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Total antioxidant status and adiponectin levels in gestational diabetes mellitus in Kaduna State, Nigeria

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Abstract

Antioxidants play a key role in treating and reducing the complication of diabetes mellitus. Adiponectin exerts insulin-sensitizing effects and possesses anti-inflammatory and anti-angiogenic properties, which may play crucial roles in gestational diabetes mellitus (GDM) pathophysiology. This study aim at evaluating total antioxidant status and adiponectin levels in gestational diabetes mellitus patients. The study evaluated a cross sectional design in which a total of 160 subjects between the ages of 18- 40 years were recruited for the study. Sixty (60) subjects were gestational diabetic women, 50 non-diabetic pregnant women as $Control_1$ all attending Antenatal clinics at BarauDikko Teaching Hospital, Yusuf Dantsoho Memorial Hospital and GwamnaAwan General Hospital, Kaduna State, Nigeria as well as 50 apparently healthy non-pregnant non diabetic staff as $Control_2$. From the participants, 60 were gestational diabetic mellitus (GDM) (37.50%) with mean age 30.93 ± 0.55years, 50 non GDM pregnant women (31.25%) with mean age 27.68±0.50 years and 50 non GDM non pregnant (31.25%) with mean age 29.24±0.42 years. Adiponectin (APN) level was significantly lower compared with total antioxidant status (TAS) and vitamin C levels in pregnant women. The random blood glucose (RBG), fasting blood glucose (FBG) and 2 hours prospandial blood glucose (2HBG) concentrations in GDM patients and Controls 1 and 2 subjects were all significant different ($p < 0.05$). However, inter group comparism of C_1vsC_2 in RBG, FBG and 2HBG were all similar ($p>0.05$). The correlations between AGE vs BMI was significant ($r= 0.276$, $p < 0.05$), Age vs 2HBG ($r = -0.256$, $p <0.05$) FBG vsRBG ($r = 0.369$ $p<0.05$). FBG versus 2HBG ($r = 0.646$ $p<0.05$) and 2HBG vs RBG ($r = 0.524$, $p<0.05$) in GDM patients. The study indicated a relationship between total antioxidant capacity (TAS) and adiponectin in pregnant women with GDM compared pregnant women without GDM and control none pregnant women. Majority of the women take daily intake of vegetables, which could positively affect their antioxidant status. There was significantly lower APN compared with TAS, while a significant level of vitamin C compared with APN.

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1.0 Introduction

Gestational Diabetes Mellitus (GDM) is a type of diabetes that occurs in pregnancy usually as a result of blood sugar levels. This condition occurs at a middle of pregnancy between 24 and 28 weeks. GDM appears as a result of insulin resistance or if there is decrease in insulin production and occurs during pregnancy. Overweight, previously having gestation diabetes mellitus, family history of type two diabetes are the risk factors associated with GDM. In view of the fact that GDM happens at the middle of pregnancy, thus, screening is recommended between 24 and 28 weeks' gestation for those at normal risk. Like other diabetes GDM can be treated using insulin injections, in addition to this, regular exercise between pregnancy and maintenance of healthy weight helps in preventing the

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condition. GDM usually become over after given birth to the baby. Base on different studies, 30 and 84% are the chances of having GDM in the next pregnancy if a woman had GDM in her previous pregnancy (Kim *et al*., 2011).

Adiponectin, known for its role in glucose homeostasis and insulin sensitivity, exhibits changes during pregnancy. Several studies have reported lower levels of adiponectin in women with GDM compared to healthy pregnant women (Durnwald *et al*., 2006). For instance, a study by Durnwald *et al*. (2006) demonstrated that women with a history of GDM had significantly lower adiponectin levels than women with a normoglycemic history. These findings suggest a potential relationship between reduced adiponectin levels and the development of GDM.

Adiponectin exerts insulin-sensitizing effects and possesses anti-inflammatory and anti-angiogenic properties, which may play crucial roles in GDM pathophysiology. Adiponectin enhances insulin sensitivity by activating adenosine monophosphate-activated protein kinase (AMPK) and peroxisome proliferator-activated receptor-alpha (PPAR-α) signaling pathways, leading to increased glucose uptake and utilization (Retnakaran *et al*., 2005). Additionally, adiponectin's anti-inflammatory and anti-angiogenic properties may modulate GDM-associated inflammation and impaired placental vascularization. These effects could potentially influence insulin resistance and glucose intolerance observed in GDM.

