Interaction of body weight and ethnicity on risk of gestational diabetes mellitus[1–3]

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ABSTRACT

Background: The James Bay Cree of Canada have one of the highest recorded rates of gestational diabetes mellitus (GDM) among aboriginal people worldwide; the reasons for this elevated risk remain to be documented.

Objective: Our objective was to compare predictors and risk of GDM between the James Bay Cree and non-Native Canadians.

Design: Risk for GDM was compared between Cree and non-Native women by *1*) adjusting statistically for differences in age, parity, pregravid weight, and smoking status ($n = 402$ Cree, 7718 non-Natives), and *2*) matching Cree women with non-Native women for age and pregravid weight ($n = 394$ Cree, 788 non-Natives). Dietary and physical activity information was available for a subset of Cree women ($n = 152$).

Results: Age and pregravid weight were independent predictors of GDM in both Cree and non-Native women. After these predictors were controlled for, normal-weight (≤ 77 kg) Cree women were not at increased risk of GDM (OR: 1.42; 95% CI: 0.67, 2.71) but overweight Cree women had a higher risk than did overweight non-Native women (OR: 2.25; 95% CI: 1.32, 3.80).

Conclusions: Overweight Cree women are at increased risk of GDM. Given the high prevalence of pregravid overweight among the Cree, the burden of GDM is higher than among non-Native Canadians.   *Am J Clin Nutr* 1999;70:1083–9.

KEY WORDS   Pregnancy, race, gestational diabetes, body weight, ethnicity, Native American, Canada

INTRODUCTION

Gestational diabetes mellitus (GDM) defined as "carbohydrate intolerance of variable severity with onset or first recognition during pregnancy" (1), afflicts ≈3–5% of women in the general North American population, with higher rates being reported among specific ethnic groups such as blacks, Hispanics, and Asians compared with non-Hispanic whites (2–6). A high prevalence of GDM has also been reported among several North American Native groups (7–9), but the reasons for this high prevalence compared with the general population is unknown. GDM increases the risk of pregnancy complications and subsequent type 2 diabetes in the mother and her offspring (10, 11). The high rates of GDM among Native groups are of concern given the young age of the women with GDM and the likelihood of early onset of type 2 diabetes.

Independent predictors of GDM identified in multiethnic populations include age (2–5), parity (5), prepregnancy body mass index (BMI; kg/m^2) (2–5), prepregnancy and pregnancy waist-to-hip ratio (12, 13), prepregnancy smoking status (4), and weight gain during early adulthood (4). The elevated prevalence of GDM reported for some ethnic minority groups such as Hispanics, blacks, and Asians compared with whites persists even after some of the aforementioned predictors, namely age and body weight, are controlled for (2–6). The high prevalence of GDM reported for some North American Native groups compared with the general population may be due to a disproportionate distribution of risk factors for GDM between the 2 populations, genetic predisposition among the former, or both, and needs to be investigated.

The purpose of this study was therefore *1*) to identify and compare predictors of GDM among the Cree of eastern James Bay, Canada, who have a high prevalence of GDM (9), with those of the general Canadian population by using a large obstetric database of non-Native pregnancies, and *2*) to determine whether differences in GDM prevalence between the Cree and the general Canadian population could be explained by differences in the GDM risk profiles of age, parity, height, pregravid weight or BMI, and smoking status between the 2 populations.

SUBJECTS AND METHODS

Subjects

About 11 000 Cree live in 9 communities east of James Bay (northern Quebec). Of these, 7 communities are accessible by road year-round. The size of the communities ranges from 485 to 2951 inhabitants (Public Health Module–Cree Region, Quebec Government, unpublished observations, 1996). Traditionally, the Cree were hunter-gatherers. The establishment of schools and the hydroelec-

tric project in James Bay in 1975 led to the beginning of a more settled existence for the Cree. At present, all houses have electricity and modern appliances but are often overcrowded. Although traditional foods such as wild game and fish are still highly valued, traditional dietary patterns have changed, with the younger generation consuming predominantly market foods (K Gray-Donald, E Robinson, K David, A Collier, S Rodrigues, unpublished observations, 1999). The recent lifestyle changes have been accompanied by high rates of obesity and type 2 diabetes, especially among Cree women (14). Ethical approval for the study was obtained from the Human Ethics Review Board of McGill University.

