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Original Research Article

Cross-Sectional Analysis of Cardiovascular Risk Markers among Obese Males and Females in Southern Nigeria

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Abstract: Several studies in different populations indicate that obesity is a significant risk factor to the development of cardiovascular diseases, in part through its associations with dyslipidemia, atherosclerosis and high blood pressure. This study aims at evaluating lipid profile parameters, atherogenic index of plasma and anthropometric parameters among obese subjects in calabar, Nigeria. A total of one hundred and sixty subjects (160) were recruited for the study. One hundred and ten (110) obese subjects and fifty (50) non-obese control subjects. Anthropometric parameters and blood pressure were measured; body mass index and waist-hip ratio were calculated for all the participants recruited in this study. Obese subjects were further grouped based on their BMI values as; class I (BMI 30-34.9kg/m^2), class II (BMI 35-39.9kg/m^2) and class III (BMI 40kg/m^2 and above). Total cholesterol and triglycerides were determined using the enzymatic colorimetric method; high density lipoprotein cholesterol was determined using precipitation cholesterol enzymatic method. Low density lipoprotein cholesterol was calculated using the Friedewald*et al.*, equation. Atherogenic index of plasma was calculated from the concentrations of TG and HDL using the formula; log TG/HDL.The mean values of T-C, TG, LDL, VLDL, AIP, SBP and DBP were significantly higher in obese subjects compared to the non-obese apparently healthy controls ($P<0.05$). HDL was however significantly lower in the obese participants compared to the controls ($P < 0.05$). The values of WHR, TG, VLDL, DBP and AIP were significantly higher in male obese subjects compared to obese female ($P<0.05$). A significant positive correlation was observed between WHR and TG ($r = 0.260$), BMI and SBP ($r = 0.380$), WHR and AIP ($r = 0.244$), among the obese subjects.Findings from the study suggest that obesity is a strong predictor of dyslipidemia which is associated with cardiovascular risk factors such as high blood pressure.
Keywords: Total cholesterol, atherogenic index of plasma, Obesity, Triglyceride, Systolic blood pressure

INTRODUCTION

Obesity is an important contributor to ill health and is now so common in our population that it is beginning to relieve undernutrition as a major disease that affects health[1]. Worldwide, obesity ranks second after smoking as the cause of avoidable deaths and its prevalence is increasing in children and adults; some medical researchersstatethat it is the most serious health challenge of this century [2].

Obesity results from the accumulation of excessive body fatthat often present a risk to health[3]. The state of one being obese is usually defined using body mass index, which is a derived by dividing an individual's weight measured in kilogram by the square of his/her height measured in meters[4]. Body mass index of 30kg/$m^2$and above marks obesity; while ranges between 25-30kg/m^2define overweight [3].

Over 60million fully grown individuals in the U.S. have been identified as been obese with BMI of 30kg/$m^2$and above, also surprizing is the fact that the prevalence of obesity has steadily gone up to30% during the past decade [5].Often thought to be a challenge only in countries with high income, overweight and obesity are now also gradually increasing in developing countries and is affecting the general world population. Herein Nigeria, the prevalence of overweight individuals has been reported to range from 20.3% to 35.1%, 8.1% - 22.2% for obesity [6].

Cardiovascular diseases (CVD) are a group of diseases that affects the cardiovascular system, especially the heart and blood vessels[7]. Cardiovascular diseases are the leading causes of death worldwide and mostly results from atherosclerosis and hypertension[8].Obesity is an established risk factor of CVD and dyslipidemia. Dyslipidemia is defined as the abnormal accumulation of lipids in the blood such as triglycerides and cholesterol[9]. Dyslipidemia in obesity is related to increased circulating free fatty acid, high triglyceride concentration and reduced high density lipoprotein cholesterol concentration [10]. These events result from the excess release of fatty acid from the adipose tissue in obese state via lipolysiswhich are taken to the liver for synthesis of very low density lipoprotein cholesterol, VLDL directly increases plasma triglyceride concentration [10].