Antioxidants play a key role in treating and reducing the complication of diabetes mellitus. During pregnancy human cells engage in huge amount of work, undergoing repairment and grow at very high speed compare to the normal time, however, these courses the production of more amount of free radicals. This is one of the reason why eating a diet rich in antioxidants is very vital at the time of pregnancy. Like the fact that glucose level is reduced by using antioxidants is not well clear but it decrease the plasma glucose while increase the metabolic of glucose in pheripheral tissue at the same time. Hence, antioxidants can reduce the risk of of many disease like diabetes (Boden, 2005).

Antioxidants are molecules, compounds that delay, decrease or slow down oxidation or transfer of electron of another molecules. By stopping the formation of free radicals antioxidants ease oxidative stress. Antioxidants give one of their free electrons to free radical and terminating their chain reaction (Afzal and Armstrong, 2002). Antioxidants can be made by man or natural substances that decrease cell damage. The good source of antioxidants are diets high in fruits and vegetables, however, research shows that there is not known antioxidants supplements that can be used in preventing disease. Examples of antioxidants include vitamins C and E, selenium, and carotenoids, such as beta-carotene, lycopene, lutein, and zeaxanthin (Sies and Stahl, 2003). This study aims at evaluating total antioxidant status and adiponectin levels in gestational diabetes mellitus.

2.0 Materials and methods

2.1 Study Area

The study was conducted in Kaduna, Kaduna State, Northwest Nigeria. The state is located in the Northern part of Nigeria's High Plains (Coordinates: 10°20′N7°45′E). It consists of a total of 46,053 km^2 (17,781 sq meter) area with a population recorded of 6,113,503 in 2006 (https://nurhi.org/en/nurhi-kaduna/).

Figure 1: Location of Kaduna State in Nigeria
Olaghere, 2022

2.2 Study Design

This study is a cross sectional design in which a total of 160 subjects between the ages of 18- 40 years were recruited for the study. However, 60 subjects were gestational diabetic women, 50 non-diabetic pregnant women as $Control_1$ all attending Antenatal clinics at BarauDikko Teaching Hospital, Yusuf Dantsoho Memorial Hospital and GwamnaAwan General Hospital, Kaduna State as well as 50 apparently healthy non-pregnant non diabetic staff as $Control_2$. Arrangements were made with the clinicians whereby subjects who satisfy the study inclusion criteria were selected. A structured questionnaires was administered to the study population. Vital information including the name, age, ethnic group, height, weight, blood pressure and pregnancy induced complications were obtained through personal interview followed by blood sample collection.

2.3 Inclusion Criteria

All pregnant women within the age of 18–40 years, permanent residents of Kaduna Metropolis, within 24–28 weeks of gestation according to the WHO diagnostic criteria, who give their consent and underwent GDM universal screening, were included in the study. Non-GDM and screened GDM women who are non-hypertensive and who agreed to participate were also included in the study. Apparently, healthy aged matched non-GDM pregnant women as well as apparently healthy non pregnant women too were included in the study as controls [1 and 2].

2.4 Exclusion Criteria

Primigravidas, obesse subjects, women who are <18 or >45 years, pregnant women with chronic hypertension, multiple gestation, pre-eclamsia and eclamsia would be excluded in the study All those who personally decline to give consent for inclusion shall also be excluded from the study.

2.5 Informed Consent and Ethical Approval

Kaduna State Ministry of Health ethical committee consents were obtained from all subjects before inclusion using approved protocol. Ethical approval of the study was obtained from the Ethics Committees of the Kaduna State Ministry of Health in accordance with Helsinki declaration.

2.6 Sample Size Determination

The sample size was determined from a standard formula (Kyriazos, 2018).

$$n = \frac{(Z1 - a)2\ (P)\ \ (1 - P)}{d2}$$

Where **n**= minimum sample size;

Z_1-a= value of standard normal deviation which at 95% confidence level has been found to be 1.96,

P = the best estimate of the population prevalence obtained from literature review (3.4%)

d = difference between the true population rate and sample that can be tolerated, that is the absolute precision required (in percentage point) on either side of the population i.e. degree of confidence = 0.05

$$\boldsymbol{n} = \frac{(3.8416)\ (0.034)\ \ (0.9966)}{0.0025}$$

$\boldsymbol{n}$ = 51

Therefore a total of 51 with 10% (5) of these subjects will be added to the research for attrition making a total of 56 total subjects but for the purpose of these study 60 samples shall be used.

2.7 Specimen Collection and Processing

A consecutive sampling method screening was done with 50 g oral glucose challenge test followed by fasting 75g OGTT were performed in all women between 24 and 28 weeks of gestation. Diagnosis of GDM was established according to the diagnostic criteria of the American Diabetes Association 2018. Subjects consent was a priority and was obtained using consent forms. Findings of the blood samples collected from all subjects were fully documented in the proforma. Assessments such as blood pressure (BP), weight (W), height (H) and basal metabolic index (BMI) were also observed.

