The Effect of Gestational Weight Gain by Body Mass Index on Maternal and Neonatal Outcomes

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Abstract

Objective: To evaluate the effects of gestational weight gain on maternal and neonatal outcomes in different body mass index (BMI) classes.

Methods: We compared maternal and neonatal outcomes based on gestational weight gain in underweight, normal weight, overweight, obese, and morbidly obese (BMI ≥ 40.00) women. The study group was a population-based cohort of women with singleton gestations who delivered between April 1, 2001, and March 31, 2007, drawn from the Newfoundland and Labrador Provincial Perinatal Program Database. Univariate analyses and multivariate logistic regression analyses (controlling for maternal age, parity, smoking status, partnered status, and gestational age) were performed and odds ratios (ORs) were calculated.

Results: Only 30.6% of women gained the recommended amount of weight during pregnancy; 52.3% of women gained more than recommended, and 17.1% gained less than recommended. In women with normal pre-pregnancy BMI, excess weight gain was associated with increased rates of gestational hypertension (OR 1.27; 95% CI 1.08–1.49), augmentation of labour (OR 1.09; 95% CI 1.01–1.18), and birth weight ≥ 4000 g (OR 1.21; 95% CI 1.10–1.34). In overweight women, excess weight gain was associated with increased rates of gestational hypertension (OR 1.31; 95% CI 1.10–1.55) and birth weight ≥ 4000 g (OR 1.30; 95% CI 1.15–1.47). In women who were obese or morbidly obese, excess weight gain was associated with increased rates of birth weight ≥ 4000 g (OR 1.20; 95% CI 1.07–1.34) and neonatal metabolic abnormality (OR 1.31; 95% CI 1.00–1.70). In morbidly obese women, poor weight gain was associated with less use of epidural analgesia (OR 0.34; 95% CI 0.12–0.95). In women who were of normal weight, overweight, or obese, the rate of adverse outcome (Caesarean section, gestational hypertension, birth weight < 2500 g or birth weight ≥ 4000 g) was lower in women with recommended weight gain than in those with excess weight gain. Adverse outcomes were reduced in nulliparous morbidly obese women who had poor weight gain (OR 0.18; 95% CI 0.04–0.83).

Conclusion: The effects of gestational weight gain on pregnancy outcome depend on the woman's pre-pregnancy BMI. Pregnancy weight gains of 6.7–11.2 kg (15–25lb) in overweight and obese women, and less than 6.7 kg (15lb) in morbidly obese women are associated with a reduction in the risk of adverse outcome.

Key Words: Gestational weight gain, obesity, body mass index, pregnancy, maternal outcome, neonatal outcome

Competing Interests: None declared.

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Résumé

Objectif : Évaluer les effets du gain pondéral gestationnel sur les issues maternelles et néonatales, selon différentes catégories d'indice de masse corporelle (IMC).

Méthodes : Nous avons comparé les issues maternelles et néonatales en fonction du gain pondéral gestationnel chez des femmes présentant une insuffisance pondérale, un poids normal, une surcharge pondérale, une obésité ou une obésité morbide (IMC ≥ 40,00). Le groupe d'étude était une cohorte de femmes en population générale dont la grossesse monofœtale avait donné lieu à un accouchement entre le 1er avril 2001 et le 31 mars 2007; cette cohorte était tirée de la *Newfoundland and Labrador Provincial Perinatal Program Database*. Des analyses univariées et des analyses de régression logistique multivariées (l'effet de l'âge maternel, de la parité, de la situation quant au tabagisme, de la situation quant à la vie de couple et de l'âge gestationnelle ayant été neutralisé) ont été menées, et des rapports de cotes (RC) ont été calculés.

