# **Research Article**

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# Adiponectin and cardiovascular risk factors in relation with glycemic control in type 2 diabetics

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#### **ABSTRACT**

**Background:** Adiponectin has been associated with insulin resistance and dyslipidemia in Type 2 diabetes, though the mechanism of association is still uncertain. The adiponectin levels and lipid profile in relation to glycemic control were investigated in type 2 diabetics.

**Methods:** Forty two diabetic subjects (35-64 years) and 33 age-matched non-diabetic subjects were recruited into this case control study. Socio-demographic characteristics, anthropometric indices and blood pressure were obtained. Total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL), high density lipoprotein, (HDL), fasting plasma glucose (FPG), and glycated hemoglobin (HbA1c) were estimated using colorimetric methods, atherogenic index (AI) was calculated, while serum adiponectin was determined by ELISA method.

**Results:** Adiponectin levels of type 2 diabetics were not significantly different from the non-diabetics studied (p>0.05). Higher TG levels were observed in diabetics with poor glycemic control compared with those with good glycemic control (p<0.05). Hypertensive diabetics have higher TC and lower HDL-C levels compared with non hypertensive diabetics (p<0.05). Adiponectin correlated positively with HDL-C (r = 0.739, p = 0.01) and negatively with AI (r = -0.539, p = 0.001) only in the non diabetic group. No significant differences were observed in the adiponectin levels in relation with gender, duration of diabetes and glycemic state (p>0.05).

**Conclusion:** Type 2 diabetics do not have lower adiponectin levels. Gender, duration of diabetes and glycemic control does not seem to exert any influence on adiponectin levels in type 2 diabetes. Adiponectin may be associated with reduced risk of atherosclerosis through its effects on HDL cholesterol metabolism.

Keywords: Type 2 diabetes, Adiponectin, Lipid profile, Glycemic control

### INTRODUCTION

Type 2 diabetes mellitus is characterized by insulin receptor defects and insulin resistance in peripheral tissues such as the liver, muscle and fat. Insulin resistance and the consequent hyperglycemia are often associated with increased body weight, dyslipidemia and increased risk for atherosclerosis and other complications. Insulin secretion

has been reported to enhance the secretion of an adipocyte complement related protein known as adiponectin. Adiponectin has been shown to play important roles in carbohydrate and lipid metabolism and vascular biology. Dysregulation of adiponectin secretion have been implicated in the development of non-insulin dependent (Type 2) diabetes. Studies have shown that decreased expression of adiponectin correlates with insulin

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resistance,<sup>3,4</sup> and that adiponectin appears to be a potent insulin enhancer linking adipose tissue and whole body glucose metabolism.<sup>5</sup> Low levels have been reported in insulin resistant states including type 2 diabetes. Adiponectin has also been related to lipid metabolism, higher levels has been associated with higher levels of HDL cholesterol and lower levels of triglycerides,<sup>6</sup> suggesting that adiponectin may have anti-atherogenic properties.<sup>7</sup> The association of low adiponectin levels with obesity, insulin resistance, coronary artery disease, and dyslipidemia indicates that this protein may be an important marker of the metabolic syndrome.<sup>8</sup>

The development of diabetic complications has been associated with the level of glycemic control. Glycemia and blood lipids seem to be independently associated with adiponectin levels. Diabetics with good glycemic control were reported to have favorable lipids and lipoprotein profiles compared to their counterparts with poor glycemic control. The association of adiponectin levels with insulin resistance and dyslipidemia therefore, seems to be mediated in part by the degree of glycemia.

We examined the lipid profile, protein glycosylation and adiponectin levels in type 2 diabetics to determine the effect of glycemic control on the levels of these indices.

### **METHODS**

# Selection of subjects

This case control study was carried out at the Diabetic Clinic of the University of Uyo Teaching Hospital Uyo, Nigeria. After informed consent, 42 type 2 diabetic subjects (both males and females) aged between 35 and 64 years and 33 age-matched non diabetic apparently healthy volunteers (males and females) living within Uyo and its environs were recruited for the study. Type 2 diabetics in this study were defined as individuals who were diagnosed of diabetes mellitus after the age of 25 years and have been successfully managed only with oral hypoglycemic agent sulphonyurea.

