Original Article

Eur J Gen Med 2016; 13(1): 45-52

DOI : 10.15197/ejgm.01471

Serum Lipid Profile and Inflammatory Status in Women with Gestational Diabetes Mellitus

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ABSTRACT

Objective: *Gestational diabetes mellitus (GDM) is associated with increased risk of postpartum type 2 diabetes mellitus and cardiovascular risk factors such as obesity, hypertension, dyslipidemia, and systemic inflammation. We aimed to evaluate the lipid profile and inflammatory status assessed by high sensitive C-reactive protein (hsCRP) and TNF-a levels. We also evaluated insulin resistance for all participants.* ***Methods:*** *This study was performed including the pregnant with normal glucose challenge test (GCT) and normal glucose tolerance (NGT) (n:20), abnormal GCT and NGT (n:27), and GDM (n:29) defined by Carpenter and Coustan criteria.* ***Results:*** *In our study, we could not find significantly differences by means of hsCRP levels and lipid profile parameters between groups. But, TNF-a levels increased significantly in the GDM or abnormal GCT NGT groups as compared to the normal GCT NGT group. hsCRP was correlated independently with LDL-cholesterol and parity in the abnormal GCT NGT group and atherogenic index of the plasma (AIP) in GDM group. In addition, there was not an independent relationship between AIP and hsCRP in the GDM group when multiple linear regression analysis was performed after adjustment for maternal age was evaluated at 29.49 years.* ***Conclusion:*** *In conclusion, gestational insulin resistance was apparently associated with TNF-a, whereas dyslipidemia was slightly associated with hsCRP because of the possible effects of maternal age on lipid markers.*

Key words: *Gestational diabetes mellitus, maternal age, lipid profile, high sensitive C-reactive protein, tumor necrosis factor-a*

Gestasyonel Diabetes Mellituslu Kadınlarda Serum Lipit Profili ve İnflamatuar Durum

ÖZET

Amaç: *Gestasyonel diabetes mellitus, postpartum tip 2 diabetes mellitus ile obezite, hipertansiyon, dislipidemi ve sistemik inflamasyon gibi kardiyovasküler risk faktörlerinin artışı ile ilişkilidir. Lipit profili ile high sensitif C-reaktif protein (hsCRP) ve TNF-a ile değerlendirilen inflamatuar durumu değerlendirmeyi amaçladık. Ayrıca, tüm katılımcılarda insülin rezistansını değerlendirdik.* ***Yöntem:*** *Bu çalışma Carpenter ve Coustan'a göre tanımlanan normal glukoz tarama test (GTT) normal glukoz toleranslı (NGT) (n:20), abnormal GTT NGT'li (n:27) ve GDM'li (n:29) gebe bireyler dâhil edilerek yapılmıştır.* ***Bulgular:*** *Çalışmamızda hsCRP ve lipit profili açısından gruplar arasında anlamlı farklılıklar saptanmadı. Fakat TNF-a düzeyleri normal GTT NGT grubuyla karşılaştırıldığında GDM ve abnormal GTT NGT gruplarında anlamlı olarak artmıştı. hsCRP anormal GTT NGT grubunda LDL-kolesterol ve parite ile, GDM grubunda ise plazmanın aterojenik indeksi (AIP) ile bağımsız ilişkiliydi. Ek olarak, anne yaşının 29.49 yıl olarak belirlendiği düzenleme sonrası yapılan çoklu linear regresyon analizi ile GDM grubunda AIP ve hsCRP arasında bağımsız bir ilişki saptanamadı.* ***Sonuç:*** *Sonuç olarak, gestasyonel insülin resistansı TNF-a ile ilişkili iken, anne yaşının lipit belirteçlerine olası etkilerinden dolayı hsCRP dislipidemi ile hafif derecede ilişkili idi.*

Anahtar kelimeler: *Gestasyonel diabetes mellitus, anne yaşı, lipit profili, high sensitif C-reaktif protein, tümör nekroz faktör-a*

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Received: 06.02.2015, Accepted: 28.06.2015

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INTRODUCTION

Gestational diabetes mellitus (GDM) is a common medical complication of pregnancy, characterized by the metabolic defects of ß-cell dysfunction and insulin resistance with onset or first recognition in pregnancy (1). GDM is associated with increased risk of adverse obstetrical outcomes related to fetal overgrowth (2) and the development of type 2 diabetes in the postpartum period (3). It is known that the states of diabetes and prediabetes are associated with cardiovascular risk factors, such as obesity, hypertension, dyslipidemia, and systemic inflammation (4,5).

