Link between Plasma Total Adiponectin and Small Dense Low Density Lipoprotein-Cholesterol among Overweight and Obese Nigerians

Adaja TM,1* Ayina CN,2 Idogun SE.3

1University of Medical Sciences, Department of Chemical Pathology, Ondo City, Ondo State, Nigeria.
2University of Douala, Department of Biology of Animal Organisms, Douala, Cameroon.
3Department of Chemical Pathology, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria.

ABSTRACT

Adiponectin an adipocytokine synthesized by adipocytes and small dense low-density lipoprotein-cholesterol (sdLDL-C), a subfraction of LDL-cholesterol was found to be more atherogenic and may predispose to increased risk of cardiovascular diseases among the overweight and the obese persons. This study determined the relationship between the two biomarkers along with the traditional lipid profile among apparently healthy, ideal weight, overweight and the obese Nigerians. The ideal weight, overweight, and obese subjects were selected based on their body mass indices. Plasma total adiponectin was determined using a sandwich immunoassay technique; while serum small dense LDL-cholesterol was measured using precipitation method. The fasting serum lipid profile was assessed using the enzymatic methods for total cholesterol, triglyceride; and HDL-cholesterol after precipitation. LDL-cholesterol was determined using Friedewald equation. Mean plasma total adiponectin levels in the ideal weight, overweight and obese were 17.55 ± 4.49, 7.57 ± 1.74 and 4.96 ± 1.62 ng/ml while mean small dense LDL-cholesterol levels were 0.79 ± 0.16, 0.96 ± 0.15 and 1.33 ± 0.26 mmol/l respectively which were statistically significant (p<0.05). In the ideal weight subjects, positive correlation was found between sdLDL-C and waist circumference (p>0.05). In the obese, a negative relationship was found between adiponectin and body mass index. A significantly (p<0.05) positive correlation was found between adiponectin and HDL-cholesterol across the three groups which were strongest among the overweight category (r=0.728, p=0.000). There is a negative significant (p<0.05) relationship between plasma total adiponectin and sdLDL-cholesterol (r= -0.563). In conclusion, obese individuals have reduced plasma adiponectin and increased small dense LDL-cholesterol levels. A negative correlation exists between plasma total adiponectin and small dense LDL-cholesterol.

Keywords: adiponectin, obesity, overweight, small-dense LDL-cholesterol

INTRODUCTION

Non-communicable diseases are rapidly contributing to high morbidity and mortality rates among Nigerians as found in other parts of the world.1 Obesity has been identified as the major risk factor fuelling the onslaught of non-communicable diseases most especially diabetes mellitus, cardiovascular diseases and some cancers.2 The metabolic and endocrine roles of dysregulated adipocytes in the elaboration of pro-inflammatory adipocytokines have been well documented.3 Adiponectin is a specific protein secreted by white adipocytes with anti-atherogenic, insulin-sensitizing and anti-inflammatory properties.4 In obesity, low adiponectin levels has been reported to contribute immensely to metabolic complications commonly seen as insulin resistance, pro-inflammatory state and even certain cancers.5 Augmentation of plasma adiponectin levels using adiponectin receptor agonists has been reported to improve...
metabolic outcome in overweight and obese patients. On the other hand, small dense low density lipoprotein-cholesterol (sdLDL-C), another biomarker known to be elevated in obese individuals, is synthesized in the liver from very low density lipoprotein-1 (VLDL1), is characterized by high atherogenicity and consequently increased risk of atherosclerotic cardiovascular diseases (ASCVD).