Data collection

Maternal medical charts for all Cree deliveries from January 1995 to December 1996 in the 9 communities of James Bay ($n = 681$) were reviewed for obstetrical information. Data for non-Native Canadian pregnancies were extracted from the McGill Obstetric and Neonatal Database (MOND), which is a computerized database of all deliveries at the Royal Victoria Hospital in Montreal since 1978. The hospital serves a multiethnic Montreal population. Less than 1% of 71 415 First Nations people in Quebec live in Montreal (15).

Diagnosis of GDM among the Cree and at the Royal Victoria Hospital was in accordance with the National Diabetes Data Group recommendations (16). Specifically, women were screened with a 50-g oral glucose load between 24 and 30 wk gestation. If the plasma glucose value at 1 h was ≥7.8 mmol/L, the patient was asked to undergo a 3-h 100-g oral-glucose-tolerance test (OGTT) after an overnight fast. GDM was diagnosed if any 2 of the 4 values on the OGTT were met or exceeded (fasting: 5.8 mmol/L; 1 h: 10.6 mmol/L; 2 h: 9.2 mmol/L; 3 h: 8.1 mmol/L). Information on the following variables of interest was obtained for both populations: diabetes status, date of birth, pregravid weight, height, parity, and smoking status during pregnancy. Women with pregestational diabetes, with uncertain GDM status due to missing screening, or OGTT information, with a preterm birth, with a spontaneous abortion or receiving glucocorticoid therapy were excluded from the analyses. In addition, high-risk referrals from other hospitals were also excluded from MOND.

Of the 681 deliveries among the Cree, 499 met the inclusion criteria. Of these, pregravid weight information was missing for 85 pregnancies, parity information was missing for 1, maternal smoking status was unknown for 11, and height information was missing for 138. Therefore, complete information on maternal age, pregravid weight, parity, and smoking status was available for 402 pregnancies, with 16 women contributing 2 pregnancies between January 1995 and December 1996. If height was included as a predictor, complete information was available for 264 pregnancies. Women with missing information on pregravid weight or height were similar in most characteristics to women with complete data. The one exception was that women with no information on height ($n = 138$) had a lower prevalence of GDM than did women with complete data ($n = 264$; 4.4% compared with 15.2%; $P < 0.001$).

Pregravid weight information for Cree women was based on maternal recall (147/402; if within 5 kg of measured weight up to 10 wk gestation or within 7 kg of measured weight between 10 and 20 wk gestation) or the first available measured weight up to 20 wk gestation (255/402). Height was either measured (174/264) or based on maternal report at admission (90/264). High correlations between self-reported and measured weights and heights have been reported in population-based studies (17, 18).

Information on parity and smoking status was based on maternal report. Information on diet, physical activity patterns, and rate of weight gain before GDM diagnosis and GDM status in the previous pregnancy was available in a subset of Cree women ($n = 152$). In analyses of this subset, women with impaired glucose tolerance (IGT) (one abnormal value on the 3-h, 100-g OGTT) were pooled with women with diagnosed GDM to increase statistical power ($n = 24$ women with GDM or IGT, 128 normoglycemic women). Women in the Cree subset ($n = 152$) were not significantly different in age, parity, pregravid weight, height, or smoking status from women in the entire Cree sample with complete data ($n = 402$). Energy and macronutrient intakes were estimated from a single 24-h recall before GDM diagnosis by using FOOD PROCESSOR II (version 5.03; ESHA Research, Salem, OR). Physical activity patterns were determined from a questionnaire administered at the time of the 24-h recall; women were categorized as sedentary or active on the basis of frequency of participation in various activities (19). To determine the rate of weight gain before GDM diagnosis in the Cree subset, the last available weight before the diagnosis of GDM or IGT was deducted from the first available pregnancy weight and then divided by the number of weeks elapsed. Because normoglycemic women did not undergo an OGTT, the last available weight before the median gestational age at which the OGTT was administered in the GDM and IGT group was used as the last weight. Information on previous GDM was based on maternal reports and validated against laboratory reports of glucose screening in the previous pregnancy when available.