Résultats : Seulement 30,6 % des femmes ont connu le gain pondéral recommandé pendant la grossesse; 52,3 % des femmes ont connu un gain pondéral supérieur à ce qui était recommandé et 17,1 % en ont connu un qui était inférieur à ce qui était recommandé. Chez les femmes dont l'IMC prégrossesse était normal, le gain pondéral excessif était associé à une hausse des taux d'hypertension gestationnelle (RC, 1,27; IC à 95 %, 1,08–1,49), d'accélération du travail (RC, 1,09; IC à 95 %, 1,01–1,18) et de poids de naissance ≥ 4 000 g (RC, 1,21; IC à 95 %, 1,10–1,34). Chez les femmes présentant une surcharge pondérale, le gain pondéral excessif était associé à une hausse des taux d'hypertension gestationnelle (RC, 1,31; IC à 95 %, 1,10–1,55) et de poids de naissance ≥ 4 000 g (RC, 1,30; IC à 95 %, 1,15–1,47). Chez les femmes présentant une obésité ou une obésité morbide, le gain pondéral excessif était associé à une hausse des taux de poids de naissance ≥ 4 000 g (RC, 1,20; IC à 95 %, 1,07–1,34) et d'anomalie métabolique néonatale (RC, 1,31; IC à 95 %, 1,00–1,70). Chez les femmes présentant une obésité morbide, le faible gain pondéral était associé à une utilisation moindre de l'analgésie péridurale (RC, 0,34; IC à 95 %, 0,12–0,95). Chez les femmes présentant un poids normal, une surcharge pondérale ou une obésité, lorsque le gain pondéral recommandé était respecté, le taux d'issue indésirable (césarienne, hypertension gestationnelle, poids de naissance < 2 500 g ou poids de naissance ≥ 4 000 g) était plus faible qu'en présence d'un gain pondéral excessif. Les issues indésirables étaient atténuées chez les nullipares présentant une obésité

morbide qui avaient connu un faible gain pondéral (RC, 0,18; IC à 95 %, 0,04–0,83).

Conclusion : Les effets du gain pondéral gestationnel sur l'issue de grossesse sont fonction de l'IMC prégrossesse de la patiente. Les gains pondéraux gestationnels de 6,7–11,2 kg (15–25 lb), chez les femmes qui présentent une surcharge pondérale ou une obésité, et inférieurs à 6,7 kg (15 lb), chez les femmes qui présentent une obésité morbide, sont associés à une atténuation du risque d'issue indésirable.

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INTRODUCTION

Obesity is becoming an increasingly common problem, both in the general population and in women of reproductive age.[1] Obesity in pregnant women increases the risk of maternal and perinatal complications.[1–5] In 1990, the Institute of Medicine in the United States recommended that weight gain during pregnancy be based on pre-pregnancy BMI. For women with a BMI < 19.8 kg/m^2, a weight gain of 28–40 lb was recommended; with a BMI 19.8–24.9 kg/m^2, a weight gain of 25–35 lb; with a BMI 25.0–29.9 kg/m^2, a weight gain of 15–25 lb; and with a BMI > 29.9 kg/m^2, a weight gain of at least 15 lb with no upper limit.[6] However, there was limited information on weight gain in obese women at that time. The American College of Obstetricians and Gynecologists adopted these recommendations.[3] Since these recommendations were initially made, the prevalence of obesity during pregnancy has increased.[7] In 2006, those present at the Institute of Medicine conference on the influence of pre-pregnancy weight on maternal and child health concluded that further research is needed on the effect of weight gain in pregnancy.[8] Some investigators have agreed with the Institute of Medicine's initial recommendations for gestational weight gain,[4,9,10] but more recent studies have recommended lower gestational weight gains.[11–13] The objective of our study was to evaluate the effects of gestational weight gain on maternal and perinatal outcomes in women according to their pre-pregnancy BMI.

MATERIALS AND METHODS

We performed a population-based cohort study of women with singleton pregnancies who delivered between April 1, 2001, and March 31, 2007, in the Eastern Health–Avalon Region of the province of Newfoundland and Labrador. The cohort was identified using the Newfoundland and Labrador Provincial Perinatal Program Database. This computerized database collects information on pregnancy outcomes for several regions of Newfoundland and Labrador. Data have been collected for the Eastern Avalon region (including the Women's Health Centre of Eastern Health, the tertiary care referral centre for the province) since April 1, 2001. Data collected include demographic information, antenatal, intrapartum, and postpartum events, and perinatal outcomes for deliveries of every pregnancy of at least 20 weeks' gestation. Quality assurance and data quality were ensured through the NLPPP Database's routine edit checking process on all extracted data. The study was limited to residents of the Eastern Avalon region to avoid referral bias. Women were excluded from the study if their pre-pregnancy BMI or gestational weight gain was not recorded. Pre-pregnancy BMI was based on self-reported height and weight. Gestational weight gain was the difference between maternal weight at delivery, or the last prenatal visit, and pre-pregnancy weight. Pre-pregnancy BMIs were divided into categories based on Health Canada guidelines and World Health Organization recommendations. These categories were: underweight (BMI < 18.50 kg/m^2), normal weight (BMI 18.50–24.99 kg/m^2), overweight (BMI 25.00–29.99 kg/m^2), obese (BMI 30.00–39.99 kg/m^2), and morbidly obese (BMI ≥ 40.00 kg/m^2).[14] The category of morbid obesity was based on the National Institutes of Health guidelines for class III obesity.[15] Recommended gestational weight gains were based on Health Canada recommendations (adapted from the Institute of Medicine): for women with BMI < 20.00 kg/m^2, a gain of 12.5–18 kg (28–40 lbs); with BMI 20.00–27.00 kg/m^2, a gain of 11.5–16 kg (25–35 lbs); and with BMI > 27.00 kg/m^2, a gain of 7.0–11.5 Kg (15–25 lbs).[16]

