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ORIGINAL COMMUNICATION

Plasma AA and DHA levels are not compromised in newly diagnosed gestational diabetic women

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Objective: The polyunsaturated fatty acids, arachidonic (AA) and docosahexaenoic (DHA), are vital structural and functional components of the neural, vascular and visual systems. There is increased demand for these fatty acids during pregnancy. Diabetes impairs the synthesis of both AA and DHA. We have investigated the possibility that pregnancy-induced diabetes compromises the levels of plasma AA and DHA in newly diagnosed expectant mothers.
Design: Cross-sectional study.
Setting: London, UK.
Subjects and methods: Venous blood was obtained from 44 women with gestational diabetes mellitus (GDM) and from the same number of nondiabetics, during the third trimester. Fatty acid composition of plasma choline phosphoglycerides (CPG), triglycerides (TG) and cholesterol esters (CE) was analysed.
Results: The GDM women had higher levels of AA (20:4n-6; $P<0.0001$) and AA/linoleic acid ratio (20:4n-6/18:2n-6; $P<0.01$) in the CPG, and linoleic acid (LA; $P<0.0001$), total n-6 ($P<0.01$), DHA ($P<0.05$) and n-3 metabolites ($P<0.05$) in TG compared to their nondiabetic counterparts. Similarly, AA ($P<0.0001$), osbond acid (22:5n-6; $P<0.05$), total n-6 metabolites ($P<0.0001$), AA/LA ($P<0.0001$) and n-6 metabolites/LA ($P<0.01$) were higher in the CE of the GDM women. There was no difference in the levels of DHA in CPG and CE between the two groups ($P>0.05$).
Conclusions: The results of this study do not provide evidence that the activity of delta-6 or delta-5 desaturases, which are vital for the synthesis of AA and DHA, is compromised by pregnancy-induced diabetes. However, since the samples were taken at diagnosis, it is conceivable that the duration of the diabetes was too short to have a discernable adverse effect on the levels of AA and DHA in plasma lipids.
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Introduction

Gestational diabetes mellitus (GDM) affects 3–5% of women (Engelgau *et al*, 1998) and is associated with congenital malformations (Williams *et al*, 1999), perinatal mortality (Bartha *et al*, 2000), macrosomia (Langer & Hod, 1996) and organomegaly (Persson & Hanson, 1998). Women with a history of GDM and their offspring have a higher risk of developing blood lipid abnormality (dyslipidaemia), high blood pressure and diabetes later in life (Ko *et al*, 1999).

In human (type 1 and 2) and experimental diabetes, the activity of delta-6 and -5 desaturase, enzymes required for the synthesis of the polyunsaturated fatty acids, arachidonic (AA, 20:4n-6) and docosahexaenoic (DHA, 22:6n-3), is impaired (Brenner *et al*, 2000). In addition, membrane levels of these fatty acids are depressed (Tilvis & Meittinen 1985, Mikhailidis *et al*, 1986, Igal *et al*, 1991). Insulin therapy ameliorates both the activity of the enzymes and membrane AA and DHA abnormality (Shin *et al*, 1995). There is also evidence from animal studies that diabetes-induced embryopathy is associated with a deficiency of myo-inositol and AA (Khandelwal *et al*, 1998) and could be corrected by dietary AA supplementation in rats (Eriksson *et al*, 2000).

There are no comprehensive published reports on fatty acid status of GDM women or neonates. This is surprising since the disorder is characterised by insulin resistance,

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inability to increase output of insulin (Bowes *et al*, 1996), impaired glucose transport and insulin receptor autophosphorylation (Friedman *et al*, 1999; Yamashita *et al*, 2000) and vascular endothelial dysfunction (Knock *et al*, 1997). Abnormalities of plasma (Wijendran *et al*, 1999) and red cell (Wijendran *et al*, 2000) fatty acids have been reported in diet-treated GDM women. Similarly, we have recently found lower levels of AA and DHA in red cell choline phosphoglycerides of newly diagnosed gestational diabetics (Min *et al*, 2004). However, it is not clear whether the observed abnormality was a reflection of dietary insufficiency, impaired synthesis or a reduction in incorporation into cell membranes. The aim of this study was to examine the possibility that pregnancy-induced diabetes compromises plasma essential fatty acid levels, particularly AA and DHA, in newly diagnosed expectant mothers.

