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ORIGINAL ARTICLE

Maternal obesity, associated complications and risk of prematurity

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Objective: We aimed at (a) examining the rates of obesity over a 12-year period; (b) studying the effect of obesity and morbid obesity on gestational age and birth weight and (c) determining the influence of race on the association between maternal obesity and the gestational age of a newborn.

Study Design: We conducted a retrospective analysis using data from the perinatal data set of mothers delivering at the George Washington University between 1992 and 2003. We stratified mother/infant pairs ($n = 14\,183$) into three groups on the basis of maternal prepregnancy body mass index (BMI): not obese (BMI < 30), obese (BMI 30 to 39) and morbidly obese (BMI $\geqslant$ 40). We identified all spontaneous and induced preterm deliveries in each group. Bivariate and multivariate analyses were conducted to control for significant differences between groups.

Result: We identified obesity in 1707 (12%) and morbid obesity in 415 (3%) of the mothers. Obesity and morbid obesity increased over time during the study period. In crude analysis, mothers with obesity and morbid obesity were more likely to deliver prematurely (16.7 and 20.3%, respectively) when compared with nonobese women (14.5%), and were also more likely to have other complications including smoking, anemia, hypertension, diabetes and cesarean delivery. When controlling for these complications in a logistic regression model, obesity and morbid obesity were not associated with prematurity.

Conclusion: There is no direct link between obesity and prematurity. Prematurity is more likely caused by medical complications that frequently occur in obese women. Further studies are needed on this growing population to test whether providing adequate prenatal care can control the associated medical conditions and subsequently ameliorate the rate of prematurity.

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Introduction

Obesity continues to be a major problem in the United States, especially among women in the reproductive age group.[1] Over the past 15 years, the prevalence of obesity in women of reproductive age has been increasing, ranging between 19% and 38%.[2] This increase is a cause for alarm because of the medical risks associated with obesity in pregnancy, including hypertension, diabetes[3] and increased cesarean deliveries.[4] Adverse birth outcomes are also increased in obese pregnant mothers, including stillbirth and early neonatal death.[4–6] Obesity is associated with increased risks of premature deliveries and low birth weight (LBW) infants.[5,7] However, it is unclear whether premature and LBW deliveries occur as a result of obesity itself, or are simply a consequence of frequently associated comorbidities such as hypertension and diabetes. The distribution and mechanisms of obesity, genetic versus environmental, may be influenced by ethnic and racial affiliation. African-American pregnant women are more prone to obesity and morbid obesity, and are more likely to suffer from pregnancy and labor complications when compared with Caucasians.[1,8] This study on a large cohort of mother–infant pairs at the George Washington University Medical Center aimed at: (a) examining the rates of obesity over a 12-year period; (b) studying the effect of obesity and morbid obesity on gestational age and birth weight and (c) determining the influence of race on the association between maternal obesity and the gestational age of a newborn.

Methods

GWUMC perinatal database

The database used in this study was developed at George Washington University and includes a patient record for every delivery performed between 1992 and 2003. The database contains 517 fields representing primarily clinical variables for both mothers and babies. A linkage is maintained to the medical record of patients. For each patient, nearly 3000 fields of data including demographic, antepartum and intrapartum parameters, preoperative care and postoperative data are stored in a fully

relational, integrated database. Validated clinical information was contemporaneously recorded into the database in a consistent manner. One of the strengths of this data set is that, in addition to weight on admission, it also includes records of mothers' height and prepregnancy weight. Therefore, an accurate determination of body mass index (BMI) is feasible. All fields for all patients were entered by a single senior obstetrician during the entire study period. The study has been approved by the Institutional Review Board at George Washington University.

Analysis

A retrospective analysis was conducted on the entire cohort of African-American and Caucasian singleton mother–infant pairs. The independent variable for this study was prepregnancy BMI, and the dependent outcome was the incidence of prematurity (spontaneous and induced) during that pregnancy. Gestational age was analyzed categorically, either as premature (<37 weeks) or as full-term (37 to 42 weeks) newborns. Birth weight was analyzed as a continuous variable using linear regression. The Cochran–Armitage test for trend was used to determine the change over time in BMI.

Mothers were divided on the basis of their prepregnancy BMI into the following three categories: nonobese (BMI <30), obese (BMI 30 to 39) and morbidly obese (BMI $\geqslant$40). Women who were considered underweight (BMI <19) were excluded from the study population.