Obesity has an undiserable effect on health. Yearly, obesity associated co-morbidities cost above 150 billion dollars and result in an estimated 300,000 early deaths in the United States [11]. This high cost results from its related co-morbid conditions that include type 2 diabetes mellitus, coronary artery disease, hypertension, dyslipidemia, respiratory disorders and certain types of cancers such as colon, breast and ovarian cancers [12].

Atherogenic index of plasma (AIP), defined as log (TG/HDL), has recently been proposed as a marker of plasma atherogenicity and reflects the balance between risk and protective lipoprotein forces-Triglyceride refers to atherogenic lipids while HDL refer to the protective lipid[13]. It has been suggested that AIP values of -0.3 to 0.1 are associated with low, 0.1 to 0.24 with medium and above 0.24 with high cardiovascular risks [13].

MATERIALS AND METHODS

Selection of subjects

A total number of one hundred and sixty (160) volunteers aged between 20 – 45 years were recruited for this study, hundred and ten (110) obese subjects (BMI $\geq$ 30kg/m^2) and fifty (50) non-obese controls (BMI 18.5 – 24.9kg/m^2). Both male and female were enrolled in the study; subjects were sourced from churches, market places, schools and around neighborhoods in Calabar.

Ethical considerations

This study was conducted with the approval of the Research ethical committee of the Cross River State Ministry of Health, Calabar. An informed written consent was obtained from all subjects participating in the study.

Exclusion criteria

Subjects with diabetes mellitus, or any cardiovascular disease, taking medications interfering with vascular reactivity and those who are underweight, pregnant and/or lactating mothers were excluded from the study.

Anthropometric parameters

Anthropometric parameters such as height (m), weight (kg), waist circumference (cm), hip circumference (cm) were recorded. Weight and height were measured with the subjects wearing light clothing and without shoes.Weight was measured in kilogram using a balanced scale; height was measured in meters using a wall-mounted ruler with the subjects standing with feet together and with head, shoulder, buttocks and heels touching the wall. Waist and hip circumference were measured to the nearest 0.1cm using a flexible but inelastic measuring tape; waist circumference was taken between the costal marginand the iliac crest in the mid-auxillary line around the gluteal region.

Body mass index was calculated as weight in kilogram divided by the square of the height in meters (kg/m^2), waist-to-hip (WHR) was calculated by dividing the measurement of the waist (cm) by that of the hip (cm) and was used together with waist circumference as an index of central obesity [6].

Sample collection

A standard venepuncture method was used to obtain five milliliters (5ml) of blood fromall the subject under asceptic conditions. 3milliliters dispensed into a plain container capped, labeled appropriately and allowed to clot at room temperature.

The serum was separated from the red cell by spinning at 3,000 r.p.m. for 5minutes. The supernatant serum obtained was stored frozen at -20^{0}C until the day of analysis. The remaining 2ml of blood was dispensed into a fluoride oxalate container for the estimation of fasting blood glucose.

Analytical Methods

Total cholesterol and triglyceride were determined using enzymatic colorimetric method. High density lipoprotein cholesterol was determined using the precipitation cholesterol enzymatic method; the kits were obtained from EliTech clinical systems (SAS-Zone Industrielle- 61500 SEES France).

Very low density lipoprotein-cholesterol concentration was calculated from the triglyceride concentration using the formula;

$$\text{VLDL} = \frac{\text{Triglyceride concentration}}{2.2}$$

Low density lipoprotein cholesterol concentration was calculated from the total cholesterol concentration, HDL-cholesterol concentration and the triglyceride concentration using the Friedewal*et al.*, formula;

$$\text{LDL} - \text{C (mmol/L)} = \frac{\text{Total cholesterol} - \text{HDL - C} - \text{(Triglyceride)}}{2.2}$$

Atherogenic index of plasma (AIP) was calculated from the concentrations of triglyceride and high density lipoprotein cholesterol (HDL) using the formula;

$$\text{AIP} = \frac{\log (\text{TG (mmol/L)})}{\text{HDL (mmol/L)}}$$

Statistical analysis

Statistical analysis was performed using SPSS software version 18 (California Inc.). Data are expressed as mean ± standard deviation. Data from 2 groups were compared using Students 2 tailed t-test for paired samples. Data between groups were compared using a one way analysis of variance (ANOVA), followed by post hoc analysis with Tukey's test. Pearson's Correlation analysis was used to determine the inter-variable association between the various parameters. Values of $P<0.05$ were considered statistically significant.