Small dense LDL-cholesterol derived its atherogenic properties by virtue of its small size, high affinity for proteoglycans in the arterial wall, rapid entrance into the arterial wall, prolonged stay in the sub endothelial space and increased susceptibility to oxidative damage. All these properties lead to increased risk of atherosclerosis in arterial vessel wall. Low plasma adiponectin and elevated sdLDL-cholesterol are biomarkers known to increase atherosclerotic cardiovascular risk among overweight and obese individuals. Despite this widely reported occurrence, there is paucity of information concerning the relationship between adiponectin and sdLDL-C among overweight and obese Nigerians. This is the main thrust of this study. In fact, very few studies documented the levels of sdLDL-C among Nigerians even though the widely accepted calculated LDL-cholesterol, determined using Friedewald equation, is fraught with errors. This study aimed at determining the relationship between plasma total adiponectin and sdLDL-cholesterol among overweight and obese Nigerians

**MATERIALS AND METHODS**

**Subject location**

This is a comparative cross-sectional study carried out at the University of Benin Teaching Hospital (UBTH), Benin City between July and September, 2016. Benin City is located in South-South part of Nigeria with a population of 3.21 million. It consists of three Local Government Areas viz: Egor, Ikpoba-Okha and Oredo LGAs. UBTH is a federal government owned tertiary hospital serving as a referral center to Edo State as well as its neighbouring states (Ondo, Delta, Kogi, Bayelsa and Anambra states).

**Study population**

This consisted of male and female apparently healthy subjects (normal weight, overweight and obese) aged 18-65 years. A total of 138 subjects were categorized into three equal groups based on their BMI as (ideal weight, overweight and obese). Consenting individuals who met the inclusion criteria based on their BMI were recruited while those persons who are diabetic, hypertensive on angiotensin converting enzyme inhibitors (ACE I) or angiotensin II receptor blocks (ARBs), cancer patients, breastfeeding, pregnant women; and those persons on lipid lowering agents were excluded from the study. Ethical approval for this study was given by the Ethical Committee of UBTH and utmost confidentiality was ensured in all the processes involved in the study.

**Anthropometric and blood pressure measurement**

Subjects were weighed in their light clothing without shoe to the nearest 0.5kg. Their heights were measured to the nearest 0.1cm using stadiometer (RQZ -120) with the subjects standing erect on the instrument. Body mass index was calculated as weight divided by height² in kg/m². BMI >30kg/m² was considered as obese, 25-29.9 kg/m² as overweight and 18-24.9 kg/m² as normal weight. Waist circumference was measured midway between the inferior margin of the last rib and the iliac crest in a horizontal plane with the measuring tape not compressing the soft tissue. Hip circumference was measured using pubic symphysis and maximum gluteal protuberance. Blood pressure was measured using Accousson® sphygmomanometer and Littman® stethoscope in a sitting position after 5 minutes of rest. Waist –hip ratio was calculated by dividing waist circumference by hip circumference.

**Preparation of subjects and sample collection**

Subjects were asked to fast overnight for about 8-12 hours. Venipuncture site was cleared with 70% methylated spirit, allowed to dry, and 6ml of venous blood was collected under aseptic procedure from the antecubital vein. Three millilitre of blood was dispensed into a plain tube for fasting lipid assay and allowed to clot while 3ml of blood was collected into EDTA bottle for plasma total adiponectin assay. Samples were centrifuged and separated into plain tubes and kept at -80°C refrigerator until they are analyzed.

**Biochemical assays**

**Determination of total cholesterol, HDL-cholesterol, LDL-cholesterol and triglyceride**

Serum total cholesterol and triglyceride were determined by enzymatic spectrophotometric method. Serum HDL-cholesterol was determined after precipitating other lipoprotein as reported by Burstein et al; while LDL-cholesterol was calculated using Friedewald equation (LDL-C =Total cholesterol – HDL-cholesterol – Triglyceride /2.2).
Determination of plasma total adiponectin
Plasma total adiponectin was determined using enzyme-linked immunosorbent assay (ELISA) technique and kits from Elabscience Technology Inc, MD, USA. Concentration of total adiponectin was read using microplate reader (AD Touch-11000, apDia, Raadsherenstraat, Belgium).

