

ABSTRACT

Objective: Weight change between pregnancies was examined to determine if there were an association between weight gain (or loss) and delivery by cesarean section, gestational diabetes or pregnancy-induced hypertension.

Methods: A cohort study was conducted which included Nova Scotia residents with two or more singleton deliveries between 1988 and 1996. Weight change between pregnancies was calculated as the difference in weight from a woman's initial pre-pregnancy weight and the pre-pregnancy weight recorded from her final recorded pregnancy.

Results: Weight change between pregnancies was examined in 19,932 women. Women in the highest weight gain category were at an increased risk for developing gestational diabetes (RR = 1.59, 95% CI 1.22 - 2.08), independent of their weight prior to the final pregnancy, and other confounders. Weight gain (or loss) between pregnancies was not associated with the other outcomes.

Interpretation: Weight gain between pregnancy is an independent risk factor for gestational diabetes.

ABRÉGÉ

Objectif: Les changements de poids entre les grossesses ont été étudiés pour vérifier s'il existait une association entre le gain (ou la perte) de poids et les accouchements par césarienne, le diabète gestationnel ou l'hypertension induite par la grossesse.

Méthodes: Il s'agit d'une étude de cohorte incluant les résidentes de la Nouvelle-Écosse ayant eu deux accouchements ou plus entre 1988 et 1996. Le changement de poids entre les grossesses a été calculé comme la différence entre le poids pré-grossesse initial et le poids pré-grossesse du dernier accouchement.

Résultats: Les changements de poids ont été évalués chez 19 932 femmes. Les femmes avec un gain élevé de poids ont un risque accru de diabète gestationnel (RR=1.59, IC 95 % 1.22 - 2.08), indépendamment de leur poids pré-grossesse lors de leur dernier accouchement, et des autres facteurs confondants. Le gain (ou la perte) de poids entre les grossesses n'était pas associé aux autres événements étudiés.

Interprétation: Le gain de poids entre les grossesses est un facteur de risque indépendant pour le diabète gestationnel.

Maternal Outcomes Associated with Weight Change Between Pregnancies

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Pre-pregnancy weight and weight gain during pregnancy have been shown to affect infant and maternal outcomes.¹⁻⁴ Several studies have shown that there is a relationship between childbearing and long-term weight gain, although recently it has been suggested that this association may be specific to women who give birth after the age of 25.^{1,3,5} Very few studies have looked at the association between weight change between pregnancies and its effect on maternal and infant outcomes during subsequent pregnancies and births. The purpose of this study is to examine the relationship between weight gain (and weight loss) between pregnancies and maternal outcomes of a subsequent pregnancy, independent of weight at the time of the final pregnancy and other confounders.

SUBJECTS AND METHODS

A retrospective cohort study was conducted using data from the Nova Scotia Atlee Perinatal Database (NSAPD) and included Nova Scotia residents who had a singleton delivery between 1988 and 1996, inclusive. The NSAPD began province-wide data collection in 1988 and includes information on all deliveries in Nova Scotia. The database contains extensive information on all women who deliver a live or stillborn infant weighing at least

500 grams. Information is abstracted from prenatal forms, labour and delivery records and post-partum records pertaining to the mother and infant.

Subjects were included in this study if they had two or more singleton deliveries recorded in the database. The outcomes of interest included the occurrence of cesarean section, gestational diabetes (defined as two abnormal values on a glucose tolerance test using either the Joslin Clinic or O'Sullivan criteria, whichever is positive) and pregnancy-induced hypertension (defined as an elevated diastolic blood pressure of > 90 mmHg observed at least twice in a 24-hour period). These outcomes were chosen because of their known associations with pre-pregnancy weight and gestational weight gain.^{4,6-9} Information on the outcomes was obtained from the last pregnancy recorded in the database.

Weight change between pregnancies was defined as the difference in weight between a woman's initial pre-pregnancy weight and the pre-pregnancy weight from her last recorded pregnancy. This difference in weight was then expressed as a percentage of the initial pre-pregnancy weight, in order to examine weight change relative to an individual. Women were grouped into four categories according to their weight change: women who lost weight, women whose weight change was minimal or none (gained or lost less than 3% of their initial pre-pregnancy weight), women who gained between 3% and 9% of their initial pre-pregnancy weight and women who gained 10% or more of their initial pre-pregnancy weight. The top category was chosen to reflect, approximately, the top quartile of weight differences.

Several infant and maternal factors were evaluated as potential confounders.

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Potential confounding factors from the last recorded pregnancy included: infant birthweight (in grams), gestational age (defined from the date of the woman's last known menstrual period or, if missing, a clinical determination of gestational age), sex of the infant, gestational weight gain of the mother (adjusted for the birthweight of the infant), difference in parity between the first recorded pregnancy and the last recorded pregnancy, maternal age, marital status, smoking during the last pregnancy, and diabetic status (not included with the gestational diabetes outcome). In order to examine weight change between pregnancies independent of the weight at the start of the last recorded pregnancy, pre-pregnancy weight prior to the last recorded pregnancy was also considered as a potential confounding variable. As well, the following factors from previous pregnancies were considered as potential confounders: prior cesarean section, prior pregnancy-induced hypertension, prior gestational diabetes, having had a low birthweight infant, or a prior stillbirth.