During early pregnancy, maternal hyperphagia and an accumulation of fat deposits by increased lipids synthesis occur (6). This is followed by enhanced lipolytic activity and decreased lipoprotein lipase (LPL) activity in adipose tissue during late pregnancy, which prompt a wide range of dyslipidemic conditions, mainly hyperlipidaemia caused by increased triglycerides in all circulating lipoproteins (7). The enhanced insulin resistance and decreased oestrogens are responsible for the reported dramatic alterations of lipid profiles in circulating triglycerides, fatty acids, cholesterols, and phospholipids in patients with GDM (7,8). Maternal hypertriglyceridemia contributes significantly to fetal growth during pregnancy (8), and increased maternal triglycerides have also been related to the risk of preterm birth (9) and future cardiovascular disease (10).

There are several possible explanations for the role of inflammation in the development of insulin resistance to gestational diabetes mellitus. First, it is possible that mediators of inflammation in the acute phase may present a triggering factor in the elevation of productions secreted from adipose cells (11). Second, the ability of the inflammatory cytokines to interfere with the most proximal part of the insulin signal-transduction pathway is likely to have physiological relevance for insulin resistance (12). Still another interpretation is that the overproduction of free fatty acids by lipolysis in adipose cells triggered by the inflammatory cytokines and this could lead to a reduced sensitivity to insulin in the peripheral tissues (13).

Studies have demonstrated association between GDM and dyslipidemia and systemic inflammation. But these studies are unable to describe the possible confounding effects of demographic variables, especially maternal age. In the present study, we aimed to evaluate lipid profile and inflammatory status assessed by high sensitive C-reactive protein (hsCRP) and tumor necrosis factor-α (TNF-α), taking into account the possible effect of maternal age on lipid and inflammatory markers in GDM.

MATERIAL AND METHODS

Study Population

This was a cross-sectional study carried out with 76 consecutive pregnant women attending the Gynaecological and Obstetrical Department of the Taksim Research and Training Hospital, Istanbul, Turkey. Screening of GDM was done with a 50 g oral glucose challenge test (GCT) between the 24th and 28th weeks of gestation. Irrespective of the GCT results, all cases underwent a 3-h 100 g oral glucose tolerance test (OGTT) for diagnosis. The participants were stratified into the following three groups based on the GCT and OGTT: Group 1, patients with GDM (n:29), defined by Carpenter and Coustan (14), which required at least two of the following on the OGTT: fasting glucose > 95 mg/dl; 1-h glucose > 180 mg/dl; 2-h glucose > 155 mg/dl or 3-h glucose > 140 mg/dl. Group 2, abnormal GCT normal glucose tolerance (NGT) (n:27), defined as having an abnormal 50 g GCT (1-h post-challenge glucose ≥ 140 mg/dl) and meeting none of the Carpenter and Coustan criteria. Group 3, normal GCT and NGT (n:20), defined as having a normal 50 g GCT (1-h post-challenge glucose < 140 mg/dl) and meeting none of the Carpenter and Coustan criteria.

Information concerning clinical status was collected, and the following exclusions were established: those younger than 18 years; those with preexisting chronic medical conditions (polycystic ovarian syndrome, collagen vascular diseases, inflammatory bowel disease, and chronic inflammatory conditions) that may affect acute phase markers; those with known endocrinopathy, renal insufficiency, hepatic disease and/or diabetes before pregnancy; those receiving drugs affecting insulin secretion; and those with multiple pregnancy.

Measurements

In the first blood tests performed, each woman was evaluated at screening. The following variables were recorded: maternal age; gestational age; parity; pregnancy weight, height and body mass index (BMI); homeostasis model assessment index for insulin resistance (HOMA-IR) using the Mathew's simplified formula (15); measures

Table 1. *Demographic profile and basic clinical variables in each of the studied groups*

	Normal GCT NGT (n:20)	Abnormal GCT NGT (n:27)	GDM (n:29)	p value
Maternal age (years)	27 ± 5	29 ± 4	32 ± 4 [c,d]	< 0.0001
Gestational age (weeks)	25.4 (24.1 - 26.3)	26.1 (25.1 - 28.0)	27.0 (25.6 - 28.0)	= 0.0640
Parity > 1 (%)	45.0	51.9	69.0	= 0.2070
Birth weight (g)	3080 (2965 - 3257)	3260 (3040 - 3780)	3600 (3325 - 3990) [b,d]	< 0.0001
BMI (kg/m^2)	26.0 (23.5 - 28.0)	26.2 (24.5 - 28.4)	27.6 (25.5 -29.9)	= 0.1140
Systolic blood pressure (mmHg)	100 (100 - 110)	100 (100 - 110)	110 (105 - 120) [a,e]	= 0.0030
Diastolic blood pressure (mmHg)	60 (50 - 68)	70 (60 - 70) [a]	70 (60 -80) [b]	= 0.0010