Determination of small dense LDL-cholesterol
Small dense LDL-Cholesterol was determined by simple precipitation method. This was done by heparin-manganese precipitation according to the method described by Hirano et al.\textsuperscript{15} Thirty (30) mmol/l of MnCl\textsubscript{2} (LobaChemie, LOT: L157011601) was prepared by dissolving 1.485 g in 250 ml of distill water while 40 IU/ml sodium-heparin (Elabscience, LOT: AKOOI7MAY13042) was prepared by dissolving 2 g of the salt in 500 ml of distill water (20,000 IU in 500 ml of distill water) since 100 IU sodium–heparin is equivalent to 1mg of the salt.

1. The precipitation reagent (0.1 ml), containing 150 IU/ml heparin-sodium salt and 90 mmol/L Manganese II chloride tetrahydrate was added to each serum sample (0.1ml), mixed and incubated for 10 minutes at 37\textdegree C.
2. The samples were placed in an ice bath and allowed to stand for 15 minutes and then the precipitate was collected by centrifuging at 15,000 rpm for 15 minutes at 4\textdegree C using a cold centrifuge (Rotina 360R).
3. An aliquot of the supernatant was taken for Cholesterol analysis.
4. The cholesterol content was determined using enzymatic method for total cholesterol. This was described as \textit{sdLDL-C} = Measured cholesterol-HDL-C.

Statistical analysis
The data obtained were analyzed using SPSS version 20 (IBM, Chicago IL). Results were expressed as mean and standard deviation. The differences in the means between two and three groups were analyzed using students t-test and analysis of variance (ANOVA) respectively. Relationship between biochemical parameters were determined using Pearson's correlation analysis as data were normally distributed after testing with Kolmogrov-Smirnov test. Statistical significance was taken as $p<0.05$. Results of biochemical analysis were interpreted using centre-based reference intervals (total cholesterol 2.38-4.65 mmol/L, triglyceride 0.22-0.87 mmol/L, LDL-cholesterol 1.99-3.36 mmol/L, and HDL-cholesterol mmol/L). Reference interval for plasma total adiponectin is 2-30 µg/mL.\textsuperscript{16}

RESULTS
One hundred and thirty-eight subjects made up of 88 females and 50 males were recruited in this study. They include 46 normal weight, 46 overweight and 46 obese. Their mean ages of 55.57 ± 10.48, 48.91 ± 8.33 and 45.11 ± 7.61 years respectively. Thirty-eight (82.6\%) of the normal weight subjects were females, 22 (47.8\%) of the overweight subjects were males while 30 (65.2\%) of the obese were females. There was no statistical difference in their age distribution ($p>0.05$). Their anthropometric, clinical and biochemical parameters were measured and documented in the table I.

The mean weight, height, BMI, waist circumference, hip circumference and waist hip ratio are shown in Table I. There was a significant difference ($p<0.05$) in the anthropometric parameters. More so, there was a significant difference ($p<0.05$) in systolic blood pressure, respiratory and pulse rates but no difference was found in diastolic blood pressure ($p=0.064$).