Socio-demographic characteristics of the study population - family history, education, social history, past medical history and medication were obtained using a semi-structured questionnaire. Anthropometric indices - height, weight, hip and waist circumference were taken to calculate the body mass index and waist to hip ratio respectively. The blood pressure (Systolic blood pressure and Diastolic blood presure) of all the patients were recorded by standard methods.

## Sample collection

Ten milliliters of fasting venous blood samples were collected aseptically from the subjects via venepuncture. Two milliliters were transferred into fluoride oxalate bottles for fasting plasma glucose determination; one milliliter was transferred into dipotassium ethylene

diamine tetracetic acid ( $K_2EDTA$ ) container for glycated heamoglobin estimation. The remainder was transferred into plain bottles, allowed to clot and retract and then centrifuged at 3000 revolutions per minute for five minutes to extract serum. Sera were stored frozen at  $-20^{\circ}C$  for subsequent estimation of total cholesterol, triglyceride, high density lipoprotein and adiponectin.

## Estimation of plasma glucose by Glucose oxidase method

Glucose is determined after enzymatic oxidation in the presence of glucose oxidase. The hydrogen peroxide produced, reacts with phenol and 4-aminophenazone to form a red - violet quinoneimine dye. The intensity of the final color which is directly proportional to the glucose concentration is measured at 505 nm. Glucose standard and test samples were dispensed into appropriately labeled test tubes followed by glucose oxidase peroxidase aminophenazone (GOD-PAD) reagent. The mixture was incubated for ten minutes at 37° and absorbances of the standard and the test were read against the reagent blank at 500nm.

# Glycohemoglobin estimation by column chromatography with cation exchange resin for glycated haemoglobin separation

This method utilizes the interaction of antigen and antibody to directly determine the HbA1c in whole blood. Total hemoglobin and HbA1c have the same unspecific absorption rate to latex particles. When mouse antihuman HbA1c monoclonal antibody is added, latex-HbA1c-mouse anti human HbA1c antibody complex is formed. Agglutination is formed when goat anti-mouse IgG polyclonal antibody interacts with the monoclonal antibody. The amount of agglutination is proportional to the amount of HbA1c absorbed on to the surface of latex particles. The amount of agglutination is measured as absorbance at 415nm.

# Human adiponectin determination by ELISA method

Pre-treated samples and serially diluted standard (recombinant human adiponectin) solutions were added to appropriate number of wells of the microtiter plate and incubated. Adiponectin in the sample bonded to the primary anti-adiponectin monoclonal antibody immobilized in the well. Secondary rabbit anti-adiponectin antibody was added to each well and allowed to bind to the adiponectin trapped in the well. A conjugate of horse radish peroxidase and goat anti -rabbit IgG was added, which recognized and bonded to the rabbit anti-adiponectin antibody trapped in the well. A coloured enzyme substrate was added which produced a colour, the intensity of which was a measure of the rat anti-adiponectin antibody in the well and hence adiponectin in the sample. The adiponectin concentration of the test samples were intrapolated from a calibration curve.

#### Total cholesterol estimation by colorimetric method

The cholesterol in the sample was determined after enzymatic hydrolysis and oxidation. The indicator quinoneimine was formed from hydrogen peroxide and 4-aminoantipyrine in the presence of phenol and peroxidase. Sample, standard and distilled water were dispensed into tubes followed by cholesterol reagent. Mixture was incubated for 10 minutes and absorbances of the samples and the standard were measured against reagent blank at 490 nm.

# Triglycerides estimation by colorimetric method

The triglycerides were determined after enzymatic hydrolysis with lipases. The indicator was quinine imine formed from hydrogen-peroxide, 4-aminophenazone and 4-chlorophenol under the catalytic influence of peroxidase. Sample, standard and distilled water were dispensed into tubes followed by triglyceride reagent. Mixture was incubated for 10 minutes and absorbances of the samples and the standard were measured against reagent blank at 490 nm.

# High density lipoprotein cholesterol (HDL-C) estimation by colorimetric method

High density lipoprotein cholesterol (HDL-C) was determined after elimination of chylomicron, VLDL-Cholesterol and LDL-Cholesterol by cholesterol esterase, cholesterol oxidase and subsequently catalase. The intensity of the quinone imine dye produced is directly proportional to the cholesterol concentration. Supernatants of sample, standard and distilled water were dispensed into tubes after precipitation with the precipitant. This was followed by cholesterol reagent. Mixture was incubated for 10 minutes and absorbance of the samples and the standard were measured against reagent blank at 500 nm.