Maternal characteristics including maternal age, parity, partnered status, smoking status during pregnancy, preconception folic acid use, and pre-gestational diabetes were described and compared in the BMI groups. Maternal outcomes evaluated included CS, gestational hypertension, gestational diabetes, induction of labour, augmentation of labour, epidural use (excluding elective CS), prostaglandin use for cervical ripening among those undergoing labour induction, operative vaginal delivery, shoulder dystocia, third- and fourth-degree tears, and length of stay > 3 and > 5 days (excluding all deliveries by CS). Gestational hypertension was defined according to the Canadian Hypertension Society as a diastolic blood pressure ≥ 90mm Hg on at least two measurements at least four hours apart.[17] Neonatal outcomes evaluated included gestational age at delivery, preterm birth < 34 and < 37 weeks of gestation, birth weight (including birth weight < 2500 g, birth weight

ABBREVIATIONS

BMI	body mass index
CI	confidence interval
CS	Caesarean section
NICU	neonatal intensive care unit
NLPPP	Newfoundland and Labrador Provincial Perinatal Program
OR	odds ratio

Table 1. Demographic data

	Normal weight n = 2489	Under weight n = 160	*P*	Overweight n = 1418	*P**	Obese n = 1077	*P*†	Morbidly obese n = 233	*P*‡	Obese and morbidly obese n = 1310	*P*§
% Total population	46.29%	2.98%		26.37%		20.03%		4.33%		24.36%	
Age–yrs‖	29.40 (5.32)	26.00 (5.77)	< 0.001	30.13 (4.86)	< 0.001	29.77 (4.55)	0.036	29.72 (4.51)	0.31	29.76 (4.58)	0.03
Nulliparous	54.76%	58.13%	0.41	51.87%	0.08	49.86%	0.007	50.21%	0.18	49.92%	0.004
Partnered	69.86%	52.67%	< 0.001	75.88%	< 0.001	73.79%	0.02	76.92%	0.028	74.34%	0.005
Smoker	13.42%	34.59%	< 0.001	13.86%	0.70	13.48%	0.97	17.17%	0.11	14.13%	0.55
Folic acid	77.27%	64.71%	< 0.001	79.27%	0.16	76.29%	0.54	76.74%	0.86	76.37%	0.55
Pre-existing diabetes	0.52%	0%	1.00	0.56%	0.86	1.49%	0.003	0.86%	0.37	1.37%	0.006

*Normal weight versus overweight

†Normal weight versus obese

‡Normal weight versus morbidly obese

§Normal weight versus (obese and morbidly obese)

‖Mean (standard deviation)

≥ 4000 g, and birth weight ≥ 4500 g), Apgar score at one and five minutes, bag and mask ventilation at neonatal resuscitation, sepsis, intraventricular hemorrhage, respiratory distress syndrome, necrotizing enterocolitis, neonatal seizure, neonatal metabolic abnormality (including hypoglycemia, hypomagnesemia, and hypocalcemia), NICU admission, malpresentation (non-cephalic presentation), congenital malformations, and stillbirth. A composite adverse outcome was also evaluated, including any one of delivery by CS, gestational hypertension, birth weight < 2500 g or birth weight ≥ 4000 g. Outcomes were based on international classification of diseases (ICD) 10 coding.[18]