Of the 20 982 deliveries in the MOND database (1990–1996), 20 619 met the inclusion criteria. In addition, the data were restricted to women born in North America or Europe to limit ethnic heterogeneity of the sample because no other indicators of ethnicity were available. This reduced the sample size to 13 734 pregnancies. Of these, no information on pregravid weight was available for 5864 pregnancies, information on maternal smoking status was unknown for 152 pregnancies, and height information was missing for 1483 pregnancies. Therefore, complete information on maternal age, parity, pregravid weight, and smoking status was available for 7718 non-Native pregnancies, with 800 women contributing 2 pregnancies, 45 women contributing 3 pregnancies, and 4 women contributing 4 pregnancies over the time period studied. If height was included as a predictor, the sample size decreased to 6235 pregnancies. The only difference between non-Native women with missing data for pregravid weight or height and women with complete data was that GDM prevalence was lower by 3.7–4.1% ($P < 0.001$) among women with missing information. In the MOND population, information on pregravid weight, height, parity, and smoking status was based on maternal reports at hospital admission. No information on previous GDM, rate of weight gain before GDM diagnosis, diet, or physical activity patterns was available from this database. Because of the large number of missing heights for both Cree and non-Native women, obesity was defined as pregravid weight >77 kg, which is equivalent to a BMI > 29 (recommended as the obesity cutoff by the US National Institute of Medicine; 20) for a woman of average stature (1.6 m for both Cree and non-Native women).

Data analyses

The primary outcome was the presence or absence of GDM. The following predictor variables were evaluated for their effects

on GDM risk for Cree ($n = 402$) and non-Native ($n = 7718$) women separately: age, pregravid weight, and smoking status. To determine the effects of ethnicity (Cree or non-Native) on GDM, data for the 2 ethnic groups were pooled together and the effect of ethnicity on GDM was determined in multivariate analyses with adjustment for the effects of age, pregravid weight, and smoking status.

Cree and non-Native women were also frequency matched 1:2 for pregravid weight (± 2.5 kg) and age (± 10 y) to control for differences in the distribution of these 2 variables. Even with a large non-Native database and a wide margin for age, we could not find appropriate pregravid weight matches for 8 young Cree women who were very overweight, and they were therefore excluded. The final sample size for the matched sample was thus 394 Cree women and 788 non-Native women.

All analyses were repeated by *1*) substituting height and BMI in the model for pregravid weight ($n = 264$ Cree and 6235 non-Natives for the unmatched sample and $n = 258$ Cree and 623 non-Natives for the matched sample), and *2*) restricting the data to only the most recent pregnancy among women with more than one pregnancy over the study period ($n = 386$ Cree and 6816 non-Natives). The magnitude of risk associated with previous GDM, rate of weight gain, energy and macronutrient intakes, and physical activity levels before GDM diagnosis were evaluated for the Cree subset ($n = 152$).

Student's independent *t* test and the chi-square test were used to test differences between continuous and categorical variables, respectively. Multiple logistic regression analysis was used to estimate adjusted odds ratios (ORs) and 95% CIs. The Breslow-Day test of homogeneity of ORs across strata of ethnicity was used to explore interactions between ethnicity and other predictors of GDM. The level of significance was set at $P \leq 0.05$ for all predictors and at $P \leq 0.1$ to detect interactions between predictors. All analyses were conducted by using the Statistical Analysis System (SAS, version 6.12; SAS Institute Inc, Cary, NC).