# Estimation of LDL cholesterol using the Friedewald Equation

The Friedewald equation was used in the estimation of LDL cholesterol since the triglyceride (below 400mg/dl or 4.4 mmol/l) and HDL levels are known and chylomicrons are absent (fasting samples).<sup>11</sup>

# By Friedewald Formula:

LDL- C (mg/dL) = TC - HDL-C - TG/5.0

LDL-C (mmol/l) = TC - HDL-C - TG/2.2

# Atherogenic index (AI)

Triglycerides and HDL-cholesterol in AI reflect the balance between the atherogenic and protective lipoproteins. AI correlates with the size of pro- and antiatherogenic lipoprotein particles.

By calculation

$$AI = \frac{\text{Total cholesterol}}{\text{HDL cholesterol}}$$

### Statistical analysis

Paired student's t-test was used to test the significance of difference between mean values. Analysis of variance (ANOVA) was used to test significance of variations within and among group means and Post-Hoc was used for comparism of multiple variables. Pearson correlation analysis was employed to determine association between variables.

#### **RESULTS**

Table 1 shows the mean age, body mass index (BMI), waist circumference (WC), fasting plasma glucose (FPG), glycated heamoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), high density lipoprotein (HDL), low density lipoproteins (LDL), atherogenic Index (AI) and adiponectin (Adipo) levels in diabetics and non-diabetic controls. The BMI, WC, FPG, HbAIc and TG levels were significantly higher (p<0.05) in diabetics compared with non-diabetic control group. No significant differences (p>0.05) were observed in the levels of other parameters between the two groups.

Table 1: Age, Anthropometric Indices (BMI, WC, FPG), HbA1c, TC, TG, HDL-C, LDL, AI and adiponectin (Adipo) in diabetic and non-diabetic subjects.

Variable	Diabetics	Non- Diabetics	P
Age (yrs)	$50.57 \pm 1.48$	$53.78 \pm 1.97$	0.197
BMI (kg/m <sup>2</sup> )	$27.57 \pm 0.58$	$23.12 \pm 0.47$	0.00*
WC (cm)	$93.74 \pm 1.36$	82.61 ± 1.37	0.00*
FPG (mmol/l)	$9.18 \pm 0.48$	$3.98 \pm 0.12$	0.00*
HbA1c (%)	$8.45 \pm 0.21$	$6.84 \pm 0.13$	0.00*
TC (mmol/l)	$4.48 \pm 0.15$	$4.30 \pm 0.14$	0.37
TG (mmol/l)	$1.26 \pm 0.07$	$0.89 \pm 0.04$	0.00*
HDL (mmol/l)	$0.78 \pm 0.03$	$0.74 \pm 0.04$	0.41
LDL (mmol/l)	$3.14 \pm 0.14$	$3.14 \pm 0.15$	0.98
AI	$6.08 \pm 0.30$	$6.39 \pm 0.47$	0.57
Adipo(ng/ml)	$5.16 \pm 0.27$	$5.64 \pm 0.21$	0.16

BMI = Body mass index

WC = Waist circumference

TC = Total cholesterol

TG = Triglyceride

 $HDL = High \ density \ lipoprotein$ 

LDL = Low density lipoprotein

FPG = Fasting plasma glucose

HbA1c = Glycated hemoglobin

AI = Atherogenic index

Adipon = Adiponectin

\* = significant at p<0.05

Table 2 shows effect of gender, glycemic control, duration of diabetes and hypertension on biochemical indices in Type 2 Diabetic subjects. The FPG, HbAIc and TG levels were significantly higher (p<0.05) in diabetics

with poor glycemic control compared with diabetics with good glycemic control. No significant differences (p>0.05) were observed in the levels of other parameters in the different states of glycemia. Hypertensive diabetics have higher levels of TC and lower HDL-C compared to non-hypertensive diabetics. The levels of other parameters were not significantly different (p>0.05) between the two groups. Gender and duration of diabetes do not have any significant (p>0.05) effects on all the parameters studied.