Statistical analysis was performed using SPSS for Windows version 15.0, (SPSS Inc., Chicago IL) and PEPI 3.01, 2000 (Computer Programs for Epidemiologists, Stone Mountain, GA). Descriptive statistics were used for the BMI groups. Univariate analyses including chi-square and Fisher exact tests were used to compare dichotomous outcomes among the BMI groups, and Student *t* test and analysis of variance were used to compare continuous outcomes. Multiple logistic regression models were used to evaluate outcomes, controlling for maternal age, parity, smoking status, partnered status, and gestational age (for outcomes other than gestational age at delivery). For multivariate analyses, comparisons were made between recommended weight gain, less than recommended weight gain, and more than recommended weight gain in each BMI class. Adjusted OR and 95% CI were calculated. A value of $P < 0.05$ was considered significant. A trend was noted if the *P* value was between 0.05 and 0.075. The number of women with more or less than recommended weight gain resulting in one extra or one less case of the composite adverse outcome was calculated.

Ethics approval for the study was obtained from the Human Investigation Committee of Memorial University and the Women's Health Centre of Eastern Health.

RESULTS

The database contained the records of 11 243 women, and, of these, 5377 women met all inclusion criteria and were included in the study: 160 (3.0%) were underweight, 2489 (46.3%) were of normal weight, 1418 (26.4%) were overweight, 1077 (20.0%) were obese (BMI 30.00–39.99 kg/m^2), and 233 (4.3%) were morbidly obese (BMI ≥ 40.00 kg/m^2). Only 30.6% of women had gained the recommended amount of weight, with 17.1% gaining less than recommended, and 52.3% gaining more than recommended. Within each BMI category, excess weight gain occurred: 48.7% of women with normal BMI, 58.7% of overweight women, and 67.0% of obese or morbidly obese women recorded excess weight gain. Overweight and obese women were more likely to gain excess weight than were women with a normal BMI ($P < 0.001$).

The demographic characteristics of each BMI class are summarized in Table 1. Overweight and obese women were older and more likely to have a partner than women with a normal BMI. Obese women were also less likely to be nulliparous than women with a normal BMI.

The results of the univariate analyses for maternal outcomes are summarized in Table 2, and neonatal outcomes are described in Table 3. A variety of maternal and neonatal

Table 2. Maternal outcomes by pre-pregnancy BMI class

	Normal weight, %	Under weight, %	*P*	Over weight %	*P**	Obese, %	*P*†	Morbidly obese, %	*P*‡	Obese and morbidly obese, %	*P*§
Gestational HTN	4.66	2.50	0.20	9.38	< 0.001	18.94	< 0.001	20.17	< 0.001	19.16	< 0.001
GDM	1.65	2.50	0.42	3.10	0.003	6.31	< 0.001	11.59	< 0.001	7.25	< 0.001
Labour Induced‖	30.19	21.05	0.017	36.71	< 0.001	48.48	< 0.001	50.29	< 0.001	48.78	< 0.001
PG¶	46.92	40.63	0.49	55.68	0.005	60.24	0.001	63.95	0.003	60.88	< 0.001
Augment labour	23.60	20.39	0.37	25.04	0.35	25.12	0.38	34.50	0.001	26.68	0.059
Caesarean section¶	23.78	13.13	0.002	31.10	< 0.001	38.16	< 0.001	50.21	0.001	40.31	0.001
OVD#	17.04	15.11	0.56	18.32	0.39	14.41	0.11	18.10	0.77	14.96	0.19
Epidural‖	53.43	45.39	0.055	59.11	0.002	63.79	< 0.001	74.85	< 0.001	65.63	< 0.001
Shoulder dystocia#	1.11	0	0.39	1.02	0.84	1.35	0.62	6.90	< 0.001	2.17	0.034
3rd/4th degree tear#	2.48	0.72	0.25	3.79	0.049	2.10	0.58	1.72	1.00	2.05	0.50
LOS > 3 days#	26.23	18.71	0.05	28.45	0.20	34.68	< 0.001	34.48	0.051	34.65	< 0.001
LOS > 5 days#	4.91	1.44	0.061	6.55	0.066	9.01	< 0.001	10.34	0.011	9.21	< 0.001

HTN: hypertension; GDM: gestational diabetes mellitus; PG: prostaglandin; OVD: operative vaginal delivery; LOS: length of stay.