Table 1: Anthropometric and Clinical characteristics of the study subjects

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal Weight mean±SD</th>
<th>Overweight mean±SD</th>
<th>Obese mean±SD</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Kg)</td>
<td>63.3±9.48</td>
<td>75.5±7.78</td>
<td>88.9±10.65</td>
<td>7.6</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.68±0.10</td>
<td>1.65±0.08</td>
<td>1.61±0.07</td>
<td>1.6</td>
<td>0.0540*</td>
</tr>
<tr>
<td>BMI (Kg/m\textsuperscript{2})</td>
<td>22.19±1.61</td>
<td>27.82±1.16</td>
<td>34.28±3.21</td>
<td>26.5</td>
<td>0.0002*</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>86.99±10.20</td>
<td>98.87±7.94</td>
<td>98.56±15.42</td>
<td>4.6</td>
<td>0.0004*</td>
</tr>
<tr>
<td>Age (years)</td>
<td>55.57±10.48</td>
<td>48.91±8.33</td>
<td>45.11±7.61</td>
<td>46.3</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Meal frequency</td>
<td>2.56±0.65</td>
<td>2.52±0.66</td>
<td>2.48±0.75</td>
<td>1.14</td>
<td>0.3100</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>110±9.35</td>
<td>137.26±19.58</td>
<td>132.87±18.48</td>
<td>4.8</td>
<td>0.0001*</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>83.26±9.74</td>
<td>82.0±11.50</td>
<td>87.87±10.07</td>
<td>1.6</td>
<td>0.0040*</td>
</tr>
<tr>
<td>PR (bpm)</td>
<td>74±12.0</td>
<td>74.13±11.81</td>
<td>75.96±11.93</td>
<td>1.7</td>
<td>0.0400*</td>
</tr>
<tr>
<td>RR (cpm)</td>
<td>13.35±1.34</td>
<td>16.17±10.33</td>
<td>14.3±1.40</td>
<td>123.4</td>
<td>0.0002*</td>
</tr>
</tbody>
</table>

\(a\) statistically significant ($p<0.05$); BMI: Body mass index; WC: Waist circumference; HC: Hip – circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PR: Pulse rate; RR: Respiratory rate.

Clinical parameters were statistically significant except the meal frequency ($p=0.310$). There was statistical difference in all the anthropometric parameters except the height of the subjects ($p=0.054$).

Serum total cholesterol, LDL-cholesterol and small dense LDL-cholesterol were found to increase significantly ($p<0.05$) among the obese participants. More so, highest level of mean concentration of HDL-cholesterol was found among the overweight category while mean concentration of triglyceride was the highest among the normal weight.
participants. The mean plasma adiponectin levels were 17.55 ± 4.49, 7.57 ± 1.74 and 4.96 ± 1.62 ng/ml among the normal weight, overweight and obese participants respectively. There was a significant difference between the mean adiponectin levels across the three groups (F=17.9, p<0.05). The average sdLDL-cholesterol levels were found to be 0.79 ± 0.16, 0.96 ± 0.15 and 1.33 ± 0.26 mmol/l among the normal weight, overweight and obese participants respectively (F=7.3, p<0.05). There was no significant difference in the serum levels of triglycerides among the groups.

Table 2: Biochemical profile of study subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal Weight mean ±SD</th>
<th>Overweight mean±SD</th>
<th>Obese mean±SD</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mmol/L)</td>
<td>5.64±1.99</td>
<td>5.36±1.25</td>
<td>6.28±1.05</td>
<td>2.9</td>
<td>0.0002*</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>1.41±0.73</td>
<td>1.33±0.61</td>
<td>1.31±0.73</td>
<td>1.1</td>
<td>0.3540</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>0.85±0.20</td>
<td>1.05±0.34</td>
<td>0.94±0.30</td>
<td>3.2</td>
<td>0.0001*</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>4.61±1.09</td>
<td>3.70±1.09</td>
<td>4.75±1.04</td>
<td>2.8</td>
<td>0.0001*</td>
</tr>
<tr>
<td>sdLDL-C (mmol/L)</td>
<td>0.79±0.16</td>
<td>0.96±0.15</td>
<td>1.33±0.26</td>
<td>7.3</td>
<td>0.0004*</td>
</tr>
<tr>
<td>%sdLDL</td>
<td>18.05±5.22</td>
<td>27.74±10.88</td>
<td>28.94±9.4</td>
<td>5.66</td>
<td>0.0020*</td>
</tr>
<tr>
<td>Adiponectin (ng/mL)</td>
<td>17.55±4.49</td>
<td>7.57±1.74</td>
<td>4.96±1.62</td>
<td>17.9</td>
<td>0.0002*</td>
</tr>
</tbody>
</table>