Table 2: Effect of gender, glycemic control, duration of diabetes and hypertension on biochemical indices in type 2 diabetics

Effect	FPG (mmol/l)	HbA1c (%)	TC (mmol/l)	TG (mmol/l)	HDL (mmol/l)	LDL (mmol/l)	AI	Adipo (ng/ml)
Gender								
Males (n = 12)	8.49 ±0.84	8.65 ±0.37	4.58 ±0.29	1.31 ±0.17	0.80 ±0.08	3.19 ±0.22	6.06 ±0.57	4.57 ±0.45
Females (n = 30)	9.45 ±0.57	8.36 ±0.25	4.45 ±0.18	1.24 ±0.08	0.78 ±0.04	3.12 ±0.17	6.08 ±0.36	5.40 ±0.32
p value	0.36	0.53	0.70	0.73	0.77	0.82	0.97	0.15
HbA1c								
<8.0% (n = 18)	7.16 ±0.37	7.18 ±0.17	4.48 ±0.21	1.06 ±0.07	0.75 ±0.05	3.20 ±0.19	5.61 ±0.26	5.31 ±0.37
>8.0% (n = 24)	10.69 ±0.63	9.40 ±0.16	4.49 ±0.22	1.42 ±0.11	0.82 ±0.05	3.09 ±0.20	6.42 ±0.48	5.03 ±0.38
p value	0.00*	0.00*	0.98	0.01*	0.31	0.69	0.14	0.61
Duration								
<5 yrs (n = 31)	9.51 ±0.54	8.59 ±0.23	4.37 ±0.19	1.32 ±0.09	0.75 ±0.04	3.02 ±0.17	6.20 ±0.39	5.05 ±0.30
≥5 yrs (n = 11)	8.25 ±0.10	8.05 ±0.45	4.81 ±0.224	1.11 ±0.11	0.86 ±0.06	3.47 ±0.21	5.72 ±0.31	5.48 ±0.60
p value	0.28	0.30	0.16	0.16	0.16	0.11	0.34	0.53
Hypertension								
Hyper (n = 14) Non hyper	8.65 ±0.10 9.44	8.19 ±0.39 8.58	4.87 ±0.14 4.29	1.26 ±0.16 1.26	0.73 ±0.04 0.89	3.43 ±0.17 2.98	5.75 ±0.54 6.23	5.78 ±0.43 4.85
(n = 28)	±0.52	±0.24	±0.21	±0.08	±0.05	±0.19	±0.37	±0.33
p value	0.49	0.41	0.03*	0.98	0.02*	0.08	0.48	0.09

<sup>\* =</sup> Significant at p<0.05

 $TC = Total \ cholesterol$ 

TG = Triglyceride

HDL = High density lipoprotein

LDL = Low density lipoprotein

FPG = Fasting plasma glucose

HbA1c = Glycated hemoglobin

AI = Atherogenic index

Adipo = Adiponectin

Table 3: Correlation of adiponectin with other parameters in diabetics and non-diabetics.

Adiponectin Vs	Diabetics r value	(n=42) p value	Non-diab (n = 33) r value	etics p value
BMI (kg/m <sup>2</sup> )	0.156	0.323	-0.252	0.157
WC (cm)	0.096	0.546	0.153	0.390
FPG (mmol/l)	0.132	0.405	0.275	0.122
HbA1c (%)	0.097	0.542	-0.096	0.596
TC (mmol/l)	0.268	0.086	0.027	0.883
TG (mmol/l)	-0.043	0.787	-0.302	0.088
LDL-C (mmol/l)	0.234	0.135	-0.105	0.562
AI	-0.046	0.774	-0.559	0.001**

\*\* = Significant at p<0.01

BMI = Body mass index

WC = Waist circumference

TC = Total cholesterol

TG = Triglyceride

LDL = Low density lipoprotein

FPG = Fasting plasma glucose

HbA1c = Glycated hemoglobin

AI = Atherogenic index

Table 3 shows the correlation of Adiponectin with other parameters in Diabetics and Non-diabetics. A significant negative correlation (r = -0.559, p = 0.001) (p < 0.01) was observed between adiponectin levels and atherogenic index in non diabetic control group. No significant correlations (p > 0.05) were observed between adiponectin and other parameters studied in the two groups.

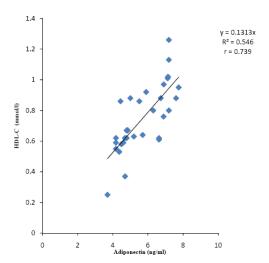


Figure 1: Correlation plot of adiponectin and HDL-C in non-diabetics.

