Pregnancy Complications and Outcomes Among Overweight and Obese Nulliparous Women

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A B S T R A C T

Objectives. This study examined the associations between prepregnancy weight and the risk of pregnancy complications and adverse outcomes among nulliparous women.

Methods. We conducted a population-based cohort study with 96 801 Washington State birth certificates from 1992 to 1996. Women were categorized by body mass index. Multivariate logistic regression was performed.

Results. The rate of occurrence of most of the outcomes increased with increasing body mass index category. Compared with lean women, both overweight and obese women had a significantly increased risk for gestational diabetes, preeclampsia, eclampsia, cesarean delivery, and delivery of a macrosomic infant.

Conclusions. Among nulliparous women, not only prepregnancy obesity but also overweight increases the risk of pregnancy complications and adverse pregnancy outcomes. (*Am J Public Health.* 2001;91:436–440)

In the United States, the prevalence of overweight and obesity has reached epidemic proportions, affecting more than 95 million adults.[1–3] Obesity contributes to significant morbidity and mortality from several conditions, including heart disease, diabetes, and cancer.[4,5] Obesity during pregnancy has been associated with increased risk of fetal macrosomia and medical complications, including pregnancy-induced hypertension, gestational diabetes, and cesarean delivery.[6–9]

A recent study from Sweden showed that higher maternal prepregnancy body mass index (BMI), a measure of weight for height, was associated with an increased risk of adverse pregnancy outcomes.[10] The effect differed by parity status, with greater risk of some outcomes, including late fetal death and delivery at or before 32 weeks' gestation, for pregnancies to nulliparous women. The risk of late fetal death was increased for both obese (BMI≥30.0) and overweight (BMI=25.0–29.9) women compared with women categorized as lean (BMI< 20.0), suggesting that not only prepregnancy obesity but also prepregnancy overweight may carry some risk.

Many factors associated with perinatal morbidity and mortality are not amenable to intervention. Recent epidemiologic findings indicate that weight control may offer the potential for affecting gestational outcomes, especially among women planning a first pregnancy.[10] With this in mind, we conducted a population-based cohort study of the effect of maternal prepregnancy obesity or overweight on pregnancy complications and adverse pregnancy outcomes.

Methods

Since 1992, Washington State birth certificates have recorded maternal prepregnancy weight. Self-reported height was obtained from Washington State drivers' license records for 1992 through 1997. Prepregnancy

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BMI was calculated as weight in kilograms divided by the square of the height in meters. Women were categorized as lean (BMI < 20.0), normal (BMI = 20.0–24.9), overweight (BMI = 25.0–29.9), or obese (BMI ≥ 30.0).[11]

Data were collected from Washington State birth certificate tapes for 1992 through 1996. The birth certificate uses a check-box format to detail demographic characteristics, pregnancy complications, obstetric procedures, and conditions of the newborn. For characteristics not suitable for a check-box format, a write-in format is used. Birth certificates are completed by trained medical records staff with information abstracted from patient records, which may include worksheets completed by staff and patients. Information on infant death was obtained from computerized death certificates. Outcome variables included low birthweight (<2500 g), fetal macrosomia (≥4000 g), small for gestational age (less than the sex-specific 10th percentile),[12] preterm delivery (<37 weeks' gestation), very preterm delivery (≤32 weeks' gestation), cesarean delivery, and infant death (within the first year). We were unable to include fetal death as an outcome because the birth certificate database includes only live births.

Conventionally, nulliparity is defined as no delivery of an infant (live or dead) beyond 24 weeks' gestation or 500 g.[13] Because Washington State birth certificates document only previous live births and terminations before and after 20 weeks' gestation, we were unable to conform to this definition. We defined nulliparous women as those reporting no previous live births. Only 1085 (1.1%) of the final study population reported a previous termination at more than 20 weeks. Analyses including and excluding these women were essentially identical, and these women were included in the final analyses.