RESULTS

Clinical and sociodemographic profiles of the Cree and non-Native samples are presented in **Table 1**. In the unmatched sample, the prevalence of GDM among Cree women ($n = 402$) was 11.4% compared with 5.3% among non-Native women ($n = 7718$). Risk profiles for GDM were very different between the 2 populations, with the Cree being younger, more parous, and heavier. More than half of the Cree women were classified as obese (pregravid weight >77 kg) compared with only 10% of non-Native women. Although there were more smokers among the Cree, the average number of cigarettes smoked per day by smokers was lower (5 compared with 13 cigarettes). In the matched sample ($n = 394$ Cree and 788 non-Natives), pregravid weight and BMI were not significantly different between the 2 ethnic groups, as expected, given the narrow pregravid weight margin used for matching (± 2.5 kg). However, Cree women in the matched sample were significantly younger and more parous than were non-Native women whereas GDM prevalence was no longer significantly different between the 2 groups (11.4% and 8.1%, respectively). In both the unmatched and matched samples, Cree women delivered heavier infants than did non-Native women (Table 1). However, whereas infant birth weight was significantly higher among Cree women with GDM than among normoglycemic Cree women (4171 ± 496 compared with 3797 ± 529 g; $P < 0.0001$), this was not the case among non-Native women (3479 ± 480 compared with 3501 ± 458 g; NS).

TABLE 1
General characteristics of study population by ethnic status[1]

	Unmatched sample		Matched sample	
Characteristic	Cree ($n = 402$)	non-Native ($n = 7718$)	Cree ($n = 394$)	non-Native ($n = 788$)
Age (y)	23.9 ± 5.7	30.3 ± 4.7[2]	23.9 ± 5.7	26.6 ± 4.8[2]
Parity (% primiparous)	57.5	84.3[3]	57.4	88.6[3]
Height (cm)	162.4 ± 5.5	163.8 ± 6.7[2,4]	162.1 ± 6.53	165.4 ± 6.8[2,5]
Pregravid weight (kg)	79.6 ± 18.1	62.0 ± 11.8[2]	78.3 ± 16.0	78.3 ± 16.0
Pregravid Weight				
≤ 77 kg (%)	48.3	90.0[3]	49.2	49.2
>77 kg (%)	51.7	10.0[3]	50.8	50.8
BMI (kg/m^2)	30.3 ± 6.8	23.1 ± 4.3[2,4]	29.8 ± 6.0	28.7 ± 6.0[5,6]
BMI ≤ 26 (%)	28.4	81.5[3]	29.8	35.5
BMI >26–29 (%)	17.6	8.9[2]	17.8	18.6
BMI >29 (%)	54.0	9.6[3]	52.3	45.9
Prevalence of GDM (%)	11.4	5.3[3]	11.4	8.1
Smokers (%)	45.5	19.2[3]	45.7	24.4[3]
Infant birth weight (g)	3840 ± 538[7]	3500 ± 459[2]	3832 ± 533[8]	3587 ± 473[2]

[1] $\bar{x} \pm$ SD; the matched sample of Cree and non-Native women were frequency matched 1:2 for pregravid weight and age. GDM, gestational diabetes mellitus.

[2] Significantly different from Cree (Student's independent *t* test, except for pregravid weight, BMI categories, GDM prevalence, and smoking status, for which chi-square tests were used): [2] $P < 0.0001$, [3] $P < 0.001$, [6] $P < 0.02$.

[4] $n = 264$ Cree and 6235 non-Natives.

[5] $n = 258$ Cree and 623 non-Natives.

[7] $n = 397$.

[8] $n = 389$.

TABLE 2
Independent risk factors for gestational diabetes mellitus stratified by ethnic status[1]

	Unmatched sample		Matched sample	
Characteristics	Cree (*n* = 402)	non-Native (*n* = 7718)	Cree (*n* = 394)	non-Native (*n* = 788)
Age (per 5 y)	1.70 (1.25, 2.33)	1.46 (1.31, 1.63)	1.66 (1.22, 2.30)	1.43 (1.07, 1.93)
Parity (primi- versus multiparous)	0.85 (0.40, 1.82)	1.40 (1.09, 1.78)	0.86 (0.39, 1.86)	1.24 (0.59, 2.44)
Pregravid weight (per 5 kg)	1.11 (1.03, 1.21)	1.13 (1.09, 1.17)	1.18 (1.06, 1.30)	1.09 (1.01, 1.19)
Smoking	0.81 (0.41, 1.58)	1.43 (1.12, 1.80)	0.77 (0.38, 1.51)	0.96 (0.51, 1.73)

[1] Adjusted odds ratio, with 95% CI in parentheses, derived by using multiple logistic regression analysis. The matched sample of Cree and non-Native women were frequency matched 1:2 for pregravid weight and age.