Figure 1 shows the correlation plot of adiponectin and HDL-C in non diabetic control group. Adiponectin correlated positively (r = 0.739, p = 0.001) (p < 0.01) with HDL-C in the non diabetic control group.

#### **DISCUSSION**

The relative or absolute contributions of hyperglycemia, accelerated protein glycosylation and dyslipidemia associated with type 2 diabetes in dysregulation of adiponectin metabolism were examined. The study observed no significant (p>0.05) differences in the serum adiponectin levels of the diabetics and the non-diabetics population studied. Similar observation has been reported by a previous study<sup>12</sup> between type 2 diabetics and controls. Type 2 diabetic subjects recruited in this study have been on sulphonyurea treatment from the time of diagnosis to time analysis was carried out. Therefore their adiponectin levels which were not statistically different from those of the controls may be the result of the effect of the sulphonyurea used in managing these patients. Oral anti-hyperglycaemic therapy with drugs thiazolidinedione (TZD), biguanides and sulphonylureas have been reported to affect plasma concentration of adiponectin. 13,14,15 Improved plasma adiponectin levels in subjects with type 2 diabetes after treatment with sulphonylurea (glimepiride) has been reported. 16 Sulphonylureas are potent peroxisome proliferatoractivated receptor (PPAR) gamma agonist which are regulators of adipocyte differentiation and stimulators of secretion. Sulphonylureas adiponectin stimulate adiponectin secretion by inducing adiponectin gene expression by an interaction with protein kinase A activity. 17 Contrary to our findings, several human studies have confirmed that obesity, insulin resistance and type 2 diabetes are associated with lower levels of adiponectin compared to normal healthy individuals, though the effects of drug therapy on adiponectin levels of these patients were not considered. 18-20

Type 2 diabetics studied had significantly (p<0.05) higher BMI, WC, fasting plasma glucose and HbA1c values than non-diabetics. Diabetes is a common endocrine disorder characterized by hyperglycemia leading to non-enzymatic glycation of proteins, responsible for chronic complications. The non-enzymatic reaction between proteins and sugars (mainly glucose and fructose) leads to glycated proteins which, depending on the number of glucose molecule condensed on them, would exhibit a different functionality.<sup>21</sup> Hyperglycemia leads to increase protein glycation hence the high levels of glycated hemoglobin seen.<sup>22</sup> Higher BMI in diabetics compared to controls have been previously demonstrated. Increased BMI has been associated with increased risk for diabetes starting at a BMI as low as 21 kg/m<sup>2</sup>.<sup>23</sup>

Defects in insulin action and hyperglycemia could lead to changes in plasma lipoprotein in patients with type 2

diabetes.<sup>24</sup> The lipoprotein abnormality commonly present in type 2 diabetes includes hypertriglyceridemia and reduced plasma HDL cholesterol. In this study, serum triglyceride level of the diabetic population was significantly (p<0.05) higher than that of the non-diabetic population. Diabetics with poor glycemic control also have higher TG levels compared to those with good glycemic This observation has been previously control. demonstrated.<sup>23</sup> Elevated serum TGs in diabetic patients may be the result of increased hepatic production of TGs and/or a reduction in their catabolism. The precise pathogenesis of dyslipidemia in diabetes is not known; however, evidence suggests that insulin resistance has a central role in its development.<sup>25</sup> The main cause of the major features of diabetic dyslipidemia is the increased free fatty-acid release from insulin-resistant fat cells. The increased flux of free fatty acids into the liver in the presence of adequate glycogen stores promotes triglyceride production which in turn stimulates the secretion of apolipoprotein B (ApoB) and VLDL-C, thus the impaired ability of insulin to inhibit free fatty-acid release from fat cells leads to enhanced hepatic VLDL-C production, which correlates with the degree of hepatic fat accumulation.<sup>26</sup> An elevated triglyceride level may also simply be an epiphenomenon (i.e. a by-product) of insulin resistance. The serum HDL levels of the diabetics do not differ from the non-diabetics in this study. Sulphonyurea's therapy in type 2 diabetes has complementary effects on lipid profiles in addition to improved glycemic control.<sup>27</sup>