Blood specimen (5ml) for the biochemical measurements, was collected from peripheral vein (antecubital venepuncture). This was done by cleaning the antecubital fossa with methylated spirit and with the application of a tourniquet a few centimeters above the anticubital fossa to distend the veins, an overnight fasting sample of 5ml venous blood was drawn from each subject and dispensed into plane containers. The coagulated whole blood was centrifuged at 1,000 rpm (Revolution Per minute) for 15 minutes, within 30 minutes of collection. The serum was removed, transferred to Bijou bottles. The samples for glucose, antioxidants, Vitamins C and E will be analyzed immediately. Specimens for other parameters that would not be assayed within 24 hours of collection were stored frozen at -80^0C until the time for analysis.

2.8 Chemicals/Reagents

The analytical kits used for the determinations were procured from Randox Company Limited. All the chemicals and reagents were of analytical grade or higher.

2.9 Measurement of Serum parameters

Serum glucose was measured using enzymatic method of McMillin, 1990, serum adiponectin level was analyzed by ELISA, according to the method described by Dehdashti, 2020 while serum total antioxidant status (TAS) was measured according to the method of Ibuki, 2020. The weight, height and body mass index were measure and calculated using standard laboratory procedures.

2.10 Statistical Analysis

The data obtained was treated accordingly using Statistical Program for the Social Sciences (SPSS 17.0) for windows (SPSS Inc, Chicago, 1L). ANOVA was

then used to compare between different groups. Other analytes estimated along with the TAS were correlated to find relationship between them and their effect in controlling GDM. Correlation between TAS and glucose was carried out using Pearson's linear correlation analysis. A p-value of equal to or less than 0.05 ($p \leq 0.05$) was considered significant.

3.0 Results

3.1 Distribution of the Study Population

One hundred and sixty women aged 18-40 years were recruited for the study. They were made up of 60 GDM (37.50%) with mean age 30.93 ± 0.55years, 50 non GDM pregnant women (31.25%) with mean age 27.68±0.50 years and 50 non GDM non pregnant (31.25%) with mean age 29.24±0.42 years (Table 1).

3.2: Estimated Gravitational, Age and Body Mass Index of GDM Patients and Controls Subjects

Table 2, revealed estimated gravitational age, in that a greater number of the women (45) were in their 28 weeks while 28 women were in 24 weeks. However, 41 women had BMI>30 kg/m^2, 59 women were within the range of 18.5-24.9 kg/m^2 and 55 women had BMI between 25.0-29.9 kg/m^2.

3.3: Age Distributions and Blood Pressure Parameters of GDM Patients and Control Subjects

In the overall study, 18 women were > 25 years, 124 were within the age of 25 – 35 years and >35 years had only 18 women. The Systolic Blood Pressure of 111 women was about 110mmHg, 41 women had between 111-120mmHg, >120mmHg was the level in 8 women. The Diastolic Blood Pressure of 93 women was <80mmHg, 9 women had >90mmHg and 58 women had between 80-90mmHg (Table 3).

3.4 Parity, Ethnic Group and Fruits/Vegetable Intake Distributions in GDM Patients and Control Subjects

In the Table 4, 114 out of the study population had <4 children, 14 had >6 children while 32 women had between 4-6 children. Ethnic group most of the women where Hausa/Fulani and Kaduna tribes were 83 and 50 respectively, only 1 Igbo woman, 14 Yoruba women and 12 women were from other minor tribes in Nigeria. Daily intake of fruits and vegetables was observed by about 112 women, 35 women accepted taking the vegetable daily while 13 women only take vegetables monthly

3.5 Demographic Characteristics (MEAN±SEM) of GDM patients and control subjects

Table 5 shows mean values of clinical parameters in GDM patients according to their age distribution, BMI, SBP and DBP. All the parameters in GDM, Control$_1$vs Control$_2$ subjects were significant ($p < 0.05$).

3.6: Blood Glucose Levels of GDM and Control Subjects

Table 6 shows mean values of biochemical parameters in GDM and Controls 1 and 2 subjects according to OGCT (RBG) and OGTT (FBG and 2HBG). The RBG, FBG and 2HBG concentrations in GDM patients and Controls 1 and 2 subjects were all significant ($p < 0.05$). However, inter group comparism of C_1vsC_2 in RBG, FBG and 2HBG were all similar ($p>0.05$).