RESULTS

Anthropometric parameters, blood pressure, lipid profile and atherogenic index of plasma were estimated in a total of one hundred and sixty (160) subjects; one hundred and ten (110) obese subjects with a BMI of 30kg/m^2 and above and fifty (50) non-obese control subjects with a body mass index (BMI) of between 18.5kg/m^2 to 24.9kg/m^2.

Table 1 shows the comparison of anthropometric parameters and blood pressure in obese and non-obese control subjects included in the study. Obese subjects had significantly higher mean value of body mass index, waist circumference, hip circumference, waist-hip ratio, systolic and diastolic blood pressure compared to the non-obese control group ($P<0.05$).

Table 1: Comparison of anthropometric parameters and blood pressure in obese subjects and non-obese control group

Parameters	Obese (n=110)	Control (n=50)	Cal. 't' value	P-value	Remarks
Age (years)	31.82±8.58	30.64±6.99	0.87	0.532	NS
Height (m)	1.69±0.09	1.68±0.09	0.96	0.961	NS
Weight (kg)	106.11±14.95	66.42±9.52	17.23	0.000	S
BMI (kg/m^2)	37.38±5.49	23.11±1.87	17.90	0.000	S
Waist C (cm)	108.44±12.47	76. 70±7.90	16.54	0.000	S
Hip C (cm)	122.12±12.74	94.43±5.44	14.75	0.000	S
W-H ratio	0.88±0.05	0.81±0.06	7.81	0.000	S
SBP (mmHg)	126.83±11.30	114.72±7.00	6.98	0.000	S
DBP (mmHg)	87.64±11.34	74.78±8.35	7.17	0.000	S

Mean ± SD

Table 2 shows the comparison of lipid profile and atherogenic index of plasma in obese and non-obese control subjects. The results revealed that the mean values of TC, TG, LDL, VLDL and AIP were significantly higher in obese subjects compared to the non-obese control group ($P<0.05$). High density lipoprotein was however higher in the non- obese control compared to the obese subjects ($P < 0.05$)

Table 2: Comparison of lipid profile and atherogenic index of plasma in obese subjects and non-obese control group

Parameters	Obese (n=110)	Control (n=50)	Cal. 't' value	P-value	Remarks
T-C (mmol/L)	5.00±1.11	4.25±0.87	4.17	0.000	S
TG (mmol/L)	1.05±0.53	0.81±0.33	2.92	0.004	S
HDL-C (mmol/L)	1.21±0.25	1.50±0.33	5.72	0.004	S
LDL-C (mmol/L)	3.27±1.08	2.36±0.78	5.34	0.000	S
VLDL (mmol/L)	0.48±0.24	0.37±0.15	2.98	0.003	S
AIP	0.05±0.11	0.01±0.04	2.55	0.012	S

Mean ± SD

Table 3 shows the comparison of anthropometric parameters and blood pressure between male and female obese subjects. Male obese subjects had significantly higher mean values of waist-to-hip ratio and diastolic blood pressure compared to the female obese subjects (P<0.05). Obese females had significantly higher BMI, and hip circumference compared to male obese subjects (P<0.05). No significant difference were observed in the mean values of waist circumference and systolic blood pressure between the two groups (P>0.05).