We performed multiple logistic regression analysis with SPSS, Version 8.0 (SPSS, Inc, Chicago, Ill), to evaluate the association between prepregnancy BMI and pregnancy complications and adverse pregnancy outcomes. Some models excluded women with hypertensive or diabetic conditions. All estimates were adjusted for the following potential confounders: maternal age (<20, 20–29, or ≥30 years), marital status (married or unmarried), educational level (did or did not complete high school), smoking during pregnancy (yes or no), trimester prenatal care began, and payer of prenatal care (Medicaid or charity vs self-pay, health maintenance organization, or commercial insurance). Some estimates also adjusted for weight gain during pregnancy. Because ideal weight gain probably differs by prepregnancy BMI,[14] we used the 1990 Institute of Medicine guidelines for maternal weight gain during pregnancy to assess this variable.[15] These guidelines recommended total pregnancy weight gain of 28 to 40 lb for women with a BMI of less than 19.8, 25 to 35 lb for women with a BMI of 19.8 to 26.0, and 15 to 25 lb for women with a BMI of 26.1 to 29.0. Women with a BMI greater than 29.0 were advised to gain at least 15 lb, and epidemiologic investigations have suggested 15 to 25 lb as an appropriate range for these women.[9] We categorized women as below, within, or above these recommended ranges.

Results

A total of 159 072 singleton births to nulliparous women were recorded in Washington State between 1992 and 1996. We were able to calculate prepregnancy BMI for 96 801 (60.9%) of these births. By BMI category, 18 988 (19.6%) were to women characterized as lean, 50 425 (52.1%) were to women characterized as normal weight, 17 571 (18.2%) were to women characterized as overweight, and 9817 (10.1%) were to women characterized as obese.

Women in the lowest BMI category tended to be younger than women in the other categories and were less likely to have completed high school and to be married (Table 1). They were more likely to be Asian and less likely to be White or African American.

The proportion of women who developed gestational diabetes, preeclampsia, or eclampsia consistently increased with BMI (Table 2). After potential confounders were controlled for, obese and overweight women were at significantly increased risk for each of these outcomes compared with lean women. Women categorized as having normal prepregnancy BMI had slightly elevated risks of these pregnancy complications.

Compared with lean women, women with normal BMI were slightly less likely to deliver a low-birthweight (<2500 g) infant, and obese, overweight, and normal-weight women were each slightly less likely to deliver a small-for-gestational-age (<10th percentile) infant and were each more likely to deliver a macrosomic infant (≥4000 g) (Table 3). Obese and overweight women were at elevated risk for delivering prematurely (<37 weeks' gestation) and very prematurely (≤32 weeks' gestation) compared with lean women, although only the risk for obese women of very premature delivery was more than marginal. The risk of cesarean delivery increased with each level of increasing BMI. The risk of infant death within 1 year of birth was significantly higher for obese women than for lean women.

To determine the contribution of gestational diabetes, preeclampsia, eclampsia, or prepregnancy diabetes or hypertension to the risk of adverse pregnancy outcomes, we calculated risk estimates, excluding 9560 women with any of these conditions. The estimates were similar to those calculated with these women included (Table 3).

Separate analyses were performed for White, African American, Native American, Asian, and Hispanic women. The strength of the associations was generally similar for each of these groups when compared with the results for all races/ethnicities (data not shown), although small numbers in each of the non-White categories limit the inferences that can be drawn for these groups.

We evaluated the possibility of selection bias by comparing the rates of complications and adverse outcomes between those women with and those women without BMI data. In logistic regression models similar to those shown in Tables 2 and 3, except that pregnancy weight gain was not adjusted for (because these data often were missing for women without data on prepregnancy weight), substantial differences were not present (odds ratios = 0.8–1.3), although women with BMI data were at reduced risk for very preterm delivery (adjusted odds ratio = 0.5; 95% confidence interval = 0.5, 0.6).

Discussion

Our results confirmed that obesity is a strong risk factor for pregnancy complications and adverse outcomes. Importantly, not only obese women (prepregnancy BMI ≥ 30.0) but also overweight women (prepregnancy BMI = 25.0–29.9) had a markedly increased risk for gestational diabetes, preeclampsia, and eclampsia compared with women with a prepregnancy BMI of less than 20.0. There were consistent increases in the risk of gestational diabetes, preeclampsia, eclampsia, cesarean delivery, and delivery of a macrosomic infant for women in each category of BMI of 20.0 or greater, with women defined as having normal BMI before pregnancy even showing increased risks compared with lean women. Higher BMI was inversely associated with delivery of a small-for-gestational-age infant. Obese and overweight women were at increased risk for delivering at or before 32 weeks' gestation and were slightly more likely to deliver before 37 weeks. Infants born to obese women had a nearly 2-fold increased risk of death within the first year of life.