Table 3: Correlation study of adiponectin and small dense LDL-cholesterol with anthropometric and biochemical parameters in normal weight subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Adiponectin r</th>
<th>p-value</th>
<th>sdLDL-C r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>-0.391</td>
<td>0.007</td>
<td>0.278</td>
<td>0.062</td>
</tr>
<tr>
<td>WC</td>
<td>-0.443</td>
<td>0.002</td>
<td>0.644</td>
<td>0.000</td>
</tr>
<tr>
<td>WHR</td>
<td>0.071</td>
<td>0.637</td>
<td>0.316</td>
<td>0.033</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.587</td>
<td>0.000</td>
<td>0.331</td>
<td>0.025</td>
</tr>
<tr>
<td>Wt</td>
<td>-0.375</td>
<td>0.010</td>
<td>-0.052</td>
<td>0.733</td>
</tr>
<tr>
<td>sdLDL-C</td>
<td>-0.305</td>
<td>0.040</td>
<td>1.000</td>
<td>0.000</td>
</tr>
<tr>
<td>TC</td>
<td>0.013</td>
<td>0.931</td>
<td>0.212</td>
<td>0.157</td>
</tr>
<tr>
<td>TG</td>
<td>0.011</td>
<td>0.944</td>
<td>0.035</td>
<td>0.816</td>
</tr>
<tr>
<td>LDL-C</td>
<td>0.000</td>
<td>0.995</td>
<td>0.360</td>
<td>0.014</td>
</tr>
<tr>
<td>HDL-C</td>
<td>0.111</td>
<td>0.463</td>
<td>-0.339</td>
<td>0.021</td>
</tr>
</tbody>
</table>

A significant positive correlation was observed between adiponectin and HDL-cholesterol (r=0.728, p=0.000) but no significant negative correlation was found between adiponectin and sdLDL-C (r=-0.106, p=0.484) in the overweight subjects.

Table 4: Correlation study of adiponectin and small dense LDL-cholesterol with anthropometric and biochemical parameters in overweight subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Adiponectin r</th>
<th>P</th>
<th>sdLDL-C r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>-0.108</td>
<td>0.473</td>
<td>0.046</td>
<td>0.763</td>
</tr>
<tr>
<td>WC</td>
<td>0.007</td>
<td>0.965</td>
<td>0.211</td>
<td>0.159</td>
</tr>
<tr>
<td>WHR</td>
<td>-0.156</td>
<td>0.295</td>
<td>0.143</td>
<td>0.345</td>
</tr>
<tr>
<td>BMI</td>
<td>0.024</td>
<td>0.875</td>
<td>0.154</td>
<td>0.159</td>
</tr>
<tr>
<td>sdLDL-C</td>
<td>-0.106</td>
<td>0.484</td>
<td>1.000</td>
<td>0.000</td>
</tr>
<tr>
<td>TC</td>
<td>0.106</td>
<td>0.483</td>
<td>-0.233</td>
<td>0.137</td>
</tr>
<tr>
<td>TG</td>
<td>-0.010</td>
<td>0.950</td>
<td>-0.131</td>
<td>0.384</td>
</tr>
<tr>
<td>LDL-C</td>
<td>-0.106</td>
<td>0.482</td>
<td>0.193</td>
<td>0.199</td>
</tr>
<tr>
<td>HDL-C</td>
<td>0.728</td>
<td>0.000</td>
<td>-0.088</td>
<td>0.562</td>
</tr>
</tbody>
</table>

There was no significant difference between LDL-C levels in normal weight and obese subjects. However, a statistically significant difference was found in sdLDL-C between normal weight and obese subjects (p<0.05).

Correlation between anthropometric and biochemical parameters in the normal weight, overweight and obese participants.

In the normal weight category; plasma adiponectin level was found to be negatively correlated with the body mass index (r= -0.587, p=0.000), waist circumference (r = -0.443, p=0.002) and hip circumference (r = -0.391, p=0.007) while small dense LDL-cholesterol positively correlated with the body mass index (r= 0.331, p=0.025), waist hip ratio (r=0.316, p=0.033) and waist circumference (r= 0.644, p=0.000) as shown in table 4 and figure 2. In the overweight category, no significant correlation was observed between adiponectin and anthropometric parameters; and sdLDL cholesterol and anthropometric parameters among the overweight participants (p>0.05).
Figure 1: Correlation graph of adiponectin and sdLDL-cholesterol in the normal weight subjects (r = -0.305, p=0.040).