Table 3: Comparison of anthropometric parameters and blood pressure in male and female obese subjects

Parameters	Male obese (n=36)	Female obese (n=74)	Cal 't' value	P-value	Remarks	P -value	Remarks
Age (years)	31.67±6.97	32.86±9.12	1.86	0.481	NS	>0.05	NS
Height (m)	1.77±0.06	1.64±0.06	10.22	0.000	S	<0.05	S
Weight (kg)	106.11±13.80	104.46±15.30	1.67	0.097	NS	>0.05	NS
BMI (kg/m^2)	34.92±3.53	38.57±5.87	3.43	0.001	S	<0.05	S
Waist C (cm)	106.94±12.14	109.16±12.64	0.87	0.384	NS	>0.05	NS
Hip C (cm)	116.42±9.87	124.89±13.11	3.43	0.001	S	<0.05	S
W-H ratio	0.90±0.04	0.87±0.05	2.72	0.008	S	<0.05	S
SBP (mmHg)	129.72±12.13	125.42±10.68	1.90	0.061	NS	>0.05	NS
DBP (mmHg)	92.22±10.98	85.41±10.90	3.07	0.003	S	<0.05	S

Mean ± SD

Table 4 shows the comparison of lipid profile and AIP in male and female obese subjects. Obese males recorded significantly higher mean values of TG, VLDL and AIP compared to the female obese subjects (P>0.05).

Table 4: Comparison of lipid profile and atherogenic index of plasma (AIP) in male and female obese subjects

Parameters	Male obese (n=36)	Female obese (n=74)	Cal 't' value	P -value	Remarks
T-C (mmol/L)	5.10±1.06	4.95±1.15	0.68	0.495	NS
TG (mmol/L)	1.34±0.72	0.91±0.32	4.34	0.000	S
HDL-C (mmol/L)	1.12±0.29	1.22±0.28	0.83	0.407	NS
LDL-C (mmol/L)	3.22±1.07	3.30±1.10	0.33	0.746	NS
VLDL-C (mmol/L)	0.61±0.33	0.41±0.15	4.39	0.000	S
AIP	0.10±0.15	0.03±0.08	2.99	0.004	S

Mean ± SD

Table 5 shows a comparison of anthropometric parameters and blood pressure were compared among the three classes of obesity using BMI as classification criteria. Here, BMI, WC, HC, SBP and DBP varied significantly in the 3 classes of obese subjects (P<0.05). BMI, WC, HC, SBP, DBP were significantly higher in obese class II and III group compared to the class I group. Obese class III subjects had significantly higher values of these obesity markers compared to the class II obese subjects (P<0.05).

Table 5: Anthropometric parameters and blood pressure among the three classes of obesity

Parameters	Obese Class I (BMI 30-34.9kg/m^2) n = 44	Obese Class II (BMI 35-39.9kg/m^2) n = 35	Obese Class III (BMI 40kg/m^2& above) n = 31	Critical 'f' value	P-value	Remarks
Age (years)	32.98±7.75	29.80±8.50	32.45±9.61	2.45	0.235	NS
BMI (kg/m^2)	32.61±1.67	37.18±1.11	44.37±4.47#	2.45	0.000	S
Waist C (cm)	99.85±6.20	108.61±7.37	120.42±13.84#	2.45	0.000	S
Hip C (cm)	113.15±6.52	121.30±8.74	135.71±11.53#	2.45	0.000	S
W-H ratio	0.88±0.05	0.88±0.04	0.88±0.06	2.45	0.821	NS
SBP (mmHg)	122.57±9.44	129.71±11.19*	129.61±12.26*	2.45	0.005	S
DBP (mmHg)	83.34±9.32	90.31±11.13*	90.71±12.55*	2.45	0.004	S

Mean ± SD * = significantly higher than class I group
= significantly higher than class II group

Table 6 shows the comparison of lipid profile and atherogenic index of plasma in the three classes of obesity (class I – BMI 30-34kg/m^2, class II – BMI 35-39kg/m^2, class III – BMI 40kg/m^2 and above). Insulin and HOMA-1R varied significantly in the 3 classes of obese subjects (P<0.05). No significant difference were observed in the parameters among the three groups (P>0.05).