We used population-based registry data, and our analysis achieved good statistical power and minimized selection bias. Although we were unable to calculate maternal BMI for 39.1% of our potential study population, the

TABLE 1—Demographic Characteristics and Obstetric History, by Maternal Prepregnancy Body Mass Index (BMI)

	Maternal Prepregnancy BMI			
	<20.0 (n = 18 988), n (%)	20.0–24.9 (n = 50 425), n (%)	25.0–29.9 (n = 17 571), n (%)	≥30.0 (n = 9817), n (%)
Mother's age, y				
<20	5274 (27.8)	10 425 (20.7)	3359 (19.1)	1374 (14.0)
20–29	10 063 (53.0)	27 777 (55.1)	10 173 (57.9)	6184 (63.0)
≥30	3649 (19.2)	12 222 (24.2)	4037 (23.0)	2259 (23.0)
Marital status				
Married	11 685 (61.5)	34 559 (68.5)	11 842 (67.4)	6561 (66.8)
Unmarried	7284 (38.4)	15 827 (31.4)	5714 (32.5)	3248 (33.1)
Mother's education				
<High school	3857 (20.3)	7619 (15.1)	2697 (15.3)	1224 (12.5)
High school graduate	13 639 (71.8)	39 490 (78.3)	13 797 (78.5)	8063 (82.1)
Smoking during pregnancy				
Yes	3494 (18.4)	7340 (14.6)	2911 (16.6)	1821 (18.5)
No	15 259 (80.4)	42 529 (84.3)	14 509 (82.6)	7902 (80.5)
Trimester prenatal care began				
First	14 969 (78.8)	41 634 (82.6)	14 517 (82.6)	8217 (83.7)
Second	2885 (15.2)	6248 (12.4)	2240 (12.7)	1145 (11.7)
Third	436 (2.3)	997 (2.0)	332 (1.9)	182 (1.9)
Prenatal care payer				
Medicaid or charity	6913 (36.4)	15 284 (30.3)	5759 (32.8)	3427 (34.9)
Self-pay, commercial insurance, or health maintenance organization	9354 (49.3)	28 144 (55.8)	9261 (52.7)	5124 (52.2)
Weight gain during pregnancy[a]				
Below	4594 (24.2)	7445 (14.8)	1539 (8.8)	1455 (14.8)
Within	8962 (47.2)	20 672 (41.0)	4410 (25.1)	2708 (27.6)
Above	4851 (25.5)	21 069 (41.8)	11 147 (63.4)	5338 (54.4)
Mother's race/ethnicity				
White	14 574 (76.8)	41 065 (81.4)	14 357 (81.7)	8246 (84.0)
African American	499 (2.6)	1407 (2.8)	633 (3.6)	427 (4.3)
Native American	321 (1.7)	877 (1.7)	418 (2.4)	231 (2.4)
Asian	2269 (11.9)	2971 (5.9)	614 (3.5)	186 (1.9)
Hispanic	945 (5.0)	3183 (6.3)	1277 (7.3)	584 (5.9)

[a]Weight gain during pregnancy below, within, or above 1990 Institute of Medicine recommended ranges for prepregnancy BMI.[15]

TABLE 2—Adjusted Odds of Pregnancy Complications, by Maternal Prepregnancy Body Mass Index (BMI)

	n/Total (%)	Odds Ratio (95% CI)[a]
Gestational diabetes		
BMI ≥ 30.0	579/9731 (6.0)	5.2 (4.3, 6.2)
BMI 25.0–29.9	464/17 438 (2.7)	2.4 (2.0, 2.9)
BMI 20.0–24.9	777/50 097 (1.6)	1.3 (1.1, 1.5)
BMI < 20.0[b]	231/18 878 (1.2)	1.0
Preeclampsia		
BMI ≥ 30.0	1321/9778 (13.5)	3.3 (3.0, 3.7)
BMI 25.0–29.9	1594/17 501 (9.1)	2.0 (1.8, 2.2)
BMI 20.0–24.9	2866/50 212 (5.7)	1.3 (1.2, 1.5)
BMI < 20.0[b]	731/18 893 (3.9)	1.0
Eclampsia		
BMI ≥ 30.0	119/9778 (1.2)	3.0 (2.1, 4.4)
BMI 25.0–29.9	145/17 501 (0.8)	2.0 (1.4, 2.9)
BMI 20.0–24.9	258/50 212 (0.5)	1.4 (1.0, 2.0)
BMI < 20.0[b]	68/18 893 (0.4)	1.0