3.7: Adiponectin and Vitamin C (MEAN±SEM) of GDM Patients and Control Subjects

The OGCT and OGTT mean values of Adiponectin (APN), TAS and Vitamin C in GDM patients and Controls 1 and 2 are shown in Table 7. The mean values of Adiponectin for both in OGCT and OGTT, was significantly raised ($P<0.05$) in C_1 as compared to C_2 and GDM. An intergroup comparison for OGCT reveals significant difference in G vs C_1, G vs C_2 as well as C_1vsC_2.While for OGTT (FBG), Adiponectin level was statistically different between G vs C_1 and C_1vsC_2. However, for OGTT (2HBG), the difference was seen between G vs C_1. The TAS and Vitamin C levels in OGCT and OGTT (FBG) was significantly increased in ($p< 0.05$) C_2 than G and C_2 with similar difference existing across all the groups for OGTT (2HBG). Intergroup comparison reveals significant difference between G v C_2 and C_1vC_2 for both OGCT and OGTT (FBG) with an insignificant difference between G vs C_1, G v C_2 and C_1vC_2.

3.8 Blood Glucose Levels (MEAN±SEM) of GDM Patients According to their Age Distributions in both OGCT and OGTT Samples

The mean values of biochemical analytes in GDM patients as shown in Table 8. For OGCT and OGTT (FBG), blood glucose levels were significantly increased ($P<0.05$) in younger <25years age group when compared to 25-35 and >35years age groups. However for OGTC and OGTT (2HBG) the Blood glucose levels were similar ($p>0.05$).Intergroup comparisons reveals insignificant differences occurring in G vs C_1, G vs C_2 and C_1vsC_2 for both OGCT and OGTT.

3.9 Adiponectin and Vitamin C (MEAN±SEM) According to Age of GDM Patients for OGCT and OGTT Samples

For the OGCT and OGTT components, the Adiponectin, TAS and Vitamin C levels in GDM patients according to their age distributions were similar ($p>0.05$) in all the age distributions except for Vitamin C in OGTT (2HBG) that was significantly higher ($p < 0.05$) in age range of 25 -35 years as compared to >35 and <25 years. For adiponectin, TAS and vitamin C intergroup (<25v25-35, <25v>35 and 25-35v>35) Similar levels were observed in all the groups (Table 9).

2.10 Adiponectin and Vitamin C Levels (MEAN±SEM) in GDM Patients According to BMI in OGCT and OGTT Samples

The mean values for Adiponectin, TAS and Vitamin C in OGCT and OGTT (FBG) across the BMI groups(18.5-24.9,25.0-29.9 and >30.0) kg/m^{2}was found to be similar ($P>0.05$) but for OGTT (2HBG)

level of Adiponectin was found statistically higher in >30.0 than 25,0-29.9 kg/m^{2}and 18.5-24.9 kg/m^2 groups. Intergroup comparison reveals similar levels in D, E and F (Table 10).

2.11 Correlations Between AGE, BMI, SBP, DBP and Blood Glucose Levels in GDM Patients for OGCT and OGTT Samples

Pearson's Correlation analysis in Table 11 of GDM patients. The correlations between AGE vs BMI was significant (r= 0.276, p < 0.05), Age vs 2HBG (r = -0.256, p <0.05) FBG vsRBG(r = 0.369 p<0.05). FBG versus 2HBG (r = 0.646 p<0.05) and 2HBG vs RBG (r = 0.524, p<0.05) in GDM patients.

Table 1: Distribution of the study population

Subjects	N	Percentage (%)	Mean Age (years)
GDM	60	37.50	30.93 ± 0.55
Control$_1$	50	31.25	27.68 ± 0.50
Control$_2$	50	31.25	29.24 ± 0.42

n=Number of patients, GDM = gestational diabetes mellitus, Control$_1$= non GDM pregnant women and Control$_2$ = non diabetic non pregnant.

Table 2: Estimated Gravitational Age and Body Mass Index of GDM patients and controls Subjects.

Groups	GDM (n = 60)	C1 (n = 50)	C2 (n = 50)	Total(n =160)
EGA (weeks)				
24	19	19	-	38
25	7	3	-	10
26	5	3	-	8
27	6	3	-	9
28	23	22	-	45
BMI (kg/m^2)				
18.5-24.9	10	22	27	62
25.0-29.9	27	19	9	54
>30	18	9	14	44

n=Number of patients, EGA = Estimated Gravitational Age, BMI = Body Mass Index, GDM = gestational diabetes mellitus, Control$_1$= non GDM pregnant women and Control$_2$ = non diabetic non pregnant.

Table 3: Age distributions and Blood Pressure Parameters of GDM patients and control subjects.