Materials and methods

Subjects and recruitment

A total of 44 women with GDM and uncomplicated singleton pregnancy were recruited during the third trimester (week 28–34) from St Thomas' Hospital, London, UK. Also, healthy control women ($n=44$) aged ≥ 16 y and without a family history of diabetes, high blood pressure and other chronic disorders were enrolled. Of the diabetic group, Caucasians, Afro-Caribbean/African and Asians accounted for 29.5% ($n=13$), 53% ($n=23$) and 10% ($n=4$) respectively. In contrast, the nondiabetic group consisted of 70% ($n=31$) Caucasians, 18% ($n=8$) Afro-Caribbean/Africans and 4.5% ($n=2$) Asians. Detailed demographic, clinical and obstetric data were collected from the hospital medical records and by the use of a questionnaire. Ethical approval from the Ethics Committee of Lambeth & Southwark Health Authority and written consent from the subjects were obtained.

Diagnosis

The diagnosis of gestational diabetes was based on the standard criteria of the European Association for the Study of Diabetes (EASD—National Diabetes Data Group, 1979). High-risk women—those with a history of GDM, stillbirth, macrosomia, and a pre-pregnancy BMI >26 kg/m^2—were screened for diabetes with an oral glucose tolerance test (OGTT). The women were given a 75 g glucose load and their blood glucose level monitored at 60 and 120 min. If blood glucose concentration at 60 min was less than or equal to 8 mmol/l, they were considered normal. If at 60 min the concentration was greater than 8 mmol/l, a second sample was taken at 120 min. GDM was diagnosed if the fasting plasma glucose at 120 min exceeded 9 mmol/l.

Sample collection and fatty acid analysis

After an overnight fast, 5 ml of whole blood was collected in heparinised tube from both the gestational diabetic and healthy control women. The plasma was separated from the whole blood by cold centrifugation, and stored at −70°C until analysis. Total lipids were extracted by the method of Folch *et al* (1957) by homogenising the plasma samples in chloroform and methanol (2:1 v/v) containing butylated hydroxytoluene (BHT, 0.01% w/v) under nitrogen. The plasma lipid fraction choline phosphoglycerides (CPG), triglycerides (TG) and cholesterol esters (CE) were separated by thin layer chromatography on silica gel plates by the use of the developing solvents—petroleum spirit:ether:formic acid:methanol (85:15:2:5:1v/v) containing BHT. The plasma lipid fraction bands were detected by spraying with a methanolic solution of 2,7-dichlorofluorescein (0.01% w/v) and identified by the use of authentic standards. Fatty acid methyl esters (FAME) were prepared by heating the plasma lipid fractions scraped from the silica plate with 15% acetyl chloride in methanol in a sealed tube at 70°C for 3 h under nitrogen. FAME were separated by gas chromatograph (HRGC MEGA 2 series, Fisons Instruments, Milan, Italy) fitted with a capillary column (25 m × 0.32 mm ID, 0.25 μm film, BP20). Hydrogen was used as a carrier gas, and the injector, oven and detector temperatures were 235, 210 and 260°C. The FAME were identified by comparison of retention times with authentic standards (Sigma-Aldrich Co. Ltd, UK) and interpretation of equivalent chain length values. Peak areas were quantified by a computer chromatography data system (EZChrom Chromatography Data System, Scientific Software Inc., San Ramon, CA, USA).

Data analyses

The results are expressed as mean and standard deviation (mean $\pm$ s.d.). Unpaired Student's *t*-test was used to investigate for a statistical significance difference between the data of the GDM and healthy control women. All the calculations were performed by use of the statistical package SPSS for Windows, Release 9. The specific focus of the investigation was to test whether or not diabetes-induced impairment of delta-6 and delta-5 desaturases compromises the levels of the n-6 and n-3 long-chain polyunsaturated fatty acids. The study was not concerned with a global perturbation of fatty acids. Consequently, Bonferroni, Holm or other test procedures were not used to correct for multiple testing (Perneger, 1998).

Results

Anthropometric, clinical and demographic data

Anthropometric, clinical and demographic data of the GDMs and healthy controls are presented in Table 1. Compared with the nondiabetics, the GDM women were older ($P<0.01$), had a higher body weight ($P<0.0001$), body mass index ($P<0.0001$), and systolic ($P<0.05$) and diastolic ($P<0.01$) blood pressure at recruitment. In addition, they had higher blood glucose ($P<0.0001$) and glycosylated haemoglobin ($P<0.0001$) concentrations before the oral glucose tolerance test (OGTT), and blood glucose concentration 60 min after the OGTT ($P<0.0001$).