[a] $p < 0.010$ vs. Normal GCT NGT; [b] $p < 0.001$ vs. Normal GCT NGT; [c] $p < 0.0001$ vs. Normal GCT NGT; [d] $p < 0.050$ vs. Abnormal GCT NGT; [e] $p < 0.010$ vs. Abnormal GCT NGT;

of systolic (SBP) and diastolic blood pressure (DBP) and family history of diabetes mellitus. In addition, infants' birth weights were recorded. Our main interest was parity assessed in women at the baseline interview with the question, "How many live births have you had?" The response was modeled as a categorical variable: parity > 1 and parity ≤ 1.

Venous blood samples were obtained from all participants after overnight fasting. After centrifugation, serum samples were stored at -80°C until they were analyzed. Levels of serum glucose, total cholesterol, triglyceride, high-density lipoprotein (HDL-cholesterol), insulin and TSH were determined daily using commercially available kits (Roche Diagnostics GmbH, Mannheim, Germany) with a Roche/Hitachi Modular Analytics System. Low-density lipoprotein (LDL-cholesterol) was estimated by the Friedewald equation. The atherogenic index of the plasma (AIP) was calculated as the logarithm of the ratio triglycerides/HDL-cholesterol expressed in mg/dl (16). The levels of non-HDL-cholesterol were also determined. Serum glucose was analyzed by glucose oxidase method, serum lipids by standard enzymatic colorimetric methods, insulin and TSH by electrochemiluminescence immunoassay method and HbA1c by AdamsTM A1c HA-8160 fully-automated high performance liquid chromatography device. Levels of hsCRP and TNF-α were measured in serum samples stored for up to six months using competitive enzyme-linked immunosorbent assay methods (DRG International, Inc., USA and BioSource International, Inc., USA, respectively).

Statistical analysis

Data were expressed as a mean ± standard deviation (SD) when the distribution was normal Gaussian or a median (25th and 75th percentiles). Levels of variables were analyzed with log-transformed levels in parametric analysis if distributed asymmetrically or bimodally. Statistical comparisons between the groups were performed using one-way ANOVA followed by Tukey or Tamhane's T2 post hoc for data with normally distributed and Kruskal–Wallis test followed by Tukey–Kramer post hoc for skewed data. Pearson's chi-square test was used to determine the between-group differences in categorical variables. The possible confounding effects of the variables such as maternal age, gestational age, BMI and parity on the measured parameters were assessed by the one-way analysis of covariance (ANCOVA) or two-way analysis of variance (two-way ANOVA). To perform parametric statistical analysis, skewed variables were logarithmically transformed to reduce skewness of the distribution. Pearson's correlation coefficient (r) or Spearman's rank correlation coefficient (r_s) was used to evaluate the degree of association between two variables. To determine the independent association of the variables in the presence of other significant factors, multiple or bivariate linear regression analysis was performed. The probability values are two-sided; a probability value of <0.05 was considered to indicate statistical significance.

RESULTS

The demographic and clinical variables of the study population were shown in Table 1. Because ANCOVA revealed significant or suggestive confounding effects of maternal age on triglyceride levels, AIP and HDL-cholesterol levels, the comparisons of these parameters across the three groups were produced after controlling for equality of variances and adjusting for maternal age as a covariate

(Table 2). In addition, the tests of covariates or two-way ANOVA did not designate the confounding effects of the maternal age, gestational age, BMI and parity defined categorically on the other measured parameters except the confounding effects of maternal age. The three groups did not demonstrate significantly different hsCRP levels (p= 0.4160) and lipid profile parameters such as total cholesterol (p= 0.4270), adjusted triglyceride (p= 0.1380), adjusted HDL-cholesterol (p= 0.0950), LDL-cholesterol (p= 0.4450), non-HDL-cholesterol (p= 0.9740) and AIP levels (p= 0.2480). However, TNF-α levels increased significantly in the GDM group or abnormal GCT NGT group as compared to the normal GCT NGT group (Table 2).