Table 6: Comparison lipid profile and atherogenic index of plasma (AIP) among the three classes of obesity

Parameters	Obese Class I (BMI 30-34.9kg/m^2) n = 44	Obese Class II (BMI 35-39.9kg/m^2) n = 35	Obese Class III (BMI 40kg/m^2& above) n = 31	Critical 'f' value	P-value	Remarks
T-C (mmol/L)	5.03±1.13	5.08±0.91	4.85±1.31	2.45	0.680	NS
TG (mmol/L)	1.0±0.55	1.16±0.61	1.0±0.36	2.45	0.319	NS
HDL (mmol/L)	1.20±0.28	1.25±0.30	1.19±0.27	2.45	0.664	NS
LDL (mmol/L)	3.39±1.09	3.17±0.93	3.22±1.24	2.45	0.641	NS
VLDL (mmol/L)	0.45±0.25	0.53±0.28	0.45±0.16	2.45	0.278	NS
AIP	0.06±0.12	0.06±0.12	0.04±0.10	2.45	0.747	NS

Mean ± SD

There was a significant positive correlation (r = 0.260, P<0.05) between waist-hip ratio (WHR) and triglyceride (TG) in the obese group as shown in figure 1.

Figure 2 shows a significant positive correlation (r = 0.244, P<0.05) between atherogenic index of plasma (AIP) and waist-hip ratio (WHR) in the obese group.

There was also a significant positive correlation (r = 0.308, P<0.05) between systolic blood pressure (SBP) and body mass index (BMI) in the obese group as shown in figure 3. Figure 4 shows a significant positive correlation (r = 0.271, P<0.05) of systolic blood pressure against waist circumference in the obese group.

Figure 5 shows a significant negative correlation (r = -0.294, P<0.05) of high density lipoprotein cholesterol (HDL) against waist circumference in the obese group.

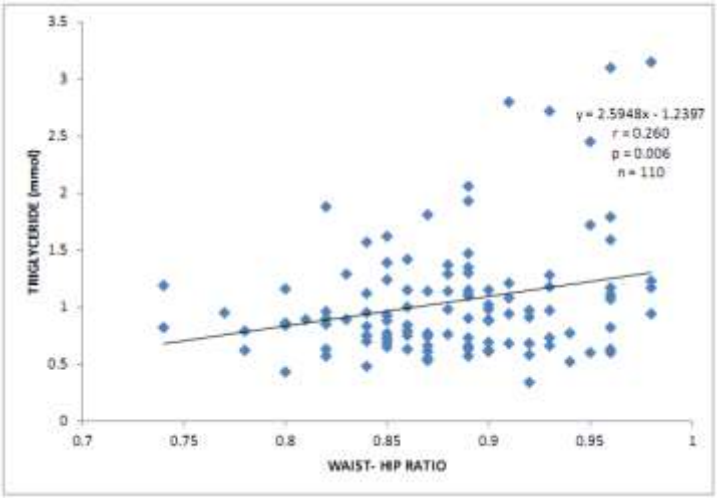

Fig-1: Correlation plot of triglyceride against waist-hip ratio in obese subjects

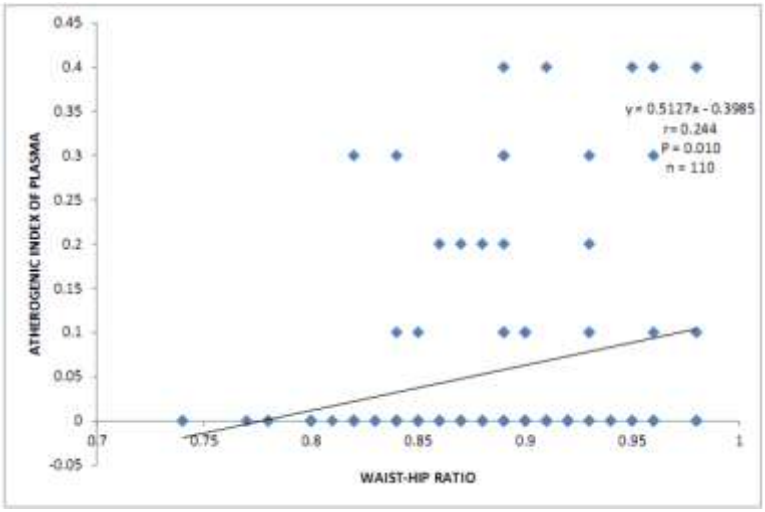

Fig-2: Correlation plot of atherogenic index against waist–hip ratio in obese subjects