*Normal weight versus overweight

†Normal weight versus obese

‡Normal weight versus morbidly obese

§Normal weight versus (obese and morbidly obese)

‖Excluding elective Caesarean sections

¶Among inductions

#Excluding all Caesarean sections

adverse outcomes were seen more frequently in overweight and obese women than in women with a normal BMI.

The multivariate logistic regression analyses are summarized in Tables 4 and 5. In women with a normal BMI, excess weight gain was associated with increased risks of gestational hypertension, augmentation of labour, birth weight ≥ 4000 g, and trends towards higher rates of length of stay > 5 days and neonatal metabolic abnormality. In overweight women, excess weight gain was associated with increased rates of gestational hypertension, birth weight ≥ 4000 g and a trend towards higher rates of induction of labour. In obese and morbidly obese women combined, excess weight gain was associated with increased rates of birth weight ≥ 4000 g, neonatal metabolic abnormality, and a trend towards increased rates of CS. In morbidly obese women, poor weight gain was associated with a lower rate of epidural use and a trend towards a lower rate of labour induction. In women of normal weight, and in overweight and obese women combined, poor weight gain was associated with birth weight < 2500 g. In women of normal weight, overweight women, and obese women, the rate of adverse outcome was increased in women with excess weight gain.

No significant differences in outcome were identified by logistic regression analysis in underweight women with more or less than recommended weight gain. The rates of gestational diabetes, shoulder dystocia, birth weight ≥ 4500 g, Apgar score < 7 at five minutes, bag and mask ventilation at neonatal resuscitation, NICU admission, and preterm birth < 34 or < 37 weeks of gestation were not different in women with more or less than recommended weight gain in the different BMI groups.

Because obese women were less likely to be nulliparous than other women, a subgroup analysis for nulliparous women was performed for the logistic regression analyses of delivery by CS and adverse outcome. The results were similar to those found with the initial logistic regression analyses, except that in nulliparous overweight and obese

Table 3. Neonatal outcomes by pre-pregnancy BMI class

	Normal weight	Under weight	*P*	Overweight	*P**	Obese	*P*†	Morbidly obese	*P*‡	Obese and Morbidly Obese	*P*§
GA-wk‖	39.08 (1.73)	38.79 (1.63)	0.044	39.10 (2.48)	0.73	39.06 (2.87)	0.80	38.77 (1.98)	0.01	39.01 (2.48)	0.31
GA < 37 wks	5.22%	7.50%	0.22	9.17%	0.17	6.88%	0.051	6.87%	0.29	6.88%	0.038
GA < 34 wks	1.25%	1.25%	1.00	1.48%	0.54	1.30%	0.89	1.72%	0.54	1.38%	0.74
BW -g‖	3448 (534)	3229 (545)	< 0.001	3535 (571)	< 0.001	3574 (567)	< 0.001	3665 (635)	< 0.001	3591 (380)	< 0.001
BW < 2500 g	3.54%	10.63%	< 0.001	3.60%	0.92	3.06%	0.48	3.86%	0.80	3.21%	0.60
BW > 4000 g	11.93%	6.25%	0.03	18.27%	< 0.001	21.17%	< 0.001	26.18%	< 0.001	22.06%	< 0.001
BW > 4500 g	2.29%	0.63%	0.26	2.68%	< 0.001	3.44%	0.05	7.73%	< 0.001	4.20%	0.001
Apgar < 7 @ 1 min	5.15%	5.66%	0.78	6.65%	0.052	6.33%	0.16	11.59%	< 0.001	7.26%	0.009
Apgar < 7 @ 5 min	1.00%	0.63%	1.00	0.92%	0.79	0.84%	0.63	2.15%	0.18	1.07%	0.85
Bag-mask	6.23%	5.00%	0.53	7.55%	0.11	8.54%	0.013	10.30%	0.017	8.85%	0.003
Neonatal sepsis	0.36%	0%	1.00	0.35%	0.96	0%	0.065	0.43%	0.59	0.76%	0.18
Metabolic disorder	1.44%	1.25%	1.00	2.68%	0.007	2.23%	0.001	6.87%	< 0.001	3.82%	< 0.001
NICU admission	7.96%	7.50%	0.84	9.38%	0.12	9.94%	0.052	14.16%	0.001	10.69%	0.005
Congenital malformation	11.01%	6.25%	0.059	9.80%	0.24	9.75%	0.26	11.59%	0.79	10.08%	0.38
Stillbirth	1.21%	0.63%	00.22	0.28%	0.26	0.37%	0.21	0.86%	0.061	0.46%	0.072
Malpresentation	5.30%	5.00%	0.87	6.63%	0.09	6.87%	0.065	10.30%	0.002	7.48%	0.007

GA: gestational age; BW: birth weight; NICU: neonatal intensive care unit.