The percentiles corresponding to the maternal age before and after adjustments were not significantly different between the groups, except the GDM group. The commonly applied risk-associated maternal age of 35 years (17) for before and after adjustment corresponded to approximately the 93th and 90th percentiles, respectively, in the normal GCT NGT group; 87th and 88th, respectively, in the abnormal GCT NGT group and 78th and 90th, respectively, in the GDM group.

The variable pairs that presented significant correlations between hsCRP, TNF-α, lipid parameters, demographic factors and clinical variables were the TNF-α and non-HDL-cholesterol levels (r_s= 0.460; p= 0.047) and AIP lev-

***Table 2**. Laboratory variables in each of the studied groups*

	Normal GCT NGT (n:20)	*Abnormal GCT NGT (n:27)*	*GDM (n:29)*	*p value*
Fasting glucose (mg/dl)	*80 (75 - 88)*	*82 (77 - 87)*	*86 (79 - 94)*	*= 0.0810*
50-g GCT 1-h (mg/dl)	*111 ± 19*	*158 ± 16 [d]*	*185 ± 22 [d, g]*	*< 0.0001*
100-g OGTT fasting glucose (mg/dl)	*84 ± 6*	*83 ± 5*	*95 ± 27 [e]*	*= 0.0330*
100-g OGTT 1-h (mg/dl)	*138 ± 17*	*145 ± 21*	*203 ± 27 [d, g]*	*< 0.0001*
100-g OGTT 2-h (mg/dl)	*121 ± 11*	*119 ± 21*	*184 ± 27 [d, g]*	*< 0.0001*
100-g OGTT 3-h (mg/dl)	*97 ± 13*	*95 ± 23*	*126 ± 41 [b, f]*	*< 0.0001*
Insulin (ng/ml)	*6.8 (4.3 - 8.8)*	*7.0 (6.0 - 9.5)*	*11.8 (7.8 - 13.6) [c, f]*	*< 0.0010*
HOMA-IR	*1.26 (0.90 - 1.75)*	*1.62 (1.22 -1.98)*	*2.52 (1.43 - 3.37) [c, f]*	*< 0.0010*
Total cholesterol (mg/dl)	*241 ± 54*	*251 ± 46*	*234 ± 46*	*= 0.4270*
Triglycerides (mg/dl)	*160 ± 49*	*195 ± 68*	*220 ± 78 [b]*	*= 0.0140*
Adjusted Triglycerides (mg/dl)*	*168 ± 70*	*198 ± 68*	*212 ± 70*	*= 0.1380*
HDL-cholesterol (mg/dl)	*69 ± 16*	*74 ± 16*	*64 ± 13 [e]*	*= 0.0490*
Adjusted HDL-cholesterol (mg/dl)*	*68 ± 15*	*74 ± 15*	*65 ± 16*	*= 0.0950*
LDL-cholesterol (mg/dl)	*141 ± 52*	*134 ± 33*	*124 ± 41*	*= 0.4450*
Non-HDL-cholesterol (mg/dl)	*172 ± 53*	*176 ± 39*	*170 ± 41*	*= 0.9740*
AIP	*0.36 ± 0.18*	*0.40 ± 0.21*	*0.52 ± 0.22 [b]*	*= 0.0290*
*Adjusted AIP **	*0.38 ± 0.22*	*0.41 ± 0.21*	*0.49 ± 0.22*	*= 0.2480*
HbA1c (%)	*4.6 ± 0.4*	*4.9 ± 0.4 [a]*	*5.4 ± 0.4 [d, g]*	*< 0.0001*
TSH (μIU/ml)	*2.1 (1.4 - 2.5)*	*2.1 (1.0 - 3.0)*	*1.9 (1.4 - 2.3)*	*= 0.8490*
hsCRP (mg/L)	*0.104 ± 0.055*	*0.121 ± 0.057*	*0.126 ± 0.061*	*= 0.4160*
TNF-α (pg/ml)	*0.588 (0.001 - 1.626)*	*2.122 (0.588 - 4.492) [b]*	*2.701 (1.329 - 4.719) [d]*	*< 0.0010*