Table 1 Anthropometric, demographic and clinical data (mean ± s.d.)

	Control (n = 44)	*GDM* (n = 44)
Age (y)	28.02 ± 5.8	31.25 ± 5.3**
Height (m)	1.64 ± 0.06	1.64 ± 0.07
Prepregnancy wt (kg)	61.4 ± 10.8	74.59 ± 20.4***
Pre-pregnancy BMI[a]	22.82 ± 4.1	27.97 ± 6.9***
Weight at recruitment (kg)	71.49 ± 12.7	89.69 ± 19.4***
BMI at diagnosis	27.57 ± 4.52	32.87 ± 6.15***
Systolic blood pressure	113.20 ± 12.16	121.08 ± 15.61*
Dystolic blood pressure	68.68 ± 8.84	76.54 ± 11.76**
Glucose at 0 min (mmol/l)	4.18 ± 0.32	5.76 ± 1.76***
Glucose at 60 min (mmol/l)	6.16 ± 1.21	12.21 ± 2.95***
Glucose at 120 min (mmol/l)	—	10.78 ± 2.42
HbA_{1C}[b] (%)	4.52 ± 0.21	5.72 ± 0.69***
Week of sample collection	33.3 ± 1.2	32.0 ± 1.5
Ethnicity (n)		
Caucasian	31	13
Afro-Caribbean & African	8	23
Asian	2	4
Others[c]	3	—
Information not given	—	4
Parity(n)		
0	29	17
1	8	11
≥2	7	12
Information not given	—	4
Smoker (n)		
Never	28	29
In the past	7	5
Current	9	6
Information not given	—	4

*$P<0.05$; **$P<0.01$; ***$P<0.001$; the mean is significantly different from corresponding control values.
[a]BMI (Body Mass Index) weight (kg)/height(m)^2. [b]Includes those who described themselves as Middle Eastern, Mediterranean and Orthodox Greek. [c]HbA_{1C}, glycosylated haemoglobin.

Plasma fatty acids

Plasma choline phosphoglycerides (CPG). Fatty acid composition of plasma CPG is given in Table 2. The gestational diabetic women had higher levels of palmitic (16:0; $P<0.01$), AA (20:4n-6; $P<0.0001$), total saturates ($P<0.01$ and AA/linoleic acid ratio (20:4n-6/18:2n-6; $P<0.01$). Although the differences were not significant, the levels of DHA (22:6n-3), n-3 metabolites, total n-3 and n-6 metabolites/linoleic acid ratio, were also higher in the GDM group. In contrast, oleic (18:1; $P<0.0001$), total monoenes ($P<0.0001$), eicosadienoic (20:2n6; $P<0.0001$), osbond (22:5n6; $P<0.01$) and alpha-linolenic (ALA, 18:3n-3; $P<0.0001$) acids were lower in the GDM.

Plasma triglycerides (TG). Table 3 shows plasma TG fatty acids of the GDM and healthy control groups. The GDM women had higher levels of linoleic acid (LA; $P<0.0001$), total n-6 ($P<0.01$) and DHA ($P<0.05$), and lower palmitoleic (16:1n-7; $P<0.05$) and eicosaenoic acid (20:1; $P<0.05$) than the nondiabetics.

Table 2 Mean percent fatty acid composition of plasma choline phosphoglycerides of gestational diabetic and healthy controls (mean ± s.d.)