Logistic regression analysis was carried out to control for confounding variables. Variables examined for their potential confounding effect were babies' gender, maternal age, gravidity, change in BMI during pregnancy, gestational age (for birth weight as outcome), cesarean delivery, anemia, hypertension, diabetes and smoking status. In this study, we defined (a) prematurity when the duration of pregnancy lasted <37 completed weeks of gestation, regardless of whether delivery was spontaneous or induced; (b) anemia when hemoglobin concentration on admission was <11 g per 100 ml; (c) hypertension when the mother had preeclampsia, eclampsia or chronic hypertension and (d) diabetes when the mother had any type of diabetes mellitus including gestational diabetes. The number of records with a positive response in variables reflecting the use of illicit drugs or alcohol during pregnancy was very low (250 and 70, respectively) and was not deemed reliable, hence these variables were omitted from the analysis. The numbers of gravidity were entered in the logistic model in the rank of (1), (2), (3), (4) and (5 or more).

Results

The database included 15 904 patients who had a singleton pregnancy, of whom 14 183 were included in this study (7612 African-American and 6571 Caucasian). Hispanic and other races represented only 1721 patients and were not included.

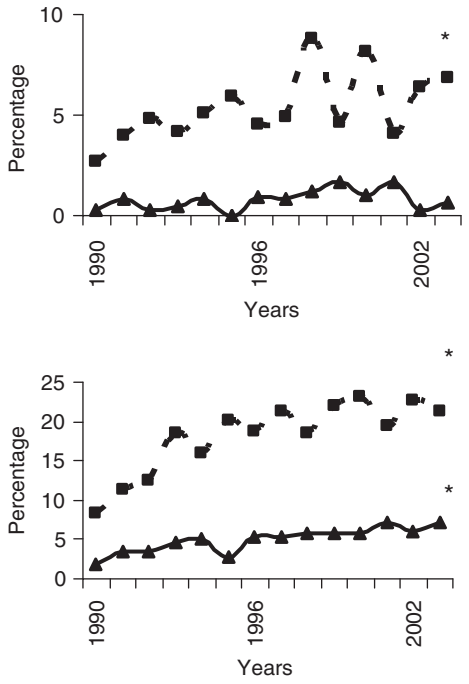

Figure 1 Trend lines for the frequency (%) of obesity and morbid obesity during pregnancy among Caucasian (upper panel) and African-American (lower panel) women during the years 1990 to 2003. . .■. ., obese women, —▲—, morbidly obese women.
*The Cochran–Armitage trend test was significant for obese women among both Caucasians and African-Americans, and for morbidly obese women among African-Americans ($P = 0.0001$). The trend was not significant for morbidly obese Caucasian women ($P = 0.1$).

Obesity has grown from a little over 4% in 1990 to 14% in 2003, and morbid obesity increased from about 1% in 1990 to 4% in 2003 (P-value for trend = 0.0001) (Figure 1). When analyzed by race, the trend among African-American women and their Caucasian counterparts was significant for obesity ($P = 0.0001$) (Figure 1). The trend for morbid obesity was significant among African-Americans ($P = 0.0001$), but not among Caucasians ($P = 0.1$).

The incidences of premature deliveries in morbidly obese, obese and nonobese women were 20.3, 16.7 and 14.5%, respectively. Crude analysis showed an increased risk for prematurity in morbidly obese (OR = 1.4; 95% CI = 1.08 to 1.82) and obese (OR = 1.15; 95% CI = 0.99 to 1.33) mothers, compared with nonobese mothers ($P = 0.01$). There was a trend for LBW in newborns of morbidly obese (3197 $\pm$ 38.46 g) and obese (3227 $\pm$ 17.96 g) mothers when compared with nonobese mothers (3256 $\pm$ 5.91 g), which did not reach significance ($P = 0.06$) (Figure 2). When compared with nonobese mothers, obese and morbidly obese mothers encountered more complications, such as anemia, hypertension and diabetes. There was a significant interaction between gravidity and BMI ($P \leqslant 0.01$). The rate of multigravida in nonobese mothers was 11.6%, compared with 20.2% in obese and 22.4% in morbidly obese women. (Table 1).

Table 1 Crude associations between maternal BMI and demographics, other confounders and study outcomes in pregnant mothers

	Not obese N = *12 061*	*Obese* N = *1707*	*Morbid obese* N = *415*	P-*value*
Maternal age (years)	31.5	30.4	30.0	NS
Multigravida (%)	11.6	20.2	22.4	0.001
Race (AA) (%)	40.9	75.2	86.2	0.001
Cesarean (%)	25.8	38.7	49.9	0.001
Anemia (%)	18.6	32.4	42.1	0.001
Hypertension (%)	5.1	13.9	20.7	0.001
Diabetes (%)	3.8	9.8	16.9	0.001
Smoking (%)	1.5	2.9	2.4	0.001
Prematurity (%)	14.5	16.7	20.3	0.01
Birth weight (g)	3256	3228	3197	0.06

Abbreviations: AA, African-American; BMI, body mass index; NS, non-significant.