** mean±SD and p values were calculated after adjustment for maternal age evaluated at 29.49 years; [a] p < 0.050 vs. Normal GCT NGT; [b] p < 0.010 vs. Normal GCT NGT; [c] p < 0.001 vs. Normal GCT NGT; [d] p < 0.0001 vs. Normal GCT NGT; [e] p < 0.050 vs. Abnormal GCT NGT; [f] p < 0.010 vs. Abnormal GCT NGT; [g] p < 0.0001 vs. Abnormal GCT NGT*

els and parity (r_s= 0.459; p= 0.048) in the normal GCT NGT group; hsCRP and LDL-cholesterol levels (r= 0.431; p= 0.028), hsCRP and TNF-α levels (r_s= 0.404; p= 0.037), hsCRP levels and parity (r_s= 0.409; p= 0.038), and TNF-α levels and maternal age (r_s= -0.507; p= 0.007) in the abnormal GCT NGT group and hsCRP and LDL-cholesterol levels (r= -0.400; p = 0.035) and hsCRP and AIP levels (r= 0.389; p= 0.037) in the GDM group.

Multiple or bivariate linear regression analysis was applied to establish independent relationships between two or more variables if there was a relationship between the two variables indicated in the significance test for r or rs in the three groups (Table 3). After the disturbances of observed values on regression equations and coefficients were revealed by measures outside two standard deviations in residual plots, these values were excluded in regression analyses. LDL-cholesterol and parity for hsCRP in the abnormal GCT NGT group and AIP for hsCRP in the GDM group remained as the independent variables. In addition, there was not an independent relationship between AIP and hsCRP in the GDM group when multiple linear regression analysis was performed after adjustment for maternal age evaluated at 29.49 years.

DISCUSSION

The findings of this study suggest that serum lipid profile did not change in an atherogenic pattern in the three groups exhibiting maternal age less than 35 years. For inflammatory markers TNF-α levels increased slightly in the abnormal GCT NGT and the GDM groups exhibiting maternal age less than 35 years. There was no statistical difference between hsCRP levels in three groups. Further, we observed significant variations in the association of hsCRP between lipid parameters in the abnormal GCT NGT and the GDM groups.

Researchers state that increased pre-pregnancy maternal adipose tissue deposition or lipid accumulation at the initial stage of a pregnancy is associated with developing of gestational insulin resistance (18,19). In this study, we showed that pregnant women with and without GDM had the hyperlipidemic pattern defined by the National Cholesterol Education Program Adult Treatment Panel III criteria for metabolic syndrome in non-pregnant women as the presence of lipid markers, such as total cholesterol greater than 200 mg/dl, triglycerides greater than 150 mg/dl and LDL-cholesterol greater than 130 mg/dl (20), despite the fact that hyperlipidemia criteria need adaptation for pregnancy due to the special physiology of pregnancy (21). However, only serum triglyceride levels among these markers and the atherogenic index of the plasma defined AIP increased significantly in patients with GDM. The results of increased triglyceride levels, decreased HDL-cholesterol levels, and unchanged total cholesterol and LDL- cholesterol levels in women with GDM compared with those without GDM obtained from our study were consistent with results of the recent meta-analysis (22). Lipidemic pattern in GDM still have controversies (23-26). These conflicting findings may be explained by the level of metabolic status degree, demographic profiles as potential confounding factors and pregnancy phase. The prevalence of particular components of metabolic syndrome - defined as increased triglyceride levels, decreased HDL-cholesterol levels, increased blood pressure, and elevated fasting glycaemia - did not occur more frequently in pregnant women with or without GDM at the third gestational trimester in our study population.

Significant increments in triglyceride levels and AIP were attenuated and did not maintain statistical significance after adjustment for maternal age evaluated at 34 years or less. The frequency of pregnant women considered to be of advanced maternal age (i.e., who became pregnant at the age of 35 or older) was roughly 21% in the GDM group before adjustment. Effects of maternal age on lipid markers have not been fully described (23-26). Enquobahrie et al. reported that, besides a linear relationship in increasing relative risk of developing GDM with increasing tertiles determined by maternal plasma triglyceride concentrations, these risk ratios decreased meaningfully notwithstanding the remaining statistical significance association after adjusting for possible confounders (e.g., maternal age, parity, BMI, and gestational age) (27). Whereas the extent to which possible factors contribute to lipid alterations did not appear clearly in their study, we designate that only maternal age had the confounding effect on lipid markers among these factors, which were investigated separately. These data proposed the evaluation of AIP as a result of triglycerides and HDL-cholesterol levels taking into account maternal age is appropriate to establish lipid alterations in patients with GDM.