Fatty acids	*Control*	*GDM*
16:0	30.23 ± 2.69	32.38 ± 2.23**
18:0	10.36 ± 0.97	10.01 ± 1.09
20:0	0.05 ± 0.01	0.05 ± 0.03
24:0	0.04 ± 0.02	0.02 ± 0.01*
∑ *Saturates*	41.36 ± 2.65	42.80 ± 1.86**
16:1n-7	0.80 ± 0.33	0.71 ± 0.25
18:1n-9	11.76 ± 1.59	10.26 ± 1.47***
20:1n-9	0.27 ± 0.09	0.21 ± 0.09*
22:1n-9	0.02 ± 0.02	0.03 ± 0.02
24:1n-9	0.07 ± 0.06	0.06 ± 0.07
∑ *Monoenes*	12.79 ± 1.67	11.30 ± 1.57***
18:2n-6	23.39 ± 2.25	22.40 ± 2.59
18:3n-6	0.07 ± 0.03	0.07 ± 0.03
20:2n-6	0.52 ± 0.12	0.40 ± 0.12***
20:3n-6	3.61 ± 0.65	3.23 ± 0.86
20:4n-6	8.47 ± 1.48	10.14 ± 2.24***
22:4n-6	0.30 ± 0.15	0.25 ± 0.11
22:5n-6	0.50 ± 0.36	0.35 ± 0.24**
∑ n-*6*	36.85 ± 2.15	36.80 ± 2.46
∑ n-*6 metabolites*	13.47 ± 1.81	14.44 ± 2.65
20:4n-6/18:2n-6	0.37 ± 0.08	0.46 ± 0.14**
n-6 met/18:2n-6	0.59 ± 0.13	0.66 ± 0.17
18:3n-3	0.38 ± 0.11	0.26 ± 0.09***
20:5n-3	0.70 ± 0.37	1.07 ± 1.08
22:5n-3	0.63 ± 0.19	0.57 ± 0.18
22:6n-3	4.16 ± 1.27	4.49 ± 1.19
∑ n-*3*	6.03 ± 1.78	6.32 ± 1.87
∑ n-*3 metabolites*	5.65 ± 1.79	6.06 ± 1.86
20:3n-9	0.26 ± 0.13	0.13 ± 0.08***

*$P<0.05$; **$P<0.01$; ***$P<0.001$. The mean is significantly different from corresponding control values.

Plasma cholesterol esters (CE). Mean fatty acids of the plasma CE is presented in Table 4. The gestational diabetics had higher levels of palmitic ($P<0.01$), stearic (18:0; $P<0.05$), total saturates ($P<0.05$), AA ($P<0.0001$), osbond acid ($P<0.05$), total n-6 metabolites ($P<0.0001$), AA/LA ($P<0.0001$) and n-6 metabolites/LA ($P<0.01$). Although it did not reach the level of a statistical significance, the mean percentage of DHA was also higher in the GDM group. In contrast, palmitoleic ($P<0.05$), eicosaenoic ($P<0.0001$), total monounsaturates ($P<0.05$) and ALA ($P<0.01$) were lower in the GDM group.

Discussion

Compared with the nondiabetics, the gestational diabetic women were older, heavier and of higher parity (parity ≥2). These findings are consistent with earlier reports, which

Table 3 Mean percent fatty acid composition of plasma triglycerides of gestational diabetic and healthy controls (mean ± s.d.)

Fatty acids	*Control*	*GDM*
16:0	29.29 ± 3.28	28.98 ± 3.77
18:0	3.59 ± 1.10	3.25 ± 0.66
20:0	0.08 ± 0.04	0.07 ± 0.04
22:0	0.12 ± 0.19	0.09 ± 0.09
24:0	0.04 ± 0.08	0.03 ± 0.03
∑ *Saturates*	35.64 ± 4.44	34.42 ± 4.15
16:1n-7	4.06 ± 0.87	3.45 ± 1.07*
18:1n-9	35.55 ± 4.09	34.87 ± 4.31
20:1n-9	0.62 ± 0.20	0.50 ± 0.24*
22:1n-9	0.13 ± 0.11	0.10 ± 0.11
24:1n-9	0.03 ± 0.02	0.03 ± 0.04
∑ *monoenes*	39.93 ± 3.94	38.93 ± 4.40
18:2n-6	15.11 ± 3.01	18.46 ± 4.60***
18:3n-6	0.14 ± 0.09	0.14 ± 0.08
20:2n-6	0.28 ± 0.12	0.27 ± 0.11
20:3n-6	0.24 ± 0.13	0.24 ± 0.09
20:4n-6	0.99 ± 0.75	0.98 ± 0.31
22:4n-6	0.25 ± 0.34	0.17 ± 0.08
22:5n-6	0.31 ± 0.27	0.45 ± 0.45
∑ n-*6*	17.32 ± 3.32	20.72 ± 4.79**
∑ n-*6 metabolites*	2.21 ± 1.44	2.25 ± 0.68
20:4n-6/18:2n-6	0.07 ± 0.06	0.06 ± 0.02
n-6 met/18:2n-6	0.16 ± 0.14	0.13 ± 0.05
18:3n-3	1.03 ± 0.34	1.01 ± 0.38
20:5n-3	0.22 ± 0.10	0.28 ± 0.24
22:5n-3	0.14 ± 0.10	0.15 ± 0.09
22:6n-3	0.56 ± 0.37	0.81 ± 0.53*
∑ n-*3*	2.26 ± 0.96	2.30 ± 1.05
∑ n-*3 metabolites*	0.92 ± 0.46	1.24 ± 0.81*
20:3n-9	0.09 ± 0.10	0.08 ± 0.05

