within the anthropometric indices and with other clinical and laboratory parameters of the participants

There was a statistically significant positive correlation between FBG and age (r = 0.209, P = 0.011) and weight (r = 0.181, P = 0.028) among the participants. BMI was positively correlated with DBP (r = 0.238, P = 0.004), MAP (r = 0.196, P = 0.017), weight (r = 0.898, P = 0.001), HC (r = 0.703, P = 0.001), WC (r = 0.605, r = 0.001) and WHtR (r = 0.581, P = 0.001) among the participants. WC

Table 2: Mean values of the clinical and anthropometric parameters of the participants and their sex-related differences

Variable	Mean±SD			*t*-test	*P*
	All participants	Male	Female		
Age (years)	22.09±4.03	21.81±2.86	22.21±4.43	−0.54	0.590
SBP (mmHg)	118.36±16.26	124.19±21.07	115.98±13.12	2.86	0.005*
DBP (mmHg)	80.11±12.89	85.12±12.61	78.06±12.49	3.11	0.002*
MAP (mmHg)	92.73±12.62	98.01±14.20	90.57±11.29	3.37	0.001*
Weight (kg)	60.54±12.16	67.81±8.79	57.56±12.12	5.03	0.001*
Height (m)	1.63±0.07	1.69±0.05	1.60±0.06	8.02	0.001*
BMI (kg/m^2)	22.77±3.95	23.75±2.78	22.37±4.28	1.94	0.054
HC (cm)	93.12±10.49	89.44±9.15	94.61±10.67	−2.78	0.006*
WC (cm)	77.91±9.35	77.07±8.58	78.26±9.66	−0.70	0.485
WHR	0.84±0.07	0.87±0.09	0.83±0.006	3.03	0.003*
WHtR	0.48±0.058	0.456±0.048	0.489±0.059	−3.19	0.002*
FBG (mg/dl)	95.51±13.36	100.51±12.89	93.47±13.06	2.99	0.003*

*Statistically significant variable. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, BMI: Body mass index, WHR: Waist-hip ratio, WHtR: Waist-to-height ratio, FBG: Fasting blood glucose, WC: Waist circumference, HC: Hip circumference, SD: Standard deviation

Table 3: Prevalence of prediabetes, diabetes, overweight, obesity and hypertension among the participants

Variable	Categories	Overall, *n* (%)	Male, *n* (%)	Female, *n* (%)	χ^2	*P*
FBG (mmol/l)	Normal	147 (99.3)	43 (00)	104 (99.05)	0.412	1.000
	Prediabetic	1 (0.7)	0 (00)	1 (0.95)		
	Diabetic	0 (00)	0 (00)	0 (00)		
BMI (kg/m^2)	Underweight	15 (10.1)	2 (4.7)	13 (12.4)	2.041	0.360
	Normal	102 (68.9)	31 (72.1)	71 (67.6)		
	Overweight	24 (16.2)	9 (20.9)	15 (14.3)		
	Obese	7 (4.8)	1 (2.3)	6 (5.8)		
WC (cm)	Normal	113 (64.9)	42 (97.67)	71 (67.62)	15.262	0.001*
	Obese	35 (23.1)	1 (2.33)	34 (32.38)		
WHR	Normal	101 (68.2)	27 (62.71)	69 (65.71)	0.114	0.735
	Obese	47 (31.76)	16 (37.21)	36 (34.29)		
WHtR	Normal	101 (68.2)	35 (81.40)	67 (63.81)	4.404	0.036*
	Obese	47 (31.76)	8 (18.60)	38 (36.19)		
SBP (mmHg)	Normal	131 (88.5)	32 (74.42)	99 (94.29)	11.843	0.001*
	Hypertensive	17 (11.5)	11 (25.58)	6 (5.71)		
DBP (mmHg)	Normal	125 (84.5)	29 (67.44)	96 (91.43)	13.373	0.001*
	Hypertensive	23 (15.5)	14 (32.56)	9 (8.57)		