Independent risk factors for GDM stratified by ethnicity in the matched and unmatched samples are shown in **Table 2**. Risk factors that were significantly associated with GDM among the Cree in the unmatched sample (*n* = 402) were age and pregravid weight, whereas parity and smoking status were not significant. When BMI and height were substituted for pregravid weight in the same model, BMI was a significant predictor (adjusted OR per 5 BMI points: 1.33; 95% CI: 1.04, 1.71), whereas height was not (adjusted OR per 5 cm of height: 1.04; 95% CI: 0.73, 1.48). Similar results were obtained for the matched Cree sample (*n* = 394). Among unmatched non-Native women, all risk factors evaluated, ie, age, parity, body weight, and smoking status, were significantly associated with GDM (Table 2). When the model was rerun after substituting BMI and height for pregravid weight, both were significant (adjusted OR per 5 BMI points: 1.50; 95% CI: 1.36, 1.65; adjusted OR per 5 cm of height: 0.83; 95% CI: 0.77, 0.89). The results were similar for the matched non-Native sample (*n* = 788), except that the effects of parity, height, and smoking status were no longer significant.

In multiple logistic regression analysis, when data for the 2 ethnic groups were pooled (*n* = 402 Cree and 7718 non-Natives) and ethnicity, age, parity, pregravid weight, and smoking status were included in the model simultaneously, a significant interaction was noted between ethnicity and pregravid weight or BMI (**Figure 1**). The adjusted OR for the interaction between ethnicity and BMI was 1.45 (95% CI: 1.02, 2.07). Interactions between ethnicity and other predictors in the model were not significant.

Further analyses were conducted after stratification by pregravid weight (≤77 kg or >77 kg) because of the observed interaction between weight and ethnicity. The magnitude of risk of GDM imparted by each risk factor after adjustment for the effects of other risk factors, stratified by pregravid weight, is shown in **Table 3** for both the unmatched and matched samples. Ethnic status was not a significant predictor of GDM in normal-weight individuals for either the matched or unmatched samples, which implies that normal-weight Cree women had a risk of GDM similar to that for normal-weight non-Native women. In contrast, ethnic status had a significant effect among obese women (matched and unmatched samples). Even after adjustment for age, parity, pregravid weight, and smoking status, the risk of GDM for obese Cree women was more than twice that for obese non-Native women (Table 3). The same effect was seen when the model was rerun after stratification by BMI instead of pregravid weight and also adjustment for height. When the analyses were repeated after the data were restricted to the most recent pregnancy in women with more than one pregnancy during the study period (*n* = 386 Cree and 6816 non-Natives), the results were very similar (data not shown).

Risk factors for GDM were also analyzed for the Cree subset (*n* = 152) with information on diet and physical activity before GDM diagnosis. In univariate analyses, Cree women with GDM or IGT (*n* = 24) had a higher frequency of GDM in the previous pregnancy (29.2% compared with 3.2%; *P* < 0.001), a significantly lower prediagnostic rate of weight gain ($\bar{x} \pm$ SD: 0.36 ± 0.20 compared with 0.50 ± 0.29 kg/wk; *P* < 0.01), and lower energy consumption ($\bar{x} \pm$ SD: 9301 ± 3402 compared with 11 958 ± 3619 kJ; *P* = 0.001) than normoglycemic women, whereas their physical activity patterns were not significantly different (54% compared with 42% sedentary; NS) from those of normoglycemic women (*n* = 128). In multivariate analyses in the Cree subset (*n* = 152), independent predictors of GDM were age (adjusted OR per 5 y: 1.85; 95% CI: 1.22, 2.87), BMI (>29 compared with ≤29; adjusted OR: 3.52; 95% CI: 1.19, 12.06), and energy intake (adjusted OR per 100 kcal or 418 kJ: 0.92; 95% CI: 0.86, 0.98). When previous GDM (adjusted OR: 7.42; 95% CI: 1.60, 41.75) was added to the model, the ORs for energy intake, age, and BMI remained unaffected. After adjustment for age, BMI, energy intake, and previous GDM, none of the other variables (ie, parity, smoking status, rate of weight gain, and individual macronutrient intakes) were significant.