Parameter	GDM (n = 60)	C$_1$ (n = 50)	C$_2$ (n = 50)	Total (n =160)
Age (years)				
18-24	5	13	0	18
25-35	40	36	48	124
36-40	15	1	2	18
SBP (mmHg)				
<=110	23	43	45	111
111-120	31	5	5	41
>120	6	2	0	8
DBP (mmHg)				
<80	44	31	18	93
80-90	10	16	32	58
>90	6	3	0	9

n=Number of patients, SBP=Systolic Blood Pressure, DBP=Diastolic Blood Pressure, GDM = gestational diabetes mellitus, Control$_1$ = non GDM pregnant women and Control$_2$ = non diabetic non pregnant.

Table 4: Parity, Ethnic group and Fruits/Vegetable intake distributions in GDM patients and control subjects.

Parameters	GDM (n = 60)	C1 (n =50)	C2 (n = 50)	Total(n = 160)
Parity				
<4	42	42	30	114
4-6	13	8	11	32
>6	5	0	9	14
Ethnic Groups				
H/Funali	35	36	12	83
Kad. Tribes	7	7	36	50
Igbo	0	1	0	1
Yoruba	9	3	2	14
Other Tribe	9	3	0	12
Fruits/Veg intake				
Daily	38	36	38	112
Weekly	13	10	12	35
Monthly	9	4	0	13

n=Number of patients, GDM = gestational diabetes mellitus, Control 1= non GDM pregnant women and Control 2 = non diabetic non pregnant.

2.12 Correlations of AGE, BMI, SBP AND DBP Versus adiponectin in GDM Patients for OGCT and OGTT Samples

Correlations analysis in GDM patients, as shown in Table 12. The correlations between AGE vs DBP was significant (r= 0.295, p < 0.05), AGE vs RBG (r = 0.253, p < 0.05), AGE vs 2HBG (r = 0.266, p < 0.05). Correlation also exist between SBP vs DBP (r = 0.740, p < 0.05) in GDM patients. RBG and FBG samples, DBPvsVitamin C. Correlated negatively (r = -0.262, p < 0.05) (r = -0.304, p< 0.05). However, in FBG sample AGE and DBP both correlated with GPx (r = -0.306, p< 0.05) (r= 0.316, p< 0.05). Also, in 2HBG sample AGE correlated positively with MDA (r = 0.358, p< 0.05).

Table 5: Demographic Characteristics of GDM patients and control subjects

Parameters	**GDM (n = 60)**	**C_1 (n = 50)**	**C_2 (n = 50)**	F-value	p-value	GvC_1	GvC_2	C_1vC_2
Age (years)	30.93± 0.55^{a}	27.68±0.50^{b}	29.24±0.42^{a}	11.576	0.000	0.000	0.141	0.002
BMI (Kg/m2)	30.06±0.71^{a}	25.57±0.63^{b}	26.18±0.43^{c}	4.639	0.011	0.010	0.010	0.000
SBP(mmHg)	110.13±0.91^{a}	102.84±0.75^{b}	101.32±0.51^{b}	24.748	0.000	0.000	0.000	0.430
DBP(mmHg)	81.22±0.14^{a}	78.64±0.81^{a,b}	78.20±0.41^{b}	2.993	0.053	0.521	0.018	0.095

n=Number of patients, GDM = gestational diabetes mellitus, Control$_1$= non GDM pregnant women, Control$_2$ = non diabetic non pregnant and values with different (^{ab}) superscripts are significantly different (p<0.05).

Table 6: The mean blood Glucose Levels of GDM and Control Subjects.

Parameter (mmol/L)	**GDM** (n = 60)	**C_1** (n = 50)	**C_2** (n = 50)	**F-value**	**p-value**	**GvC_1**	**GvC_2**	**C_1vC_2**
RBG	8.28±0.11^{a}	5.92±0.16^{b}	5.49±0.15^{b}	126.781	0.000	0.000	0.000	0.036
FBG	6.21±0.14^{a}	4.46±0.10^{b}	4.58±0.10^{c}	70.330	0.000	0.000	0.000	0.492
2HBG	8.70±0.13^{a}	5.82±0.14^{b}	5.62±0.13^{c}	174.401	0.000	0.000	0.000	0.324

n=Number of patients, GDM = gestational diabetes mellitus, Control 1= non GDM pregnant women, Control 2 = non diabetic non pregnant, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different (^{ab}) superscripts are significantly different (p< 0.05).