*$P<0.05$; **$P<0.01$; ***$P<0.001$. The mean is significantly different from corresponding control values.

Table 4 Mean percent fatty acid composition of plasma cholesterol esters of gestational diabetic and healthy controls (mean% ± s.d.)

Fatty acids	*Control*	*GDM*
16:0	12.97 ± 1.50	14.09 ± 2.25**
18:0	0.76 ± 0.45	0.86 ± 0.30*
20:0	0.03 ± 0.05	0.03 ± 0.03
22:0	0.18 ± 0.23	0.19 ± 0.23
24:0	0.04 ± 0.06	0.02 ± 0.01
∑ *Saturates*	14.66 ± 1.71	15.74 ± 2.14*
16:1n-7	4.05 ± 1.49	3.25 ± 1.57*
18:1n-9	19.63 ± 2.35	18.45 ± 2.75
20:1n-9	0.11 ± 0.05	0.07 ± 0.03***
22:1n-9	0.08 ± 0.09	0.11 ± 0.20
24:1n-9	0.05 ± 0.03	0.03 ± 0.02
∑ *Monoenes*	23.84 ± 3.14	21.83 ± 3.80*
18:2n-6	50.33 ± 4.13	50.14 ± 4.89
18:3n-6	0.42 ± 0.17	0.37 ± 0.15
20:2n-6	0.12 ± 0.12	0.09 ± 0.06
20:3n-6	0.70 ± 0.11	0.66 ± 0.18
20:4n-6	4.99 ± 1.31	6.39 ± 1.55***
22:4n-6	0.09 ± 0.16	0.06 ± 0.05
22:5n-6	0.10 ± 0.10	0.19 ± 0.19*
∑ n-*6*	56.74 ± 3.84	57.90 ± 4.53
∑ n-*6 metabolites*	6.41 ± 1.22	7.76 ± 1.64***
20:4n-6/18:2n-6	0.10 ± 0.01	0.13 ± 0.01***
n-6 met/18:2n-6	0.13 ± 0.01	0.16 ± 0.01**
18:3n-3	0.89 ± 0.26	0.70 ± 0.24**
20:5n-3	0.53 ± 0.38	0.63 ± 0.47
22:5n-3	0.03 ± 0.04	0.03 ± 0.02
22:6n-3	0.59 ± 0.25	0.62 ± 0.22
∑ n-*3*	2.04 ± 0.70	1.98 ± 0.64
∑ n-*3 metabolites*	1.15 ± 0.57	1.28 ± 0.57
20:3n-9	0.10 ± 0.15	0.09 ± 0.06

*$P<0.05$; **$P<0.01$; ***$P<0.001$. The mean is significantly different from corresponding control values.

have demonstrated that maternal age, a BMI > 27 kg/m^2 (Dornhorst *et al*, 1992), and high parity (Moses, 1996) are risk factors for gestational diabetes.

Approximately 53% of the GDM women were of African ancestry. This was unexpected since the majority of the resident population served by the hospital are Caucasians and the subjects were recruited at random. The disproportionate representation of women of African ancestry in the GDM group suggests that they may have a higher risk of developing gestational diabetes. Indeed, Koukkou *et al* (1995) have reported that Afro-Caribbean women were four times more likely to have GDM than Caucasians. It is conceivable that genetic predisposition and a change in lifestyle—including decreased physical activity and a high consumption of saturated fat—that promotes obesity, may be partly responsible for the disproportionate prevalence of the disorder of the Afro-Caribbean/African women in the current study. However, although it has to be corroborated by a larger study, dietary assessment of a subsample of the GDM ($n = 13$) and Control ($n = 10$) women did not provide evidence of a difference in intake of n-6 or n-3 between the two groups.