DISCUSSION

The aim of this study was to compare risk of GDM between Cree women and non-Native women in the general Canadian pop-
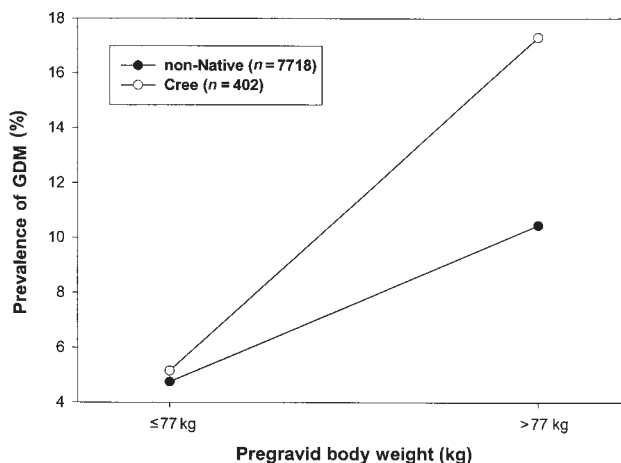

FIGURE 1. Prevalence of gestational diabetes mellitus (GDM) in Cree and non-Native Canadian women after stratification by pregravid weight. Results indicate an interaction between pregravid weight and ethnicity.

TABLE 3
Independent risk factors for gestational diabetes mellitus stratified by pregravid weight[1]

Characteristic	Unmatched sample		Matched sample	
	Weight ≤77 kg (n = 7137)	Weight >77 kg (n = 983)	Weight ≤77 kg (n = 582)	Weight >77 kg (n = 600)
Ethnicity (Cree versus non-Native)	1.42 (0.67, 2.71)	2.25 (1.32, 3.80)	1.05 (0.40, 2.61)	2.41 (1.34, 4.39)
Age (per 5 y)	1.46 (1.30, 1.65)	1.52 (1.24, 1.87)	1.48 (1.01, 2.13)	1.55 (1.19, 2.02)
Parity (primi- versus multiparous)	1.38 (1.05, 1.79)	1.24 (0.79, 1.94)	0.95 (0.28, 2.90)	1.09 (0.60, 1.93)
Pregravid weight (per 5 kg)	1.10 (1.02, 1.18)	1.09 (1.02, 1.18)	1.18 (0.91, 1.55)	1.10 (1.00, 1.22)
Smoking	1.41 (1.08, 1.83)	1.15 (0.73, 1.77)	1.07 (0.47, 2.33)	0.78 (0.43, 1.35)

[1] Adjusted odds ratio, with 95% CI in parentheses, derived by using multiple logistic regression analysis. The matched sample of Cree and non-Native women were frequency matched 1:2 for pregravid weight and age.

ulation after differences in age, parity, BMI, and smoking status were accounted for. Our results indicated that only obese Cree women had a higher risk of GDM than did obese non-Native women, whereas GDM prevalence was similar among normal-weight Cree and non-Native women. Ethnic differences in GDM risk have been shown in other studies, in which a high prevalence of GDM was noted among ethnic minority groups such as blacks, Chinese, Hispanics, and Asian Indians compared with whites in the United Kingdom or United States, even after differences in age, parity, and body weight were controlled for (2–6). However, our study is the first to report an interaction between body weight and ethnicity as a determinant of GDM and to document differences between aboriginal and non-Native women.

Independent predictors of GDM in the Cree were similar to those in non-Native women in the general Canadian population. Among the Cree, older and heavier women were at increased risk of GDM. This is supported by a study in the Cree and Ojibwa Natives of the Sioux Lookout Zone in northwestern Ontario, Canada (8) and by other reports in multiethnic populations (2–6). However, unlike observations among the Natives of the Sioux Lookout Zone, in our study, parity was not an independent predictor of GDM among the Cree. It is difficult to dissociate the effect of parity from age and BMI effects, as is evident from the existing literature, in which most studies do not report parity as an independent risk factor for GDM after adjustment for age and BMI (2–4).