Note. CI = confidence interval.
[a]Logistic regression adjusted for maternal age (<20, 20–29, or ≥30 years), smoking during pregnancy (yes or no), educational level (did or did not complete high school), marital status (unmarried or married), trimester prenatal care began (first, second, or third), payer of prenatal care (Medicaid or charity vs self-pay, health maintenance organization, or commercial insurance), and weight gain during pregnancy (below, within, or above Institute of Medicine ranges detailed in the "Methods" section).
[b]The women in this category served as the reference group.

risk of most of the outcomes we investigated was similar for women with and without BMI information, suggesting that our study population was representative.

Although birth certificates in Washington State are completed from patient medical records, it is unclear what proportion of the weight entries were from a prepregnancy visit and what proportion were self-reported at the time of delivery. Self-reported weights tend to be underestimates of true weights, and the degree of underestimation may be greater for women of higher weight.[16] In our study, these underestimates would lead to misclassification of risk exposure only among women whose amount of underestimation caused them to enter a different BMI category and would tend to underestimate the strength of the true association, especially for overweight and obese women. Height is generally accurately self-reported,[16] and driver's license files are a valid source of information for height.[17]

Incomplete recording of outcomes on birth certificates would also lead to misclassification, although the check-box format of

TABLE 3—Risk of Adverse Pregnancy Outcomes, by Maternal Prepregnancy Body Mass Index (BMI), in All Women and Among Women Without Pregestational or Gestational Medical Complications[a]

	n/Total (%)	All Women, Odds Ratio (95% CI)	Women Without Complications, Odds Ratio (95% CI)[b]
Low birthweight, <2500 g			
BMI ≥ 30.0	469/9806 (4.8)	1.1 (0.9, 1.2)	0.8 (0.8, 0.9)
BMI 25.0–29.9	695/17 547 (4.0)	1.0 (0.9, 1.1)	0.9 (0.8, 1.1)
BMI 20.0–24.9	2067/50 378 (4.1)	0.8 (0.8, 0.9)	0.8 (0.8, 1.0)
BMI < 20.0[c]	1103/18 957 (5.8)	1.0	1.0
Small for gestational age			
BMI ≥ 30.0	538/9626 (5.6)	0.8 (0.8, 0.9)	0.7 (0.6, 0.8)
BMI 25.0–29.9	881/17 210 (5.1)	0.8 (0.7, 0.9)	0.8 (0.7, 0.9)
BMI 20.0–24.9	3009/49 282 (6.1)	0.8 (0.7, 0.9)	0.8 (0.7, 0.9)
BMI < 20.0[c]	1609/18 511 (8.7)	1.0	1.0
Macrosomia, ≥4000 g			
BMI ≥ 30.0	1699/9806 (17.3)	2.1 (1.9, 2.3)	2.1 (1.9, 2.4)
BMI 25.0–29.9	2542/17 547 (14.5)	1.5 (1.4, 1.6)	1.5 (1.4, 1.6)
BMI 20.0–24.9	5370/50 378 (10.7)	1.2 (1.2, 1.3)	1.2 (1.2, 1.3)
BMI < 20.0[c]	1356/18 957 (7.2)	1.0	1.0
Delivery <37 weeks			
BMI ≥ 30.0	662/9635 (6.9)	1.3 (1.2, 1.5)	1.1 (1.0, 1.3)
BMI 25.0–29.9	997/17 233 (5.8)	1.2 (1.1, 1.3)	1.2 (1.0, 1.3)
BMI 20.0–24.9	2642/49 321 (5.4)	0.9 (0.9, 1.0)	0.9 (0.8, 1.0)
BMI < 20.0[c]	1208/18 551 (6.5)	1.0	1.0
Delivery ≤32 weeks			
BMI ≥ 30.0	117/9635 (1.2)	1.6 (1.2, 2.1)	1.5 (1.1, 2.1)
BMI 25.0–29.9	144/17 233 (0.8)	1.3 (1.0, 1.7)	1.3 (1.0, 1.8)
BMI 20.0–24.9	408/49 321 (0.8)	1.0 (0.8, 1.2)	1.0 (0.8, 1.3)
BMI < 20.0[c]	184/18 551 (1.0)	1.0	1.0
Cesarean delivery			
BMI ≥ 30.0	3142/9817 (32.0)	2.9 (2.7, 3.1)	2.7 (2.5, 2.9)
BMI 25.0–29.9	4084/17 571 (23.2)	1.8 (1.7, 2.0)	1.8 (1.6, 1.9)
BMI 20.0–24.9	8346/50 425 (16.6)	1.3 (1.2, 1.4)	1.3 (1.2, 1.3)
BMI < 20.0[c]	2384/18 988 (12.6)	1.0	1.0
Infant death			
BMI ≥ 30.0	59/9817 (0.6)	1.9 (1.2, 2.8)	2.0 (1.2, 3.1)
BMI 25.0–29.9	74/17 571 (0.4)	1.3 (0.8, 1.9)	1.5 (1.0, 2.3)
BMI 20.0–24.9	191/50 425 (0.4)	1.0 (0.7, 1.4)	1.1 (0.8, 1.6)
BMI < 20.0[c]	82/18 906 (0.4)	1.0	1.0