Figure 2: Correlation graph of Adiponectin vs sdLDL-cholesterol in the overweight subjects.

Figure 3: Correlation graph of Adiponectin versus small dense LDL-cholesterol in obese subjects (r=-0.563, p=0.000).

Figure 4: Dyslipidaemia among the study population

Dyslipidaemia was observed across the three groups; most especially elevated LDL-cholesterol elevated triglyceride occurring in more than 70% of all the subjects while elevated total cholesterol was seen in 95.7% of the obese subjects. Elevated sdLDL-C was seen in 10(12.7%) and 20(43.5%) of the overweight and obese subjects respectively, while atherogenic triad (a constellation of elevated triglyceride, reduced HDL-C and elevated sdLDL-cholesterol) was observed in 7(15.2%) of the obese subjects There was no statistical difference in triglyceride across the three groups unlike other lipids which were statistically significant (p<0.05). More so, 2 (3.6%) of the obese subjects had elevated sdLDL-C with LDL-C within the reference interval.

**DISCUSSION**

Obesity and overweight are the fifth leading risk factors for global deaths and major contributors to the global burden of chronic diseases and disability. In recent times, much has been published by different researchers stating their opinions on whether overweight and obese individuals are protected from metabolic diseases. In this study, normal weight, overweight and obese individuals were studied to find out whether some differences exist in their levels of adiponectin, small dense LDL- Cholesterol and their traditional lipid parameters. It has been widely reported that excessive fat accumulation is associated with various morbidities which now contribute immensely to most of the non-communicable diseases, which was initially thought to be most prevalent among the Caucasians but recently been found to have affected the developing countries like Nigeria. Visceral obesity is strongly associated with abnormal cytokine secretion and adverse metabolic risk factors. This study looked at the
levels of the adiponectin among the three categories of the body mass indices. A significant difference was seen in the levels of adiponectin and body mass indices among the normal weight, overweight and obese subjects. This finding is in agreement with other studies showing a low plasma adiponectin levels that correlate with increasing obesity and adiposity indices. This study reported a statistically significant difference in the level of plasma adiponectin among the normal weight, overweight and obese subjects. A similar finding was reported by Baratta et al., among the Italian non-diabetic subjects, where plasma adiponectin levels were found to be significantly higher among the non-obese subjects.

This study revealed a negative correlation between adiponectin and body mass index, waist circumference and hip circumference. This was also reported by Huang et al., where they documented a strongly negative correlation between adiponectin, body mass index and waist circumference among the overweight and obese subjects.