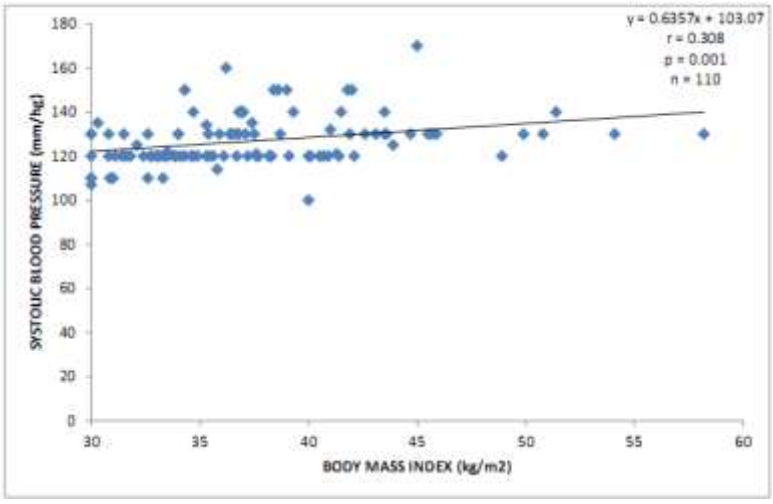

Fig-3: Correlation plot of systolic blood pressure (SBP) against body mass index (BMI) in obese subjects

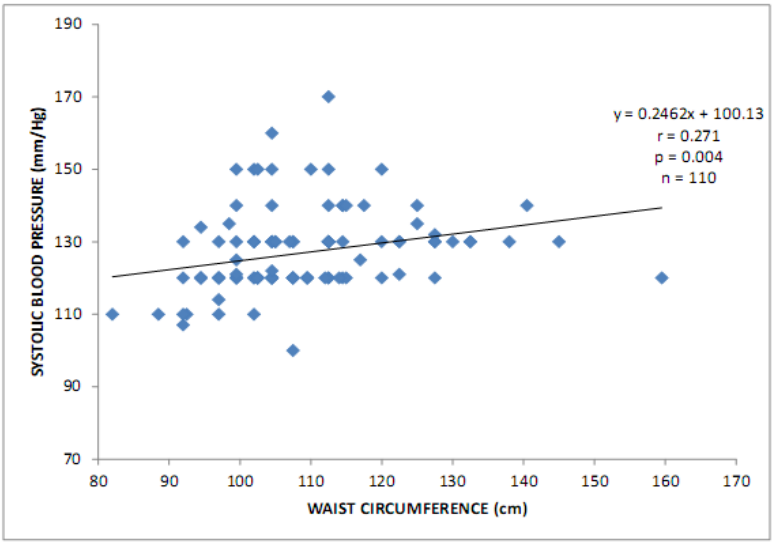

Fig-4: Correlation plot of systolic blood pressure (SBP) against waist circumference in obese subjects

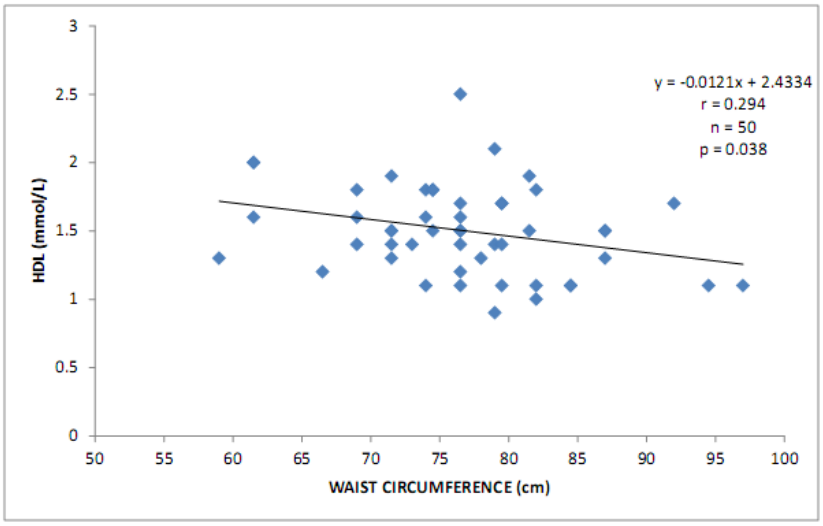

Fig-5: Correlation plot of high density lipoprotein cholesterol (HDL) against waist circumference in obese group