Note. CI = confidence interval.
[a]Logistic regression adjusted for maternal age (<20, 20–29, or ≥30 years), smoking during pregnancy (yes or no), educational level (did or did not complete high school), marital status (unmarried or married), trimester prenatal care began (first, second, or third), payer of prenatal care (Medicaid or charity vs self-pay, health maintenance organization, or commercial insurance), and weight gain during pregnancy (below, within, or above Institute of Medicine ranges detailed in the "Methods" section).
[b]Analysis excludes women with chronic hypertension, pregestational and gestational diabetes, preeclampsia, and eclampsia.
[c]The women in this category served as the reference group.

the Washington State birth certificate has high sensitivity for detecting pregnancy complications.[18] Differential reporting of outcomes by maternal BMI could lead to bias in our results. Although we controlled for several potential confounding factors, our risk estimates still may be biased. Socioeconomic status may be related to both maternal obesity and pregnancy complications. We approximated socioeconomic status by including maternal education, marital status, and payment source for prenatal care as covariates in our analyses, but these variables may not fully reflect socioeconomic status.

Because the Washington State birth certificate database records only live births, we were unable to assess the risk of fetal death in relation to maternal BMI. Limited numbers prevented complete examination of the risk profiles for different racial/ethnic groups, although risk estimates tended to be similar among those groups considered.

Our results were consistent with the findings of previous studies. Massive obesity (BMI ≥ 35) before or during pregnancy is a known risk factor for developing gestational diabetes and hypertension.[19] Obese women consistently have been shown to be at increased risk for cesarean delivery compared with nonobese women.[20,21] The greater rate of very early (≤32 weeks' gestation) delivery for obese women confirmed the 1998 findings of Cnattingius and colleagues,[10] who reported a 60% increased risk for these women compared with lean women (95% confidence interval = 1.1, 2.3).

The underlying biological mechanisms for the positive association between obesity and the risk of delivering prematurely are not understood. Heavy individuals often have sedentary lifestyles, which have been associated with increased risk of preterm birth.[22] The strong relation between obesity and maternal complications of pregnancy (gestational diabetes, preeclampsia, eclampsia) could potentially explain the higher rates of fetal macrosomia, cesarean delivery, and very early delivery for obese and overweight women in our study. However, increased risk of adverse outcomes remained after excluding women with pregestational or gestational diabetes or hypertension.