Hypo-adiponectinaemia has been well reported among the obese individuals. From this study, mean adiponectin levels among the normal weight and obese were 17.55±4.49 and 4.96±1.62 ng/ml respectively. This finding is in agreement with a study conducted among the Japanese where lower levels of adiponectin were reported in obese individuals than normal weight persons. Despite the numerous adipocytes found in the obese and overweight individuals; the paradoxical hypoadiponectinaemia seen in these group of persons have been reported to be as a result of a feedback inhibition on the production of adiponectin from increased secretion of others adipocytokines such as tumour necrosis factor-α (TNFα). A strong positive correlation was found between adiponectin and HDL-cholesterol. This is supported by the fact that both high molecular weight- and non-high molecular weight adiponectin fractions participate in the modulation of HDL metabolism. Intensive lifestyle intervention has been reported to increase adiponectin fraction with concomitant increase in HDH-cholesterol. Increased levels of adiponectin and HDL-cholesterol have been widely documented to be anti-atherogenic, anti-inflammatory and play major roles in the prevention of cardiovascular diseases. A strong positive correlation was seen among the overweight subjects (r=0.728, p= 0.0001) which may point to the recently documented paradoxical protection conferred on the overweight individuals, and this was found to be protective from certain diseases. Positive correlation seen between adiponectin and HDL-cholesterol was also reported in a cross-sectional study conducted among Africans (Nigerians and Ghanaians) where adiponectin was positively associated with HDL-cholesterol and total cholesterol after adjusting for age, gender and body mass index. Elevated triglyceride levels being one of the features of metabolic syndrome have been found to play a vital role in insulin resistance. In this study, a negative correlation was observed between adiponectin and serum triglyceride among the obese subjects. This was also reported in a study conducted among sub-Saharan African population where adiponectin was negatively correlated with serum triglyceride. Small dense LDL-cholesterol has been found to have greater atherogenic potential than LDL sub fraction, since it had significant inverse relationship with adiponectin unlike LDL-C. Therefore, it may be a better marker for prediction of cardiovascular disease than LDL-C or total cholesterol. It was reported that circulating sdLDL readily undergo multiple atherogenic modifications (desialylation, glycation and oxidation) thus imposing increased atherogenic potentials on sdLDL. There is an association between sdLDL-C concentration with various diseases linked to atherosclerosis e.g. peripheral artery disease, dyslipidaemia, diabetes mellitus, and metabolic syndrome. This study observed a significant difference in the levels of small dense LDL-cholesterol across the three categories of body mass index (F=7.3, p=0.000) with highest levels of sdLDL-C observed among the obese subjects. Hence, may explain its roles in various disease conditions such as metabolic syndrome and cardiovascular diseases. In the study, a positive correlation was observed between sdLDL-cholesterol levels and waist circumference, hip circumference, waist-hip ratio and body mass index across the three groups. This shows that accumulation of fat results in increased anthropometric indices with concomitant increase in sdLDL-C.

Similar findings were reported in a cross-sectional study of apparently healthy obese Thai adult population. Small dense LDL-C was found to be elevated among the obese subjects. They reported a significant difference between the levels of sdLDL-C in the normal weight and obese subjects. Using multivariate regression analysis, the waist circumference is the best predictor of small dense LDL-C levels. Increased waist circumference connotes visceral obesity which has been documented as a risk factor for the development of metabolic syndrome.
Elevated small dense LDL-cholesterol in obese individuals. In this study, body mass index best predicts plasma adiponectin levels in the normal weight and the obese. This shows the paradoxical hypoadiponectinaemia well documented as a result of negative feedback inhibition of other adipocytokines on the production of adiponectin by the white adipose tissue.

LIMITATION
In this study, only total adiponectin level was assessed. Studies have shown that multimeric form of adiponectin could be a better marker of adipose tissue function. Low molecular weight adiponectin for example has been implicated to account for the differences in the total adiponectin levels seen among different ethnic nationalities.

CONCLUSION
Obese individuals have reduced plasma adiponectin and increased small dense LDL-cholesterol when compared with normal weight and overweight individuals. Adiponectin level is best predicted by body mass index and waist circumference; while level of small dense LDL is strongly associated with the level of HDL-cholesterol and body mass index. Dyslipidaemia was found to be common among the study population.

RECOMMENDATIONS
1. The wellbeing of the normal weight persons should not be overlooked as metabolic derangements commonly seen in overweight and obese individuals also manifest in them. A periodic metabolic workup could be life-saving in the normal weight persons.
2. By virtue of dyslipidaemias seen in the study population, a community-based study to assess metabolic syndrome in Benin City might be helpful in curbing metabolic and cardiovascular diseases.
3. Introduction of small dense LDL-C assay as a routine test or its acceptance in local guidelines for the assessment of cardiovascular risk could be helpful in the prevention of metabolic and cardiovascular diseases.
4. By virtue of systemic roles played by adiponectin, its plasma levels should be checked periodically to ascertain the wellbeing of an individual, most especially the overweight and obese.

Conflict of interest
None declared.

REFERENCES