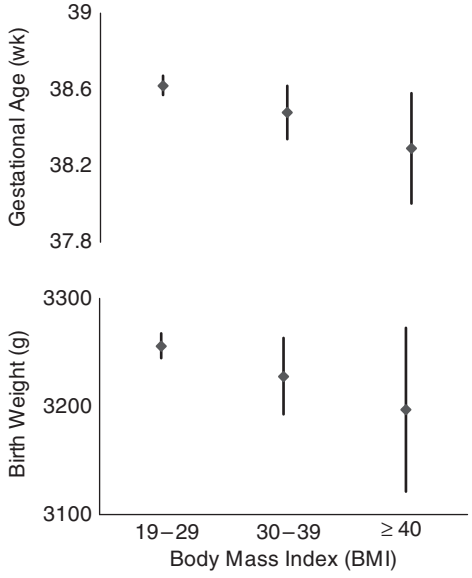

Figure 2 The relationship of maternal prepregnancy body mass index (BMI) with gestational age (upper panel) $P = 0.06$ and birth weight (lower panel) $P = 0.01$. Data are expressed as mean + SD

In Caucasian mothers, the risk of premature delivery increased with multigravidity, diabetes, anemia and hypertension. When controlling for these potential confounders, obesity and morbid obesity were not associated with prematurity (Table 2). In African-American mothers, morbid obesity (OR = 0.57; 95% CI = 0.42 to 0.77) and obesity (OR = 0.57; 95% CI = 0.47 to 0.68) were associated with a decreased risk of prematurity. (Table 2).

Factors affecting birth weight were similar in Caucasian and African-American mothers (Tables 3). Birth weight increased with morbid obesity, obesity, maternal diabetes and male gender of the newborn. Smoking and hypertension acted as risk factors for decreased birth weight. Anemia did not affect birth weight.

Table 2 Regression model for risk factors of premature birth in the study population

Risk variable	*Adjusted odds ratio (95% CI)*	
	Caucasian	*African-American*
Morbid obesity	0.46 (0.19–1.14)	0.57 (0.42 –0.77)[a]
Obesity	1.06 (0.78–1.46)	0.57 (0.47–0.68)[a]
Multigravida	1.77 (1.33–2.42)[a]	1.9 (1.5–2.4)[a]
Anemia	2.41 (1.93–3.05)[a]	1.4 (1.2–1.6)[a]
Hypertension	2.22 (1.67–2.98)[a]	2.3 (1.9–2.8)[a]
Diabetes	1.69 (1.22–2.32)[a]	1.6 (1.2–2.1)[a]
Advanced maternal age	0.97 (0.96–0.99)[a]	0.99 (0.98–1.0)[a]

[a]Risk factor is significant.

Table 3 Regression model for factors affecting birth weight in the study population

Risk variable	*Caucasian*		*African-American*	
	Parameter estimate	P-*value*	*Parameter estimate*	P-*value*
Morbid obesity	152 ± 60	0.01	77 ± 27	0.004
Obesity	74 ± 22	0.0009	46 ± 15	0.002
Male gender	135 ± 10	0.0001	97 ± 12	0.0001
Anemia	−1 ± 19	0.9	1.3 ± 13	0.9
Hypertension	−115 ± 25	0.0001	−116 ± 21	0.0001
Diabetes	122 ± 26	0.0001	120 ± 25	0.0001
Advanced maternal age	3.2 ± 1	0.004	4 ± 1	0.0001
Smoking	−156 ± 54	0.004	−220 ± 37	0.0001

Discussion

This study showed that the overall prevalence of obesity among pregnant mothers is increasing. The increase in the prevalence of obesity in women of childbearing age is of great public health concern as these women are at an increased risk for chronic

diseases,[9] pregnancy complications[10] and birth defects.[11] The overall incidence rates of obesity and morbid obesity in our study population were significantly increased in multigravida and African-American groups.

The results of this study showed that obesity and morbid obesity did not directly increase the risk of prematurity and LBW. When compared with a normal population, we showed that obese and morbidly obese women encountered more medical and behavioral problems during pregnancy, namely, diabetes, hypertension, anemia and smoking. These medical and behavioral problems were two- to threefold greater in obese than in nonobese women. It was even worse in morbidly obese women, as associated problems were four- to fivefold greater than in nonobese women. When compared with obese women, smoking in the morbidly obese group was significantly increased. This observation has not been described previously. A recent report described an increased incidence of smoking with obesity, but did not address whether any difference in the rate of smoking existed between obese and morbidly obese women.[12] In multivariate analysis, smoking did not impact the risk of prematurity in our population. The impact of smoking on birth outcomes seems to depend on multiple factors and, therefore, conflicting results have been reported. In one study, smoking was shown to increase premature birth in the overall population; whereas when compared with underweight women, obese women who smoked had less risk of premature delivery.[13] Mortensen *et al*, noticed that smoking and obesity were intermediates of educational gradients in birth weight at term. When controlling for BMI, smoking was associated with a significant decrease in birth weight in highly educated mothers, whereas a significant increase in birth weight was noticed in less educated mothers.[14]