Among the inflammatory markers, hsCRP, as an acute-phase reactant, and TNF-α, as a pro-inflammatory cytokine to evaluate the inflammatory status in patients with GDM, only the significant increase in TNF-α levels were demonstrated in the present study. The mechanism of the association of CRP with insulin resistance is not clearly understood (28), whereas investigators have shown that CRP levels were associated with BMI and serum lipids in metabolic disturbances (29,30). We established insignificant changes in hsCRP levels in patients with GDM that matched closely for BMI and exhibited increased insulin resistance assessed by HOMA-IR. This result was consistent with the previous reports wherein it was shown that, when BMI and adiposity are taken into account, hsCRP is not significantly associated with GDM (31,32). In a study of GDM patients that followed in the first year postpartum revealed weight gain and increased gestational hsCRP levels in patients with consistent hyperglycemia than in participants who became normoglycemic (33). In addition, the non-persistent significant independent relationship between hsCRP and AIP after adjustment for maternal age in patients with GDM indicated that the partial effects of maternal age on lipid markers may cause this independent association. Investigators have shown that elevated TNF-α expression in adipose and muscle tissue is positively correlated with the degree of obesity and hyperinsulinemia and negatively related to the adipose tissue lipoprotein lipase activity (34,35). This study's finding that TNF-a levels were increased significantly in increased insulin-resistant patients with abnormal GCT NGT and GDM, notably the increased insulin resistance was more evident in patients with GDM, suggested that TNF-α was a potent predictor of pregnancy-associated insulin resistance.

There were several limitations in this study. First, evaluating pregnant women in the third gestational trimester might have had an effect on the findings in regard to what studies have suggested that the inflammatory markers are related to the degree of adiposity in the different trimesters (32,35). Second, because the sample size of pregnant women with gestational impaired glucose tolerance (GIGT) defined by a single abnormal glucose value on the OGTT was relatively small, we could not evaluate GIGT. Lastly, the results of postpartum metabolic assessment in patients with GDM might implicate further explanations for our findings.

Table 3. *Results from the multiple or bivariate linear regression analyses predicting the independent associations of the variables in the presence of other significant factors in three groups*

Groups	*Regression Equations*	*Dependent Variable*	*Independent Variables*	*B*	*SE*	*p value*
Normal GCT NGT	*Equation 1*	*TNF-a*	*Non-HDL-cholesterol*	*0.004*	*0.003*	*= 0.3100*
			Constant	*-0.005*	*0.586*	*= 0.9930*
	Equation 2	*AIP*	*Parity[a]*	*0.145*	*0.080*	*= 0.0880*
			Constant	*0.296*	*0.052*	*< 0.0001*
Abnormal GCT NGT	*Equation 3*	*TNF-a*	*Maternal age*	*-0.086*	*0.044*	*= 0.0710*
			Constant	*3.942*	*1.300*	*= 0.0080*
	Equation 4	*hsCRP*	*LDL-cholesterol*	*0.001*	*< 0.001*	*= 0.0116*
			Parity[a]	*0.054*	*0.018*	*= 0.0071*
			TNF-a	*-0.002*	*0.002*	*= 0.4107*
			Constant	*-0.004*	*0.036*	*= 0.9041*
GDM	*Equation 5*	*hsCRP*	*LDL-cholesterol*	*< 0.001*	*< 0.001*	*= 0.1631*
			AIP	*0.123*	*0.034*	*= 0.0016*
			Constant	*0.083*	*0.035*	*= 0.0272*
	Equation 6[b]	*hsCRP*	*LDL-cholesterol*	*-0.001*	*0.001*	*= 0.3212*
			AIP	*0.082*	*0.076*	*= 0.2980*
			Constant	*0.159*	*0.102*	*= 0.1438*

B, unstandardized regression coefficient; SE, standard error; [a] Parity was defined categorically as party>1:1 and parity≤1:0; [b] Multiple linear regression analysis was performed after adjustment for maternal age evaluated at 29.49 years

The findings of our study indicated that patients with GDM did not present dyslipidemic pattern when the confounding effects of BMI, parity, gestational age and maternal age were controlled. To evaluate this result, the adjustment for maternal age evaluated at 34 years or less owing to an overt and significant confounding effect of maternal age on lipid markers, notably triglyceride levels, should be taken into account. Among the metabolic syndrome components, insulin resistance was apparently associated with TNF-α, whereas dyslipidemia was slightly associated with hsCRP because of the partial effects of maternal age on lipid markers. These findings suggest that TNF-α was a strong indicator of pregnancy-associated insulin resistance than hsCRP. Data from further studies with larger sample size are needed to verify our findings at different gestational periods and maternal ages.

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