Hypertensive diabetics have higher TC and lower HDL non-hypertensive diabetics Dyslipidemia have been implicated in pathophysiology of atherothrombosis. hypertension and Endothelial dysfunction which results from a reduced availability of nitric oxide (NO) due to both a decrease in its synthesis and to an enhanced degradation has been described as the link mediating these events. Hypercholesterolemia results in increase in vascular permeability to LDL, which becomes oxidized in the arterial wall where the macrophages take them up evolving into foam cells and formation of atherosclerotic plaques.<sup>28</sup> Oxidized LDL also contributes to oxidative stress, where superoxide anion is generated by endothelial oxidase enzymes. Superoxide reacts with NO yielding peroxynitrite (ONOO), a compound which, in high amount, works as a strong oxidant and is toxic to proteins. Oxidized LDL diminishes the expression of endothelial NO synthase (eNOS) thus leading to a decrease in NO production, 28 disruption of endothelium dependent vasodilatation thus affecting the peripheral vascular resistance. Type 2 diabetes on the other hand is an insulin resistant and hyperinsulinemic state; insulin itself can impair endothelium dependent vasodilatation.<sup>29</sup> Hypertension in turn can impair the glucose metabolism through various mechanisms. The exaggerated action of angiotensin II inhibits insulin like growth factor-1(IGF-1) signaling pathway which in turn hampers the vasodilator and glucose transporting actions of IGF-1 and insulin. Inhibited IGF-1 and insulin can accentuate the vasoconstriction by diminishing endothelial

nitric oxide synthase activity and impaired nitric oxide metabolism. Thus diabetes mellitus and hypertension act as vicious cycle and worsen each other. The Dyslipidemia is a well established risk factor for CVD and when hypertension coexists with diabetes mellitus, the risk of CVD increases by 75% and further contributes to morbidity and mortality.

Positive correlation was observed between serum adiponectin levels and HDL levels in non-diabetic population. This correlates with the findings of other studies, 16,32 who also observed significant positive correlation between adiponectin and HDL cholesterol levels in type 2 diabetics. Human studies have found that plasma adiponectin concentrations were positively correlated with HDL-C levels and the relationship is independent of BMI, body fat distribution and insulin sensitivity.<sup>33</sup> Mechanisms of this positive association between adiponectin and HDL-C have been reported to involve an ATP binding cassette transporter A1 (ABCA1) which plays a key role in cellular cholesterol efflux, and seems to be indispensable to the production of circulating HDL. Adiponectin has been shown to upregulate ABCA1 at both mRNA and protein levels in HepG2 cells, suggesting that adiponectin might increase HDL assembly through enhancing ABCA1 pathway and apoA-1 synthesis in the liver. Adiponectin has also been shown to reduce the release of ApoB and ApoE from hepatocytes, resulting in reduced release of TG-rich lipoproteins from the liver thus preventing the formation of TG-rich HDL and leading to elevated systemic HDL-C.34 These effects are seen in both diabetics and non diabetics. Hypoadiponectinemia have been implicated in increased risk of coronary artery disease. 16

Atherogenic index (TC/HDL ratio) correlated negatively with serum adiponectin in non-diabetic population of the study. A similar observation has been reported.<sup>35</sup> Increased total cholesterol (TC) to HDL ratio (TC/HDL) has been established as an appropriate index to predict cardiovascular diseases related to type 2 diabetes.<sup>36</sup> Adiponectin have been described as an anti-atherogenic and anti-inflammatory adipokine, properties attributed to its effect on HDL metabolism.

Gender, duration of diabetes and glycaemic control seems to have no effect on the serum adiponectin values of the diabetic population studied. A similar study reported no differences in the adiponectin levels in males and females of both diabetics and non-diabetics. <sup>14</sup> However, gender related differences have also been reported on serum adiponectin levels in diabetics. <sup>37, 38</sup> Increased adiponectin levels have been associated with better glycemic control, better lipid profile, and reduced inflammation in diabetic subjects. <sup>9,39</sup> Disease duration was reported to correlate positively with adiponectin concentrations in diabetics. <sup>40</sup>

## **CONCLUSION**

Serum adiponectin levels of Nigerian type 2 diabetics do not differ significantly from that of their non-diabetics counterparts and this may be due to effects of sulphonyurea therapy on adiponectin synthesis. Duration of diabetes, glycemic control and gender related differences do not seem to exert any influence on adiponectin levels of type 2 diabetics. Adiponectin may be associated with reduced risk of atherosclerosis, an effect mediated through its positive association with HDL cholesterol levels.

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Ethical approval: The study was approved by the

Institutional Ethics Committee

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