Table 7: Total Antioxidant Status, Adiponectin and Vitamin C levels of GDM patients and controls

Parameters	**GDM**(n=60)	**C_1**(n=50)	**C_2**(n = 50)	F-value	p- value	GvC_1	GvC_2	**C_1vC_2**
TAS(rbs) (µmol/ml)	5.04±0.19^{a}	5.62±0.21^{a}	7.14±0.24^{b}	26.261	0.000	0.051	0.000	0.000
TAS(fbs) (µmol/ml)	5.64±0.14^{a}	5.39±0.17^{a}	7.14±0.24^{b}	11.430	0.000	0.511	0.000	0.000
TAS (2hbg) (µmol/ml)	5.62±0.21^{a}	5.78±0.20^{a}	5.36±0.29^{a}	0.762	0.468	0.641	0.422	0.225
APN(rbs) (µg/L)	4.93±0.22^{a}	10.13±0.27^{b}	6.51±0.24^{c}	122.481	0.000	0.000	0.000	0.000
APN(fbs) (µg/L)	8.40±0.38^{a}	9.98±0.45^{b}	8.10±0.47^{a}	5.292	0.006	0.009	0.608	0.003
APN(2hbg) (µg/L)	6.66±0.38^{a}	5.36±0.37^{b}	6.51±0.24^{a}	4.072	0.019	0.007	0.562	0.039
Vit.C(rbs) (mg/ml)	32.53±1.97^{a}	30.03±2.78^{a}	73.80±9.31^{b}	19.854	0.000	0.742	0.000	0.000
Vit.C(fbs) (mg/ml)	34.78±2.29^{a}	39.79±3.51^{a,b}	44.06±1.50^{b}	3.345	0.035	0.161	0.010	0.253
Vit.C(2hbg) (mg/ml)	30.70±1.43^{a}	30.84±3.36^{a}	25.82±2.43^{a}	1.338	0.265	0.967	0.152	0.159

n=Number of patients, TAS = Total Antioxidant Status, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose,, SEM=standard error of mean and values with different (^{ab}) superscripts are significantly different (p< 0.05).

Table 8: Blood glucose levels of the GDM patients according to their age groups in both OGCT and OGTT samples.

Parameters (mmol/L)	>25 (n =5)	25-35 (n =40)	>35 (n =15)	F-value	p-value	A	B	C
RBG	8.40±0.77[a]	8.38±0.13[b]	7.97±0.14[c]	1.242	0.297	0.951	0.341	0.129
FBG	7.47±0.12[a]	6.04±0.13[b]	6.24±0.25[b]	4.133	0.021	0.006	0.028	0.520
2HBG	9.30±1.25[a]	8.66±0.12[a]	8.59±0.15[a]	0.985	0.380	0.193	0.181	0.808

n=Number of patients, GDM = gestational diabetes mellitus, Control 1= non GDM pregnant women, Control 2 = non diabetic non pregnant, BG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different ([a, b]) superscripts are significantly different (p< 0.05). A,B andC = <25v25-35, <25v>35 and 25-35v>35

Table 9: TAS, Adiponectin and Vitamin C according to age of GDM Patients for OGCT and OGTT Samples

Parameters	>25 (n =5)	25-35 (n =40)	>35 (n =15)	F-value	p- value	A	B	C
TAS(rbs) (µmol/ml)	4.61±0.77[a]	5.00±0.23[a]	5.32±0.39[a]	0.486	0.618	0.591	0.362	0.476
TAS(fbs) (“)	5.59±0.38[a]	5.69±0.19[a]	5.52±0.23[a]	0.132	0.877	0.841	0.915	0.619
TAS (2hbg) (“)	5.83±0.10[a]	5.67±0.28[a]	5.41±0.37[a]	0.184	0.832	0.844	0.624	0.598
APN(rbs) (µg/L)	4.80±0.89 [a]	5.00±0.29 [a]	4.80±0.42[a]	0.089	0.915	0.809	0.100	0.704
APN(fbs) (,,)	11.20±0.45[a]	8.02±0.45[b]	8.49±0.70[a,b]	2.810	0.069	0.021	0.069	0.583
APN(2hbg) (µg/L)	4.04±0.95[a]	6.76±0.45[b]	7.29±0.74[b]	2.532	0.088	0.048	0.030	0.533
Vit.C(mg/ml)	34.14±7.83[a]	30.20±2.48[a]	38.20±3.28[a]	1.548	0.221	0.586	0.606	0.087
Vit.C(fbs) (mg/ml)	26.49±2.42[a]	33.82±1.76[a]	23.76±2.25[a]	5.675	0.006	0.391	0.925	0.238
Vit.C(2hbg) (mg/ml)	39.84±12.12[a]	32.57±2.78[a]	38.98±3.75[a,b]	0.935	0.399	0.138	0.610	0.002

n=Number of patients, TAS = Total Antioxidant Status, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different ([a, b]) superscripts are significantly different (p< 0.05). A,B andC = <25v25-35, <25v>35 and 25-35v>35