The risk profile observed in this study for women who, according to current definitions, are overweight but not obese has not been documented previously. Given that more than one third of American women of childbearing age are overweight and that this prevalence is increasing rapidly among younger women,[2,4,23] our findings are of public health importance. Our results reinforce current recommendations to avoid excessive weight gain during adolescence and early adulthood,[24] before a first pregnancy. Maternal overweight is one of the few risk factors for poor gestational outcomes amenable to modification before a pregnancy, and this study further strengthens the arguments for weight control to improve the health status of populations in the United States. □

Contributors

J. M. Baeten designed and completed the statistical analysis and compiled the paper. E. A. Bukusi designed and completed the statistical analysis. M. Lambe conceptualized the study and advised the analysis and interpretation. All authors contributed to the writing of the paper.

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References

1. Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults: the National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA.* 1994;272:205–211.
2. Taubes G. As obesity rates rise, experts struggle to explain why. *Science.* 1998;280: 1367–1368.
3. Bray GA. Obesity: a time bomb to be defused. *Lancet.* 1998;352:160–161.
4. Kuczmarski RJ, Carroll MD, Flegal KM, Troiano RP. Varying body mass index cutoff points to describe overweight prevalence among US adults: NHANES III (1988 to 1994). *Obes Res.* 1997;5:542–548.
5. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW Jr. Body-mass index and mortality in a prospective cohort of US adults. *N Engl J Med.* 1999;341:1097–1105.
6. Gross T, Sokol RJ, King KC. Obesity in pregnancy: risks and outcome. *Obstet Gynecol.* 1980; 56:446–450.
7. Wolfe HM, Zador IE, Gross TL, Martier SS, Sokol RJ. The clinical utility of maternal body mass index in pregnancy. *Am J Obstet Gynecol.* 1991; 164:1306–1310.
8. Johnson JWC, Longmate JA, Frentzen B. Excessive maternal weight and pregnancy outcome. *Am J Obstet Gynecol.* 1992;167:353–370.
9. Edwards LE, Hellerstedt WL, Alton IR, Story M, Himes JH. Pregnancy complications and birth outcomes in obese and normal-weight women: effects of gestational weight change. *Obstet Gynecol.* 1996;87:389–394.
10. Cnattingius S, Bergström R, Lipworth L, Kramer MS. Prepregnancy weight and the risk of adverse pregnancy outcomes. *N Engl J Med.* 1998;338:147–152.
11. National Heart, Lung, and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. Available at: http://www.nhlbi.nih.gov/guidelines/obesity/ob_gdlns.pdf. Accessed November 27, 2000.
12. Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M. Fetal growth and perinatal viability in California. *Obstet Gynecol.* 1982;59:624–632.
13. Paverstein C, ed. *Clinical Obstetrics*. New York, NY: John Wiley & Sons; 1987.
14. Abrams B. Weight gain and energy intake during pregnancy. *Clin Obstet Gynecol.* 1994;37: 515–527.
15. Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy. *Nutrition During Pregnancy*. Washington, DC: National Academy Press; 1990.
16. Rowland ML. Self-reported weight and height. *Am J Clin Nutr.* 1990;52:1125–1133.
17. Le Marchand L, Yoshizawa CN, Nomura AMY. Validation of body size information on driver's licenses. *Am J Epidemiol.* 1988;128: 874–877.
18. Frost F, Starzyk P, George S, McLaughlin JF. Birth complication reporting: the effect of birth certificate design. *Am J Public Health.* 1984;74: 505–506.
19. Edwards LE, Dickes WF, Alton IR, Hakanson EY. Pregnancy in the massively obese: course, outcome, and obesity prognosis of the infant. *Am J Obstet Gynecol.* 1978;131:479–483.
20. Crane SS, Wojtowycz MA, Dye TD, Aubry RH, Artal R. Association between pre-pregnancy obesity and the risk of cesarean delivery. *Obstet Gynecol.* 1997;89:213–216.
21. Bianco AT, Smilen SW, Davis Y, Lopez S, Lapinski R, Lockwood CJ. Pregnancy outcome and weight gain recommendations for the morbidly obese woman. *Obstet Gynecol.* 1998;91: 97–102.
22. Misra DP, Strobino DM, Stashinko EE, Nagey DA, Nanda J. Effects of physical activity on preterm birth. *Am J Epidemiol.* 1998;147:628–635.
23. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991–1998. *JAMA.* 1999;282:1519–1522.
24. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. *N Engl J Med.* 1999;341: 427–434.