At diagnosis, the mean glycosylated haemoglobin (HBA_{1C}) concentration of the gestational diabetics was significantly higher than that of the controls. HBA_{1C} is produced by the nonenzymatic glycosylation of haemoglobin at a rate proportional to the prevailing glucose concentration, and is a marker of long-term glycaemic control. Hence, the higher HBA_{1C} level in the GDMs suggests that the diabetes may have its origin in the first or second trimester. Since early identification, management and monitoring are vital for the reduction of the potential adverse effects associated with GDM, there is an urgent need for a sensitive and specific marker that would help to identify the onset of GDM.

Animal (Brenner *et al*, 2000) and human (Arisaka *et al*, l991, Poisson *et al*, 1992) studies have demonstrated that the activity of the delta-6 and -5 desaturase enzymes, vital for the synthesis of the n-6 and n-3 LCPUFA are impaired in diabetes. The impairment is often manifested by an increase in LA and ALA, and a concomitant decrease in their respective major metabolites AA and DHA. Tilvis and Miettinen (1985) and Ghebremeskel *et al*, (l998) have reported that pregnant women with Type I diabetes also have reduced plasma AA and DHA. In a previous study (Ghebremeskel *et al*, 2001), we have reported a significant reduction in red cell membrane AA and DHA in gestational diabetics at diagnosis. This reduction was more pronounced in those gestational diabetics with a BMI $\geq 25\,kg/m^2$ (Lowy *et al*, 2002).

In contrast to the above reports, the data from the current study do not provide evidence of the impairment of either delta-6 and/or -5 desaturase in gestational diabetics. The GDM women had higher AA and DHA in CPG and CE, and, DHA in TG lipid fractions. Indeed, the higher AA/LA (in CPG and CE) and n-6 metabolites/LA (in CE) suggest that they may have had enhanced desaturase activity. These findings are consistent with previous studies that have reported enhanced levels of AA and DHA in plasma CPG (Ghebremeskel *et al*, 1998) and DHA in plasma phospholipids (Wijendran *et al*, l999) of gestational diabetics.

There is no obvious explanation for the relatively higher levels of AA and/or DHA in the three plasma lipid fractions of the GDM women. Nevertheless, it could be due to a higher consumption, mobilisation or insulin-induced enhanced synthesis. Since the blood samples were taken at diagnosis before the start of any treatment, dietary or insulin therapy could not have been a factor. Elevated plasma fatty acids are a common feature of insulin resistance (Unger & Foster, 1998). Hence, it is possible that a sustained high concentration of glucose may have led to the mobilisation of fatty acids, including LA, ALA, AA and DHA, from adipose tissue and the liver. This would lead to an increase in plasma levels of the less oxidisable AA and DHA (Leyton *et al*, l987) but not of the readily oxidisable fatty acids, LA and ALA (Leyton *et al*, l987, Cunnane, l996).

In contrast to the plasma, the red cells of the current GDM women had significantly lower levels of AA and DHA, particularly in the CPG (Min *et al*, 2004). We are unsure as to why pregnancy-induced diabetes had different effects on plasma and red cell AA and DHA. It is plausible that gestational diabetes reduces the incorporation of these fatty acids into red cell and other tissues. Poisson (1993) have postulated that, 'other factors independent of desaturation and elongation may play a pivotal role in the altered lipid biochemistry in chemically induced and genetically diabetic rats'. Similarly, Ghebremeskel *et al* (2002) have suggested that the contrasting levels of AA and DHA between neutral, and membrane phospholipids of diabetic rats could be due to alterations in the regulatory mechanism responsible for the distribution of these fatty acids between the lipid pools. Indeed, recent evidence demonstrates that the membrane protein CD36 (fatty acid translocase), which is a facilitator of long-chain fatty acids (Coburn *et al*, 2000), is deficient in a rat model of human metabolic syndrome X (Aitman *et al*, 1999).

The results of this study do not provide evidence that the activity of the delta-6 or delta-5 in plasma lipids is compromised by pregnancy-induced diabetes. It may be that the higher AA and DHA plasma level observed in the GDM group is associated with a failure to incorporate these fatty acids into the red cell membrane phospholipids in addition to a defect in placental transport. Alternatively, the samples were taken at diagnosis, and it is conceivable that the duration of the diabetes was too short to have a discernable adverse effect on plasma AA and DHA levels.

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