DISCUSSION

Several studies in different populations indicate that obesity promotes the development and progression of cardiovascular diseases, in part through its association with dyslipidemia, hypertension, and inflammation and insulin resistance [14]. This study was conducted to determine and compare the association between obesity markers (BMI, WC, WHR) and markers of cardiovascular risks (atherogenic index of plasma, blood pressure and lipid profile). Individuals included in the study were selected from a pool of those with low prevalence of cardiovascular diseases, diabetes mellitus and inflammatory diseases to minimize the odds of reverse causation.

In this study, the levels of total cholesterol, triglycerides, low density lipoprotein cholesterol (LDL), and very low density lipoprotein cholesterol (VLDL) were significantly higher ($P<0.05$) in obese subjects compared to the non-obese control group ($P<0.05$). High density lipoprotein cholesterol (HDL-C) however was significantly higher in the non-obese control group compared to the obese group ($P<0.05$). This altered lipoprotein concentration are characteristic of obesity associated dyslipidemia. Obesity-related dyslipidemia is primarily characterized by increased levels of plasma free fatty acids and triglycerides, decreased levels of high density lipoprotein (HDL), and abnormal low-density lipoprotein (LDL) composition. This is in line with the findings of Klop*et al*[15], who observed high level of TG, decreased HDL and abnormal LDL composition in the serum of obese individuals. Dyslipidaemia associated with obesity plays a major role in the development of atherosclerosis and cardiovascular disease in obese individuals. All of the components of the dyslipidaemia, including higher triglyceride, decreased HDL levels and increased LDL particles have been shown to be atherogenic.

The findings of this study also revealed that atherogenic index of plasma was significantly higher in obese subjects compared to the non-obese controls and showed a relationship with systolic blood pressure (SBP) ($P<0.05$). Atherogenic index of plasma is a mathematical relationship between TG and HDL and has been successfully used as an additional index when assessing cardiovascular risk factors. It has been suggested that AIP values of -0.3 to 0.1 are associated with low, 0.1 to 0.24 with medium and above 0.24 with high cardiovascular risks [16]. The findings of this study indicate that obese individuals with AIP values of 0.1 are at a medium risk of developing cardiovascular diseases compared to the non-obese controls.

Waist circumference and waist-hip ratio (WHR) were significantly higher in obese subjects compared to their non-obese counter parts. Increased WC and WHR have long been recognized to be associated with cardiovascular risk factors and individuals with abdominal fat often carry a physiologic profile that places them at higher risk of CVD[16]. This is evident in this study as we observed a positive association between waist-hip ratio and cardiovascular risk markers (triglyceride and atherogenic index of plasma (AIP). Gender affects lipid and lipoprotein parameters, this was also evident in this study as these findings revealed that obese males had significantly higher TG, VLDL and AIP compared to obese females. This finding is in agreement with that of Syed *et al*[17], who also reported gender differences in lipid profile among obese individuals. This difference may be due to circulating sex hormones. An association between testosterone and accumulation of upper body, abdominal and visceral fat has been reported in several studies [18]. This is evident in this study as higher values of WHR were recorded among obese males. Also a negative correlation was observed among abdominal obesity markers (WC and WHR) and HDL

($P<0.05$), in the obese group. These findings are consistent with previous reports which showed that visceral adiposity is associated with a smaller HDL particle. Smaller HDL particles have a lower capacity to transfer cholesteryl esters in reverse cholesterol transport and predict atherosclerosis [15].

CONCLUSION

This study examined the relationship between obesity and cardiovascular risk factors. The findings suggest that obesity is directly associated with dyslipidaemia and high blood pressure which are risk factors related to the development of cardiovascular disease atherosclerosis.

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