Table 10: Adiponectin and Vitamin C in GDM patients according to their BMI

Parameter	Normal 18.5-24.9 (n=13)	Over weight 25.0 -29.9 (n=26)	Obese >30 (n=21)	F- value	p-value	D	E	F
APN(rbs) (µg/L)	4.62±0.42	5.08±0.35	4.95±0.38	0.312	0.733	0.435	0.582	0.807
APN(fbs) (..)	9.58±0.83	8.50±0.52	7.55±0.66	2.041	0.139	0.270	0.049	0.265
APN(2hbg) (,,)	5.32±0.50[a]	6.42±0.50[a,b]	7.80±0.76[b]	0.323	0.043	0.255	0.015	0.097
Vit.C(rbs) (mg/ml)	24.94±3.78[a]	36.33±3.18[b]	32.52±3.03[a,b]	2.530	0.089	0.028	0.156	0.386
Vit.C(fbs) (mg/ml)	30.24±5.47	35.88±3.76	36.23±3.21	0.529	0.586	0.356	0.346	0.947

Parameter	Normal 18.5-24.9 (n=13)	Over weight 25.0 -29.9 (n=26)	Obese >30 (n=21)	F- value	p-value	D	E	F
Vit.C(2hbg) (mg/ml)	30.84±3.52	32.41±2.02	28.48±2.42	0.727	0.488	0.679	0.550	0.233

n=Number of patients, TAS = Total Antioxidant Status, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different ($^{a, b}$) superscripts are significantly different (p< 0.05), D, E,F = 18.5-24.9V25.0 – 29.90, 18.5-24.9V>30.0, 25.0 – 29.90V>30.0

Table 11: Correlations between Age, BMI, SBP, DBP and Blood glucose Levels in GDM Patients for OGCT and OGTT Samples

CORRELATED PARAMETERS	r	p-value
AGE versus BMI	0.434*	0.001
AGE versus SBP	0.277*	0.032
AGE versus DBP	0.295*	0.003
AGE versus FBG	-0.174	0.184
AGE versus 2HBG	-0.256 *	0.049
BMI versus DBP	0481*	0.000
RBG versus FBG	0.369**	0.004
FBG versus 2HBG	0.646 **	0.000
RBGversus2HBG	0.524**	0.000

GDM = gestational diabetes mellitus, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different ($^{a, b}$) superscripts are significantly different (p< 0.05)

4.0 Discussion

Gestational diabetes mellitus (GDM) is a widespread metabolic disorder characterized by glucose intolerance during pregnancy, while adiponectin, a hormone mainly secreted by adipose tissue, has gained considerable attention in recent years due to its potential role in the pathogenesis and management of GDM (Muhas and Naseef , 2017). The current study examine one hundred and sixty women with 37.50% GDM and mean age 30.93 ± 0.55 years. The estimated gravitational age, in that a greater number of the women (45) were in their 28 weeks while 28 women were in 24 weeks. However, 41 women had BMI>30 kg/m^2, 59 women were within the range of 18.5-24.9 kg/m^2 and 55 women had BMI between 25.0-29.9 kg/m^2. The systolic blood pressure of the women was about 110mmHg while the diastolic blood pressure of was < 80mmHg. Daily intake of fruits and vegetables was observed in majority of the study women, while some accepted taking the vegetable daily with others only take vegetables monthly. Furthermore, the RBG, FBG and 2HBG concentrations in GDM patients and Controls 1 and 2 subjects were all significant (p < 0.05) different. However, inter group comparism of C_1vsC_2 in RBG, FBG and 2HBG were all non-significant (p>0.05).

Adiponectin holds promise as a diagnostic marker for GDM risk assessment. Lower adiponectin levels in early pregnancy have been associated with an increased risk of developing GDM (Durnwald *et al*., 2006). Incorporating adiponectin measurements into GDM screening protocols may enhance risk stratification and early intervention, allowing for tailored management approaches. In addition, adiponectin-based therapeutic approaches are being explored. Animal studies have shown promising results, indicating that adiponectin supplementation in pregnant mice prevented the adverse effects of maternal obesity on placental function and fetal growth (Aye *et al*., 2015). These suggested that interventions targeting adiponectin signaling pathways may provide novel strategies for GDM prevention and management. It was recommended that adiponectin may serve as a valuable biomarker for GDM risk assessment, offering insights into disease progression and highlighting potential therapeutic strategies. However, further research is needed to elucidate the complex interplay between adiponectin, insulin resistance, and GDM pathophysiology (Muhas and Naseef, 2017).