*Statistically significant variable, #Fisher's exact test. FBG: Fasting blood glucose, BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio, WHtR: Waist-height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

was positively correlated with age (r = 0.328, P = 0.001), SBP (r = 0.213, P = 0.009), DBP (r = 0.196, P = 0.017), MAP (r = 0.225, P = 0.006), weight (r = 0.584, P = 0.001), height (r = 0.165, P = 0.045), HC (0.739, P = 0.001), WHR (r = 0.446, P = 0.001) and WHtR (r = 0.933, P = 0.001) among the participants. WHtR was positively correlated with age (r = 0.336, P = 0.001), weight (r = 0.403, P = 0.001), hip circumference (r = 0.695, P = 0.001) and WHR (r = 0.403, P = 0.001) while it was negatively correlated with height (r = −0.198, P = 0.016) among the participants. WHR was positively correlated with hip circumference (r = 0.266, P = 0.001), WC (r = 0.446, P = 0.001) and WHtR (r = 0.403, P = 0.001) among the participants. The results of correlation analysis are presented in Tables 4-7.

Discussion

This study has demonstrated wide variations in the prevalence of overweight and obesity among the participants when different anthropometric indices are used. BMI recorded the least prevalence rate followed by WC and then WHR and WHtR that recorded an equal rate. This pattern is similar to what was reported by Sani *et al*.[19] in their analysis of cardiovascular risk factors among 300 apparently healthy adults in North-West Nigeria. They reported a lower prevalence of generalised obesity assessed using BMI compared to measures of truncal obesity. Similarly, Adaja and Idemudia[20] reported a lower prevalence of obesity using BMI compared to WC among hospital workers in South-South Nigeria. Furthermore, Haregu *et al*.[21] reported a similar pattern among a population of urban slum dwellers in Nairobi, Kenya. They found a lower

Table 4: Correlation between body mass index and other clinical and anthropometric parameters of the participants

Variable	All participants		Male		Female	
	r	*P*	*r*	*P*	*r*	*P*
Age	0.113	0.172	−0.105	0.501	0.160	0.103
SBP	0.078	0.344	−0.193	0.215	0.148	0.132
DBP	0.238	0.004*	0.051	0.743	0.253	0.009
MAP	0.196	0.017*	−0.064	0.684	0.245	0.012*
FBG	0.141	0.087	0.066	0.672	0.120	0.223
Weight	0.898	0.001*	0.876	0.001*	0.928	0.001*
Height	0.070	0.396	−0.087	0.581	−0.007	0.940
HC	0.703	0.001*	0.450	0.002*	0.844	0.001*
WC	0.605	0.001*	−0.053	0.713	0.788	0.001*
WHR	−0.036	0.668	−0.378	0.012*	0.037	0.705
WHtR	0.581	0.001*	−0.033	0.834	0.800	0.001*

*Statistically significant variable. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, FBG: Fasting blood glucose, WHR: Waist-hip ratio, WHtR: Waist-to-height ratio, WC: Waist circumference, HC: Hip circumference

Table 5: Correlation between waist circumference and other clinical and anthropometric parameters

Variable	All participants		Male		Female	
	r	*P*	*r*	*P*	*r*	*P*
Age	0.328	0.001*	0.114	0.467	0.379	0.001*
SBP	0.213	0.009*	0.081	0.604	0.334	0.001*
DBP	0.196	0.017*	0.045	0.774	0.281	0.004*
MAP	0.225	0.006*	0.067	0.671	0.338	0.001*
FBG	0.132	0.109	0.002	0.991	0.204	0.037*
Weight	0.584	0.001	0.107	0.496	0.803	0.001*
Height	0.165	0.045*	0.346	0.023*	0.206	0.035*
HC	0.739	0.001*	0.421	0.005*	0.846	0.001*
WHR	0.446	0.001*	0.642	0.001*	0.410	0.001*
WHtR	0.933	0.001*	0.963	0.001*	0.949	0.001*