*Normal weight versus overweight

†Normal weight versus obese

‡Normal weight versus morbidly obese

§Normal weight versus (obese and morbidly obese)

‖Mean (standard deviation)

women the rate of CS was significantly increased in those with excess weight gain compared with normal weight gain (OR 1.53; 95% CI 1.17–1.99; $P = 0.002$). In nulliparous morbidly obese women, the incidence of composite adverse outcome was significantly decreased in those who had less than the recommended weight gain compared with those who had the recommended weight gain (OR 0.18; 95% CI 0.04–0.83; $P = 0.027$).

Compared with the recommended weight gain, excess weight gain resulted in one excess composite adverse outcome per 16 overweight women and one excess composite adverse outcome per 25 obese women. In nulliparous morbidly obese women, less than recommended weight gain resulted in one less adverse outcome per three women than if they had the recommended weight gain.

DISCUSSION

Because the province of Newfoundland and Labrador has the highest rate of obesity in Canada, we felt it was important to evaluate the effects of gestational weight gain in pregnancy.[19] Many pregnancies are unplanned, and overweight and obese women may not have the opportunity to normalize their BMI prior to pregnancy. For these women it is important to identify ways in which they can minimize their risk of adverse maternal and perinatal outcome, and so identification of the appropriate weight gain for each BMI class allows us to counsel these women better. We found a higher rate of excess weight gain in our study (52.3%) than has been reported in other studies (33–43%).[9,11,20] This may be related to our high provincial rate of obesity and the fact that obese women appear to have higher rates of excess weight gain than women with a normal BMI.[1,10] One can speculate why our provincial obesity rates are so high, but contributing factors may include limited availability of healthy foods, such as fresh fruits and vegetables, in remote areas, as well as limited opportunities for exercise and regular physical activity.

Our study found that 11.5–16 kg (25–35 lbs) appears to be the appropriate weight gain for women with a normal BMI, and 7.0–11.5 kg (15–25 lbs) the appropriate weight gain for

Table 4. Logistic regression analyses showing maternal and neonatal outcomes significantly associated with more than recommended weight gain, compared with recommended weight gain

Pre-pregnancy BMI	Outcome	Adjusted OR	95% CI	*P*
Normal BMI (BMI 18.50–24.99)	Gestational hypertension	1.27	1.08–1.49	0.002
	Labour augmentation*	1.09	1.01–1.18	0.023
	Length of stay > 5 days†	1.21	1.00–1.46	0.050
	Birth weight ≥ 4000g	1.21	1.10–1.34	< 0.001
	Neonatal metabolic abnormality	1.32	0.99–1.76	0.058
	Adverse outcome‡	1.10	1.03–1.17	0.004
Overweight (BMI 25.00–29.99)	Gestational hypertension	1.31	1.10–1.55	0.002
	Labour induction*	1.11	1.00–1.23	0.052
	Birth weight ≥ 4000g	1.30	1.15–1.47	< 0.001
	Adverse outcome‡	1.12	1.02–1.22	0.011
Obese (BMI 30.00–39.99)	Caesarean section	1.10	0.99–1.22	0.067
	Prostaglandin use for induction§	1.19	1.01–1.40	0.036
	Length of stay > 3 days†	1.19	1.02–1.37	0.022
	Adverse outcome‡	1.21	1.09–1.33	< 0.001
All Obese (BMI ≥ 30.00)	Caesarean section	1.10	1.00–1.20	0.050
	Birth weight ≥ 4000g	1.20	1.07–1.34	0.002
	Neonatal metabolic abnormality	1.31	1.00–1.70	0.047
	Adverse outcome‡	1.19	1.09–1.30	< 0. 001

*Excluding elective Caesarean section

†Excluding all Caesarean sections

‡Adverse outcome: gestational hypertension, Caesarean section, birth weight ≥ 4000 g, or birth weight < 2500 g

§Among labour inductions

overweight and obese women. Weight gains of more than these recommendations were associated with increased rates of a variety of adverse outcomes, and weight gains of less than these recommendations were associated with higher rates of low birth weight (< 2500 g). In nulliparous morbidly obese women, a weight gain of less than 7.0 kg (15 lbs) appears to be associated with a reduction in the risk of adverse outcome.