Table 12: Correlations OF Age, BMI, SBP and DBP Versus Adiponectin and antioxidants levels of GDM patients for OGCT and OGTT samples

Parameters		R	p-value
(RBG)	AGE vs MDA	0.350	<0.05
	AGE vs GPx	-0.306	<0.05
(FBG)	BMI vs APN	0.258	<0.05
	BMI vs CAT	0.271	<0.05
	DBP vsVit. C	-0.262	<0.05
	DBP vsGPx	0.316	<0.05
(2HBG)	DBP vsVit.C	-0.304	<0.05
	BMI vs APN	0.322	<0.05

GDM = gestational diabetes mellitus, RBG= Random Blood Glucose, FBG= Fasting Blood Glucose, 2HBG= Two Hours Blood Glucose, SEM=standard error of mean and values with different (a, b) superscripts are significantly different (p< 0.05).

Data from Worda *et al*. (2004) demonstrated a decrease in plasma adiponectin levels in women with gestational diabetes mellitus compared with unaffected women (Worda *et al*., 2004).

In the study, OGCT and OGTT components, the adiponectin, TAS and Vitamin C levels in GDM patients according to their age distributions were similar ($p>0.05$) in all the age distributions except for Vitamin C in OGTT (2HBG) that was significantly higher ($p < 0.05$) in age range of 25 -35 years as compared to >35 and <25 years. Furthermore, the mean values for adiponectin, TAS and Vitamin C in OGCT and OGTT (FBG) across the BMI groups (18.5-24.9,25.0-29.9 and >30.0) $kg/m^2$was found to be similar ($p>0.05$) but for OGTT (2HBG) level of Adiponectin was found statistically higher in >30.0 than 25,0-29.9 $kg/m^2$and 18.5-24.9 kg/m^2 groups.

Insulin resistance occurs when cells no longer respond to insulin adequately. At the molecular level, insulin resistance is usually a failure of insulin to send or receive signals, which result to inadequate plasma membrane translocation of glucose transporter 4 (GLUT4) - the primary transporter that is responsible for bringing glucose into the cell to use as energy. The rate of insulin stimulated glucose uptake is reduced in GDM when compared with normal pregnancy (Catalano, 2014). While insulin receptor abundance is usually unaffected, reduced tyrosine or increased serine/threonine phosphorylation of the insulin receptor dampens insulin signaling (Barbour *et al*, 2007). In addition, altered expression and/or phosphorylation of downstream regulators of insulin signaling, including insulin receptor substrate (IRS)-1, phosphatidylinositol 3-kinase (PI3K), and GLUT4, has been described in GDM (Catalano, 2014). Many of these molecular changes persist beyond pregnancy (Friedman *et al*., 2008).

Pearson's Correlation analysis in Table 11 of GDM patients. The correlations between AGE vs BMI was significant ($r= 0.276$, $p < 0.05$), Age vs 2HBG ($r = -0.256$, $p <0.05$) FBG vsRBG($r = 0.369$ $p<0.05$). FBG versus 2HBG ($r = 0.646$ $p<0.05$) and 2HBG vs RBG ($r = 0.524$, $p<0.05$) in GDM patients. Correlations analysis in GDM patients, as shown in Table 12. The correlations between AGE vs DBP was significant ($r= 0.295$, $p < 0.05$), AGE vs RBG ($r = 0.253$, $p < 0.05$), AGE vs 2HBG ($r = 0.266$, $p < 0.05$). Correlation also exist between SBP vs DBP ($r = 0.740$, $p < 0.05$) in GDM patients. RBG and FBG samples, DBPvsVitamin C. Correlated negatively ($r = -0.262$, $p < 0.05$) ($r = -0.304$, $p< 0.05$). However, in FBG sample AGE and DBP both correlated with GPx ($r = -0.306$, $p< 0.05$) ($r= 0.316$, $p< 0.05$). Also, in 2HBG sample AGE correlated positively with MDA ($r = 0.358$, $p< 0.05$). The findings are similar to the reports of Bhograj *et al*. (2016), which indicated a decreased in serum adiponectin levels in women with GDM when compared with their age- and body mass index-matched euglycemic pregnant women (Bhograj *et al*., 2016).

5.0 Conclusion

The study indicated a relationship between total antioxidant capacity (TAS) and adiponectin in pregnant women with GDM compared pregnant women without GDM and control none pregnant women. Majority of the women take daily intake of vegetables, which could positively affect their antioxidant status. There was significantly lower APN compared with TAS, while a significant level of vitamin C compared with APN.

Declarations

Ethics approval and consent to participate

Kaduna State Ministry of Health ethical committee consents were obtained from all subjects before inclusion using approved protocol. Ethical approval of the study was obtained from the Ethics Committees of the Kaduna State Ministry of Health in accordance with Helsinki declaration.

Availability of data and material

Not Applicable.

Competing interests

Author declare no competing interests.

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