*Statistically significant variable. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, FBG: Fasting blood glucose, WHR: Waist-hip ratio, WHtR: Waist-to-height ratio, HC: Hip circumference

Table 6: Correlation between waist-to-height ratio and other clinical and anthropometric parameters

Variable	All participants		Male		Female	
	r	*P*	*r*	*P*	*r*	*P*
Age	0.336	0.001*	0.032	0.841	0.403	0.001*
SBP	0.097	0.239	−0.047	0.767	0.290	0.003*
DBP	0.109	0.188	−0.096	0.541	0.279	0.004*
MAP	0.116	0.161	−0.080	0.611	0.319	0.001*
FBG	0.085	0.302	−0.044	0.782	0.222	0.023*
Weight	0.403	0.001*	0.001	0.995	0.696	0.001*
Height	−0.198	0.016*	0.079	0.613	−0.111	0.260
HC	0.695	0.001*	0.270	0.080	0.791	0.001*
WHR	0.403	0.001*	0.743	0.001*	0.406	0.001*

*Statistically significant variable. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, FBG: Fasting blood glucose, WHR: Waist–hip ratio, HC: Hip circumference

Table 7: Correlation between waist-hip ratio and other clinical and anthropometric parameters

Variable	All participants		Male		Female	
	r	*P*	*r*	*P*	*r*	*P*
Age	0.075	0.360	0.012	0.938	0.130	0.185
SBP	0.002	0.985	−0.200	0.197	0.087	0.377
DBP	−0.027	0.743	−0.357	0.019*	0.072	0.468
MAP	−0.018	0.829	−0.310	0.043*	0.087	0.379
FBG	0.144	0.080	−0.061	0.696	0.190	0.050*
Weight	−0.005	0.951	−0.465	0.002*	0.043	0.664
Height	0.095	0.250	−0.225	0.145	0.039	0.693
HC	−0.266	0.001*	−0.410	0.006*	−0.135	0.170

*Statistically significant variable. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, FBG: Fasting blood glucose, HC: Hip circumference

prevalence of obesity using BMI which was followed by WC and then WHtR with WHR recording the highest. However, the findings of this study contrast that of Ejike and Ijeh.[22] They reported the highest prevalence using BMI and least prevalence using WHR among a population of undergraduate students in South-East Nigeria. The apparent difference between this study and theirs could be due to the definitions of WHR used in the two studies. While we used a cut-off value of ≥0.9 to define obesity using WHR, they used a cut-off value of ≥1. There is thus tendency for this study to report higher prevalence of obesity using WHR because of lower cut-off point compared to theirs. Other possibilities are geographical and ethnic differences between the two study populations. Indeed, Kandala and Stranges[23] have reported striking geographical and ethnic differences in the prevalence of obesity in their analysis of data from the 2008 Nigerian Demographic and Health Survey. The survey used BMI as the anthropometric index for assessment of obesity. Hausa ethnicities from the core northern states, where this study was conducted, had relatively lower prevalence compared to Igbos from the southeastern states where their study was conducted. Kamadjeu *et al*.[8] also reported a different pattern from the cohorts of the Cameroon Burden of Diabetes Baseline Survey. BMI provided the highest prevalence while WHR had the lowest in men.

Sex-related analysis of the variations in prevalence of obesity using different anthropometric indices revealed a similar pattern to that of the combined group. BMI had the least prevalence followed by WC in both male and female participants. Significant sex-related variation in the prevalence of obesity was only observed in WC and WHtR; and while WHR had the highest prevalence of obesity among male participants, WHtR had the highest prevalence among female participants. Overall, the prevalence of obesity was higher among female participants using all the anthropometric indices except for WHR.