Recommendations for weight gain during pregnancy in overweight and obese women are inconsistent. Some authors have agreed with the Institute of Medicine recommendation for gestational weight gain,[4,10] but others have recommended that these guidelines be reviewed and revised.[1] Some have recommended a lower weight gain for obese women, ranging from 4.5 kg to 11 kg (10–25 lbs) in women with BMI 30 to 35 kg/m^2, to recommending no weight gain in women with BMI > 40 kg/m^2.[13] Others have suggested a weight gain of less than 5.8 kg (13 lbs) in obese women.[11] In women with normal pre-pregnancy BMI, some studies have found results similar to ours and recommend a 11.5–16 kg (25–35 lbs) weight gain,[9] while others recommend lower weight gains.[11] As in our study, some previous studies have found increased complications with excess weight gain,[11–13,21] while others have not.[22,23] We also consistently noted an increased rate of low birth weight associated with poor weight gain; this was found in several other studies,[11–13] but not all.[24]

It is important that the limitations of this study be identified. Unfortunately, 47.8% of the women in the database who would have otherwise met the inclusion criteria were missing data on BMI and/or gestational weight gain, as many prenatal records did not record pre-pregnancy height and/or weight. This shortcoming has been noted in reports from a Swedish cohort,[11,12] in which information on maternal weight gain was available for only 37.7% of women. Pre-pregnancy height and weight in the present study were self reported. Although there may be errors in the self-reported measures, some studies suggest that self-reported weight is highly correlated with true weight.[9,25,26] The current study evaluated low birth weight (< 2500 g) and high birth weight (> 4000 g and > 4500 g), rather than small for gestational age and large for gestational age, as the latter outcomes were not identified in the database. Our study however controlled for gestational age. Also, as the sample size of our population was relatively small (N = 5377) we were not able to perform further

Table 5. Logistic regression analyses showing maternal and neonatal outcomes significantly associated with less than recommended weight gain, compared with recommended weight gain

Pre-pregnancy BMI	Outcome	Adjusted OR	95% CI	*P*
Normal BMI (BMI 18.50–24.99)	Birth weight < 2500g	2.49	1.19–5.23	0.016
Overweight (BMI 25.00–29.99)	Birth weight < 2500g	3.06	0.98–9.49	0.054
Morbidly obese (BMI ≥ 40.00)	Labour induction*	0.44	0.19–1.01	0.051
	Epidural use*	0.34	0.12–0.95	0.040
Overweight and Obese (BMI ≥ 25.00)	Birth weight ≥ 4000g	0.60	0.41–0.89	0.010
	Birth weight < 2500g	2.58	1.16–5.75	0.021

*Excluding elective Caesarean section

subgroup analyses of different gestational weight gain categories or BMI subcategories, as has been done in other studies.[9,11–13] In particular, we did not have adequate statistical power to evaluate outcomes in the underweight BMI group and did not have the statistical power to detect differences in several of the outcomes in morbidly obese women. Despite our small sample size, we did identify a reduction in overall adverse outcomes in nulliparous morbidly obese women if they gained less than the recommended amount of weight. Finally, our population is over 99% Caucasian, and our findings may not be generalizable to other ethnic groups.

The strengths of the study include the fact that the study cohort was drawn from a database of all the deliveries in the region. Referral bias was minimized by excluding women from outside the region. As pre-pregnancy weights and heights were recorded on prenatal records at the beginning of the pregnancy, recall bias was minimized. Finally, we were able to control for multiple potential confounders such as maternal age, parity, smoking status, partnered status, and gestational age, as this information was available in the database.

CONCLUSION

Our study has demonstrated that the appropriate weight gain during pregnancy for women with a normal pre-pregnancy BMI is 11.5–16 kg (25–35 lbs). For overweight and obese women, the appropriate weight gain appears to be 7.0–11.5 kg (15–25 lbs). For morbidly obese women, a weight gain of less than 7.0 kg (15 lbs) appears to be associated with a reduction in the risk of adverse outcome.