The increased risk of GDM among obese Cree women compared with obese women in the general population could not be explained by differences in age, parity, height, body weight, or smoking status. Potential explanations could be differences in diet, physical activity patterns, body fat patterning, or genetic predisposition to diabetes. Although information on diet and physical activity patterns during pregnancy was available for a subset of Cree women, no such information was available for our non-Native women. Lower energy intake predicted an increased risk of GDM in the Cree subset (n = 152) independently of age, previous GDM, and BMI. The inverse association between energy intake and GDM risk may be due to underreporting of total energy intake by obese Cree women. Alternatively, obese women may have reduced their energy intake to restrict weight gain during pregnancy. However, even though energy intakes were estimated from a single 24-h recall, we believe that the energy intakes measured for Cree women are a reasonably accurate reflection of their usual intakes during pregnancy for the following reasons: 1) a significant positive association was noted between energy intake and weight gain (r = 0.26, P = 0.002; n = 144) in our Cree subset; 2) because the 24-h recall was done

before GDM diagnosis, there is no possibility of contamination by treatment; and 3) a single 24-h recall has been reported to accurately reflect group intake in young women (21).

The lower energy intakes seen in our study may be a marker for lower physical activity levels. This inference is reasonable for several reasons. First, an inverse association has also been reported between energy intake or physical activity and chronic diseases such as type 2 diabetes (22, 23) and coronary heart disease (24). Second, aboriginal people who have traditional lifestyles, which include hard physical labor, have very low rates of diabetes compared with their genetically linked kin who are more modernized and sedentary (25, 26). In addition, even small increases in presumed energy expenditure through hunting and trapping in bush camps were reported to decrease plasma glucose and glycated hemoglobin concentrations in diabetic Cree men and women (27). Third, although physical activity level, as measured by a questionnaire, was not an independent predictor of GDM in our study, an inverse association was observed between physical activity and obesity in our Cree subset, with obese women reporting more sedentary behaviors (P < 0.001). Thus, lower physical activity levels among obese Cree women in our study may be one of the reasons for the higher GDM prevalence compared with obese women in the general population, who may be more active. Careful determination of physical activity patterns of obese women in the general population should help shed light on this issue. Furthermore, more precise measures of physical activity during pregnancy need to be developed to explore the relation between physical activity and GDM.

Another reason for differences in GDM prevalence between obese Cree and obese non-Native women may be differences in body fat patterning, which may be genetically predetermined (28, 29). Central adiposity, as determined by waist-to-hip ratio or waist circumference, has been reported to be an independent predictor of GDM in recent studies (12, 13). No information on body fat patterning was available for our study women, but this is a possibility that requires further investigation.

Certain limitations of our study need to be acknowledged. Ethnic characteristics of our non-Native women could not be distinctly documented. However, our limiting the data to women born in North America and Europe restricted the ethnic heterogeneity of the non-Native sample. Although the possibility of some Cree women being included in the non-Native database cannot be completely ruled out, those evacuated to Montreal because of a high-risk pregnancy were excluded because they were classified as high-risk referrals. Another limitation may be the use of pregravid weight or BMI as an adiposity index in this

study. However, good correlations between BMI and percentage body fat determined by densitometry have been reported in non-pregnant ($r = 0.60–0.82$) (30) and pregnant (correlation between pregravid BMI and percentage fat: 0.69) women (31). Moreover, our use of a relatively high cutoff to define obesity (BMI >29 or pregravid weight >77 kg) decreases the likelihood of misclassification (32). There were also a large number of missing data for pregravid weight and height for Cree and non-Native women. However, most characteristics were similar between women with missing information and women with complete data, except for a lower prevalence of GDM in the former group. This was likely due to better follow-up and more complete medical records for women with GDM.

In conclusion, our study clearly shows that the high rate of GDM seen among the Cree compared with the general Canadian population is due to a high prevalence of obesity compounded by a higher rate of GDM among obese Cree women. In contrast, Cree women who are not obese are not at a higher risk for GDM than are non-Native Canadians. The reasons why obese Cree women are at a much higher risk for GDM than obese women in the general population need to be studied. Also, comprehensive efforts to tackle pregravid obesity among the Cree need to be undertaken through culturally acceptable ways of modifying diet and increasing physical activity (33). ✾

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