None of the four anthropometric indices correlated with FBG when the participants are considered as a whole. Equally, none of the four anthropometric indices correlated with FBG in male participants. However, FBG was positively correlated with WC, WHR and WHtR in female participants. Central obesity, not general obesity, is believed to be associated with diabetes in many epidemiological studies.[24-27] However, the relationship is not uniform across regions, ethnicities and anthropometric indices. Gezawa *et al*.[28] reported WC as an independent risk factor for type 2 diabetes in both sexes among a population of randomly selected participants in Maiduguri, northeastern Nigeria. While Cho *et al*.[25] reported a positive relationship between WC and DM among the Korean population, Lee *et al*.[26] reported WHtR as a better discriminator of DM than other anthropometric indices. In contrast, Akinola *et al*.[27] reported a positive relationship between FBG and BMI among a population of post-pubescent female Nigerians. Equally, Battie *et al*.[29] found no difference in the ability of BMI, WC and WHtR to predict DM or hypertension among Filipino-American women. In a review of published works relating measures of central and general obesity to risk of DM, Huxley *et al*.[9] concluded that the evidence supporting measures of central obesity as better predictors of DM compared to BMI is fairly strong. This conclusion agrees with the findings of this study concerning female participants; it, however, contradicts our findings on the participants as a whole and on the male participants. A relationship between measures of central obesity, DM and indeed CVDs tends to be influenced by ethnicity.[24] With most reviews focusing on works from Western countries and with cut-off points for the west being used to assess obesity in Africans, ethnicity could be a factor in the observed differences between this study and others. Differences in cut-off points (every region of the world has specific cut-off points other than Africa), differences in anatomical landmarks used for measurement and the smaller sample size in this study could also account for the differences (WHO, 2008).[16]

Obesity is characterised by excessive secretion of pro-inflammatory markers, hormones, cytokines and non-esterified fatty acids that lead to derangement in glucose tolerance, impaired insulin sensitivity, abnormal lipid metabolism and hence diabetes.[9] There is, however, a striking difference in tissue fat distribution and risk of diabetes. The epidemiological observation that centrally located fat, not the peripherally located fat, is what mediates the increased risk of diabetes in obese individuals is in part explained by the quantitative difference in the amount of non-esterified fatty acid and adiponectin secreted by the omental adipocytes.[30] In addition, the genes responsible for the synthesis and secretion of the proteins implicated in the processes leading up to the development of diabetes in obese individuals are more related to the intra-abdominal fat than to peripherally located fat.[30]

Anthropometric indices varied greatly in their relationship with SBP, DBP and MAP among the participants. WC was the most consistent anthropometric index that positively correlated with SBP, DBP and MAP among all the participants as a whole and among female participants. It, however, did not correlate with any among male participants. Equally, BMI was positively correlated with DBP and MAP among all the participants as a whole and among female participants. WHtR was positively correlated with DBP and MAP in female participants only while WHR was negatively correlated with DBP and MAP in male participants only. This is similar to what was reported by Gezawa *et al*.[28] from Maiduguri in northeastern Nigeria. They reported BMI and WC to be independently associated with hypertension. However, while this study reported a positive correlation between BMI, WC and SBP, DBP and MAP among all participants and female participants, that of their study was found only in male participants. Their study had a sample size that is 10 times ours, and they used different cut-off points for defining hypertension and other anthropometric indices; theirs was conducted in an ethnically different environment; they also reported a higher prevalence of hypertension among female participants while male participants had a higher prevalence of hypertension in ours. These could be the reasons for the observed differences between the two studies. Indeed, data from three population-based studies have demonstrated a significant relationship between hypertension and WC and BMI.[31] Equally, Kucience and Dulskiene[32] reported a positive correlation between hypertension and WC and BMI in a study of adolescent Lithuanians. However, a study on hypertensive, diabetic and hypertensive diabetic patients found a positive correlation between WC and hypertension only among male participants.[33]