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REFERENCES

1. Catalano PM. Management of obesity in pregnancy. Obstet Gynecol 2007;109:419–33.
2. Yu CK, Teoh TG, Robinson S. Obesity in pregnancy. BJOG 2006;113:1117–25.
3. ACOG Committee Opinion number 315, September 2005. Obesity in pregnancy. Obstet Gynecol 2005;106:671–5.
4. Krishnamoorthy U, Schram CM, Hill SR. Maternal obesity in pregnancy: Is it time for meaningful research to inform preventive and management strategies? BJOG 2006;113:1134–40.
5. Hall LF, Neubert AG. Obesity and pregnancy. Obstet Gynecol Surv 2005;60:253–60.
6. Institute of Medicine. Nutritional status and weight gain. Nutrition in pregnancy. Washington, DC: National Academies Press; 1990. p. 27–233.
7. Yeh J, Shelton JA. Increasing prepregnancy body mass index: analysis of trends and contributing variables. Am J Obstet Gynecol 2005;193:1994–8.
8. Committee on the impact of pregnancy weight on maternal and child health. National Research Council. Influence of pregnancy weight on maternal and child health: workshop report. Washington, DC: The National Academies Press;2007.
9. DeVader SR, Neeley HL, Myles TD, Leet TL. Evaluation of gestational weight gain guidelines for women with normal prepregnancy body mass index. Obstet Gynecol 2007;110:745–51.
10. Abrams B, Altman SL, Pickett KE. Pregnancy weight gain: still controversial. Am J Clin Nutr 2000;71:1233S–41S.
11. Cedergren MI. Optimal gestational weight gain for body mass index categories. Obstet Gynecol 2007;110:759–64.
12. Cedergren M. Effects of gestational weight gain and body mass index on obstetric outcome in Sweden. Int J Gynaecol Obstet 2006;93:269–74.
13. Kiel DW, Dodson EA, Artal R, Boehmer TK, Leet TL. Gestational weight gain and pregnancy outcomes in obese women: how much is enough? Obstet Gynecol 2007;110:752–8.
14. Health reports. 1999 [cited 2008 February 12, 2008]; Available at: www.statscan.ca. Accessed November 3, 2008.
15. National Institutes of Health NH, Lung, and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults (publication no. 98–4083). Bethesda, MD: National Institutes of Health;1998.
16. Health Canada. Nutrition for a healthy pregnancy: national guidelines for the childbearing years. Minister of Public Works and Government Services: Ottawa;1999.

17. Helewa ME, Burrows RF, Smith J, Williams K, Brain P, Rabkin SW. Report of the Canadian Hypertension Society Consensus Conference: 1. Definitions, evaluation and classification of hypertensive disorders in pregnancy. CMAJ 1997;157:715–25.

18. ICD-10 [electronic resource]: international statistical classification of diseases and related health problems CD-ROM. Geneva: World Health Organization;2005.

19. Tjepkema M. Measured obesity. Adult obesity in Canada: measured height and weight. In: Nutrition: findings from the Canadian Community Health Survey 2004;issue 1 (cat no 82–620-MWE2005001). Available at: http://www.statcan.ca/english/research/82–620-MIE/2005001/articles/adults/aobesity.htm. Accessed November 4, 2008.

20. Caulfield LE, Witter FR, Stoltzfus RJ. Determinants of gestational weight gain outside the recommended ranges among black and white women. Obstet Gynecol 1996;87:760–6.

21. Thorsdottir I, Torfadottir JE, Birgisdottir BE, Geirsson RT. Weight gain in women of normal weight before pregnancy: complications in pregnancy or delivery and birth outcome. Obstet Gynecol 2002;99:799–806.

22. Scholl TO, Hediger ML, Schall JI, Ances IG, Smith WK. Gestational weight gain, pregnancy outcome, and postpartum weight retention. Obstet Gynecol 1995;86:423–7.

23. 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;87:389–94.

24. 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.

25. Rowland M. Reporting bias in height and weight data. Stat Bull Metrop Insur Co 1989;70:2–11.

26. Loderman SA, Paxton A. Maternal reporting of prepregnancy weight and birth outcome: consistency and completeness compared with the clinical record. Matern Child Health J 1998;2:123–6.