When we controlled for the increased medical and behavioral risks in reduced logistic models, the unfavorable reproductive outcomes of obese and morbidly obese women disappeared or were even reversed. In fact, when controlling for these medical and behavioral risks, various grades of obesity were associated with an increase in birth weight in both Caucasian and African-American mothers. Previous studies showed a significant association between decreased BMI and increased risk of preterm delivery, and some studies have shown BMIs above the 'normal' range to protect against spontaneous preterm births.[15–17] The effect of obesity on prematurity in our study was surprisingly different in the two racial groups when controlling for associated risks, wherein it seemed protective in African-American but did not affect Caucasian women. Several reports described an interaction between race, obesity and obstetric outcomes. When compared with obese Caucasian women, the risk of cesarean delivery was shown to increase with obesity only in African-American women.[18] In another study, high weight gain during gestation (>0.52 kg per week) was associated with a sixfold increase in risk for spontaneous preterm birth in the African-American population, but had no effect in Caucasian women.[19] Hence, obesity as well as other medical and behavioral risks interact differently with race.

Our results suggest the importance of a heightened degree of vigilance in delivering care to obese and morbidly obese pregnant women, and addressing associated medical complications early and effectively. The goals of weight control during pregnancy itself may be difficult to attain, especially in morbidly obese women, but the control of medical problems commonly associated with obesity such as diabetes and hypertension can minimize adverse maternal and neonatal morbidities.

In this study population, obesity was associated with smoking, anemia, hypertension, diabetes and gravidity. Smoking was associated with an increased incidence of LBW in both Caucasian and African-American pregnant women. Smoking has been shown to increase the risk of preterm deliveries,[20,21] although it seems to affect fetal growth more than gestational duration.[22] Although there is a well-known real health threat to infants born prematurely or with very LBW, there is also a likelihood for smoke-affected infants to have a chronic problem of excess weight and obesity later in life. Studies on the effects of maternal smoking on infant growth are consistent in that there is widespread agreement that infants born to mothers who smoke weigh less at birth compared with infants born to mothers who do not smoke.[23–25] This fetal growth restriction is followed by an accelerated 'catch up' growth rate in the early months after birth. Some studies showed smoke-affected infants to be more likely to be obese than their nonsmoke-affected counterparts from the age of 6 to 14 months.[26]

Maternal hypertension was more likely to occur in morbidly obese and obese mothers; and was associated with an increased risk of LBW and prematurity in both races. This effect on birth weight is thought to be mediated by the cardiovascular influences of insulin resistance and dyslipidemia.[27] Recently, severity of hypertension has been reported to be associated with a high rate of LBW infants and with lower gestational age at delivery when compared with mild gestational hypertension or mild preeclampsia.[28] In our study, we did not control for the severity of hypertension.

The impact of BMI on prematurity is interestingly influenced by race. Obesity was associated with less prematurity in Caucasian but not in African-American mothers, whereas morbid obesity was associated with less prematurity in both races. Although ethnicity is one of the strongest factors known to associate with LBW, reasons for the large ethnic differences in birth weight are unknown.[29] However, it has been shown that the younger the age of African-American mothers the poorer the pregnancy outcomes, compared with Caucasions.[30]

Finally, our study showed an interaction between BMI and parity. Obesity was more common in multiparous women. In a previous large cohort study, obese nulliparous women were at an increased risk of extreme preterm deliveries and neonatal death, whereas obese multiparous women were not at an increased risk for these outcomes.[31] It was hypothesized that the higher

background risk of preeclampsia among nulliparous women might lead to a stronger association between obesity and elective preterm deliveries, and might therefore explain the association between obesity and extreme preterm deliveries among these women. In addition, the risk of hypertension and subsequent premature birth increases with increasing BMI.[27]

Conclusions

Obesity and morbid obesity in pregnant women have been significantly increasing over the past decade. The high risk of pregnancy and birth complications in obese and morbidly obese women is a cause for alarm when considering this significant trend. Obesity and morbid obesity seem to exert their negative effects on gestational age and birth weight through associated risk factors that include hypertension, diabetes and anemia. When controlling for these associated medical conditions in the regression analysis, obesity and morbid obesity were not associated with negative outcomes. Further studies are needed on this growing population to test whether providing adequate prenatal care can control these medical conditions and subsequently ameliorate the rate of prematurity. Our study did not distinguish the effect of obesity on spontaneous versus induced preterm deliveries. It is important to explore in future studies whether these findings pertain to spontaneous and/or induced preterm deliveries.

Conflict of interest

The authors declare no conflict of interest.

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