The relationship between hypertension and anthropometric indices is fairly consistent.[9] There are, however, notable exceptions. In a systematic review and meta-analysis of 30 studies consisting of over 300,000 participants from different ethnicities, Ashwell *et al*.[34] reported superiority of WHtR over other anthropometric indices, especially WC, in discriminating hypertension. Obesity, both general and central, is believed to be associated with increased sympathetic activity, activation of the renin–aldosterone–angiotensin system, vascular endothelial dysfunction and alterations in renal function.[35] These factors, either in isolation or in combination, can lead to elevation in blood pressure. By far, altered sympathetic activity in obese individuals has received the most attention. Increased sympathetic activity causes generalised peripheral vasoconstriction and enhanced renal sodium reabsorption, both of which can cause elevation in blood pressure. Indeed, human and animal studies have demonstrated increased renal sympathetic activity in obese participants.[36,37] Leptin, the appetite-regulating hormone, is also believed to act on the hypothalamus of obese individuals to cause increased sympathetic discharge.[38,39]

Conclusion

The prevalence of central obesity among undergraduate students in Kano is very high. There was a wide variation in the correlation between anthropometric indices and FBG and blood pressure.

Acknowledgement

We will like to thank the leadership of FBMS for allowing us access to the students of the faculty.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organization. Obesity and Overweight. Geneva, Switzerland: World Health Organization; 2018. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. [Last accessed on 2019 Dec 05, 7:10 am].
2. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Mergono C, *et al*. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384:766-81.
3. Abubakari AR, Bhopal RS. Systematic review on the prevalence of diabetes, overweight/obesity and physical inactivity in Ghanaians and Nigerians. Public Health 2008;122:173-82.
4. Commodore-Mensah Y, Samuel LJ, Dennison-Himmelfarb CR, Agyemang C. Hypertension and overweight/obesity in Ghanaians and Nigerians living in West Africa and industrialized countries: A systematic review. J Hypertens 2014;32:464-72.
5. WHO Regional Committee for Africa. Cardiovascular Diseases in the African Region: Current Situation and Perspective. Regional Committee for Africa Fifty-fifth Session Maputo, Mozambique. WHO. Regional Office for Africa: Maputo; 2005.
6. Rothman KJ. BMI-related errors in the measurement of obesity. Int J Obes (Lond) 2008;32 Suppl 3:S56-9.
7. Larsson B, Svärdsudd K, Welin L, Wilhelmsen L, Björntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. Br Med J (Clin Res Ed) 1984;288:1401-4.
8. Kamadjeu RM, Edwards R, Atanga JS, Kiawi EC, Unwin N, Mbanya JC. Anthropometry measures and prevalence of obesity in the urban adult population of Cameroon: An update from the Cameroon Burden of Diabetes Baseline Survey. BMC Public Health 2006;6:228.
9. Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist: Hip ratio as predictors of cardiovascular risk--a review of the literature. Eur J Clin Nutr 2010;64:16-22.
10. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. Eur J Clin Nutr 2010;64:42-61.
11. Seidell JC. Waist circumference and waist/hip ratio in relation to all-cause mortality, cancer and sleep apnea. Eur J Clin Nutr 2010;64:35-41.
12. Lwanga SK, Lemeshow S. Sample Size Determination in Health Studies: A Practical Manual. Geneva, Switzerland: World Health Organization; 1991.
13. Kakale IS, Umar UI, Gwarzo GD, Ibrahim M. Prevalence of childhood and adolescent overweight and obesity in Kano state, Nigeria. EC Paediatr 2018;7:231-8.
14. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Champaign, Illinois; Human Kinetics Books: 1988. p. 3-8.
15. World Health Organization. WHO STEPwise Approach to Surveillance (STEPS). Geneva, Switzerland: World Health Organization; 2008.
16. Obesity: Preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000;894:i-xii, 1-253.
17. International Diabetes Federation. The IDF consensus worldwide definition of the Metabolic Syndrome. Brussels, Belgium: IDF Communications, IDF: 2006.
18. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr 2005;56:303-7.
19. Sani MU, Wahab KW, Yusuf BO, Gbadamosi M, Johnson OV, Gbadamosi A. Modifiable cardiovascular risk factors among apparently healthy adult Nigerian population-a cross sectional study. BMC Res Notes 2010;3:11.
20. Adaja TM, Idemudia OJ. Prevalence of overweight and obesity among health-care workers in University of Benin Teaching Hospital, Benin City, Nigeria. Ann Trop Pathol 2018;9:150-4.
21. Haregu TN, Oti S, Egondi T, Kyobutungi C. Measurement of overweight and obesity an urban slum setting in sub-Saharan Africa: A comparison of four anthropometric indices. BMC Obes 2016;3:46.
22. Ejike CE, Ijeh II. Obesity in young-adult Nigerians: Variations in prevalence determined by anthropometry and bioelectrical impedance analysis, and the development of % body fat prediction equations. Int Arch Med 2012;5:22.
23. Kandala NB, Stranges S. Geographic variation of overweight and obesity among women in Nigeria: A case for nutritional transition in sub-Saharan Africa. PLoS One 2014;9:e101103.
24. Goh LG, Dhaliwal SS, Welborn TA, Lee AH, Della PR. Ethnicity and the association between anthropometric indices of obesity and cardiovascular risk in women: A cross-sectional study. BMJ Open 2014;4:e004702.
25. Cho NH, Jang HC, Park HK, Cho YW. Waist circumference is the key risk factor for diabetes in Korean women with history of gestational diabetes. Diabetes Res Clin Pract 2006;71:177-83.
26. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: A meta-analysis. J Clin Epidemiol 2008;61:646-53.
27. Akinola OB, Omotoso OG, Akinlolu AA, Ayangbemi KD. Identification of the anthropometric index that best correlates with fasting blood glucose and BMI in post-pubescent female Nigerians. Anatomy J Afr 2014;3:324-8.
28. Gezawa ID, Puepet FH, Mubi BM, Uloko AE, Bakki B, Talle MA, Haliru I. Socio-demographic and anthropometric risk factors for type 2 diabetes in Maiduguri, North-Eastern Nigeria. Sahel Med J 2015;18:S1-7.
29. Battie CA, Borja-Hart N, Ancheta IB, Flores R, Rao G, Palaniappan L. Comparison of body mass index, waist circumference, and waist to height ratio in the prediction of hypertension and diabetes mellitus: Filipino-American women cardiovascular study. Prev Med Rep 2016;4:608-13.
30. Al-Goblan AS, Al-Alfi MA, Khan MZ. Mechanism linking diabetes mellitus and obesity. Diabetes Metab Syndr Obes 2014;7:587-91.
31. Wu X, Yang X, Shan R, Li T, Zi T, Li Y, *et al*. Potential mediating biomarkers underlying the association of body mass index or waist circumference with blood pressure: Results from three population-based studies. Sci Rep 2017;7:5364.
32. Kucience R, Dulskiene V. Associations between body mass index, waist circumference, waist-to-height ration, and high blood pressure among adolescents: A cross-sectional study. Sci Rep 2019;9:9493.
33. Asuku AY, Adamu LH, Tela IA, Gudaji A, Datti S. Relationships of anthropometric indices of centripetal adiposity with essential hypertension and type 2 diabetes mellitus in Kano metropolis. Niger J Basic Appl Sci 2017;25:32-9.
34. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and MBI for adult cardiometabolic risk factors: Systematic review and meta-analysis. Obst Rev 2011;13:275-86.
35. Rahmouni K, Correia ML, Haynes WG, Mark AL. Obesity-associated hypertension: New insights into mechanisms. Hypertension 2005;45:9-14.
36. Vaz M, Jennings G, Turner A, Cox H, Lambert G, Esler M. Regional sympathetic nervous activity and oxygen consumption in obese normotensive human subjects. Circulation 1997;96:3423-9.
37. Hall JE. The kidney, hypertension, and obesity. Hypertension 2003;41:625-33.
38. Carlyle M, Jones OB, Kuo JJ, Hall JE. Chronic cardiovascular and renal actions of leptin: Role of adrenergic activity. Hypertension 2002;39:496-501.
39. Hall JE, do Carmo JM, da Silva AA, Wang Z, Hall ME. Obesity-induced hypertension: Interaction of neurohumoral and renal mechanisms. Circ Res 2015;116:991-1006.