Statistical analysis were performed using the Statistical Analysis System (SAS) and the Epidemiological Graphics, Estimation and Testing package (EGRET). Poisson regression models were used to estimate the relative risk (RR) from the rate ratio estimates and the corresponding 95% confidence intervals (CI). One independent variable at a time was tested for significance in the model by determining the change in the deviance (-2 log likelihood) from a model with and without that variable. This process was repeated until the best possible model was constructed for each outcome. Potential interactions, determined a priori, were tested for significance in the models.

RESULTS

There were 101,332 singleton births to 73,116 mothers between 1988 and 1996 in Nova Scotia. Of these, 23,738 women had a further birth registered in the database and therefore qualified for inclusion in the study. Information on weight (either initial pre-pregnancy weight or final pre-pregnancy weight) was missing for 3,806 women. Thus, 19,932 women were included in this study.

TABLE I
Relationship with Initial Pre-pregnancy Weight and Weight Change Between Pregnancies

Initial Pre-Pregnancy Weight (lbs)	Lost		Weight Change Between Pregnancies					
	n	(%)	No Change		3-9% Increase		≥10% Increase	
			n	(%)	n	(%)	n	(%)
≤ 113	327	(10.8)	1010	(33.3)	840	(27.7)	856	(28.2)
114-164	2,090	(14.9)	4,163	(29.6)	4,210	(30.0)	3,582	(25.5)
≥ 165	603	(21.1)	710	(24.9)	757	(26.5)	784	(27.5)
Total	3,020	(15.2)	5,883	(29.5)	5,807	(29.1)	5,222	(26.2)

TABLE II
Relationship with Parity and Weight Changes Between Pregnancies

Difference in Parity from Last Recorded Pregnancy & Initial Recorded Pregnancy	Lost		Weight Change Between Pregnancies					
	n	(%)	No Change		3-9% Increase		≥10% Increase	
			n	(%)	n	(%)	n	(%)
1	2,562	(15.4)	5,118	(30.8)	4,885	(29.4)	4,036	(24.3)
2	400	(13.6)	691	(23.6)	827	(28.2)	1,014	(34.6)
3	52	(14.7)	69	(19.5)	78	(22.0)	155	(43.8)
4+	6	(13.3)	5	(11.1)	17	(37.8)	17	(37.8)

Table I shows the relationship between the women's initial pre-pregnancy weight and weight change between pregnancies. Overall, 15.2% of women lost weight between pregnancies, 29.5% had minimal weight change, 29.1% gained between 3% and 9% of their initial pre-pregnancy weight and 26.2% gained 10% or more of their initial pre-pregnancy weight. The women who were in the highest weight gain category were distributed equally between the three initial weight groups. However, as initial pre-pregnancy weight increased, the proportion of women who lost weight between pregnancies increased.

Table II shows the relationship between the difference in parity between initial and last recorded pregnancy and weight change between pregnancies. For the majority of women in this study, the initial and last recorded pregnancy in the database were consecutive pregnancies. Women who had greater differences in parity (e.g., more births) were more likely to experience larger weight gain between pregnancies.

Table III shows the association between weight change and the risk of cesarean section delivery. About 17% of the subjects in this study had a cesarean section in their subsequent pregnancy. After adjusting for

previous cesarean section, pre-pregnancy weight in the final pregnancy and other confounders, weight change between pregnancies was not associated with cesarean delivery in the last pregnancy.

The relative risks associated with changes in weight and the occurrence of gestational diabetes in the final pregnancy are shown in Table IV. Gestational diabetes was diagnosed in 2.5% of the cohort in their final recorded pregnancy. Weight at the start of the last pregnancy was associated with gestational diabetes (results not shown). As well, women who gained 10% or more of their initial pre-pregnancy weight between pregnancies were at increased risk of developing gestational diabetes (RR = 1.59, 95% CI 1.22 - 2.08), independent of weight at the start of the last pregnancy, gestational weight gain and other confounders.

Table V shows the risk of pregnancy-induced hypertension associated with weight change between pregnancies. Pregnancy-induced hypertension was diagnosed in about 4.8% of the cohort during their final recorded pregnancy. Among women who gained 10% or more of their initial pre-pregnancy weight, there was a suggestion of a slight increased risk of

TABLE III
Relative Risk Estimates for the Association of Weight Change Between Pregnancies with Cesarean Section

Weight Change	Number*	Adjusted Relative Risk†	95% Confidence Interval
No Change	5,421	1.00	
Lost Weight	2,786	0.96	0.85 - 1.07
3-9% Increase	5,339	0.96	0.88 - 1.06
≥10% Increase	4,814	1.06	0.96 - 1.17

* The difference between the number of records analyzed and those eligible for analysis is due to missing values.

† Adjusted for pre-pregnancy weight of last pregnancy (in lbs), gestational age, infant birthweight, difference in parity between initial and final pregnancy, gestational weight gain, cesarean section in previous pregnancy, insulin-dependent or gestational diabetes, previous low birthweight infant and previous stillbirth.

TABLE IV
Relative Risk Estimates for the Association of Weight Change Between Pregnancies with Gestational Diabetes

Weight Change	Number*	Adjusted Relative Risk†	95% Confidence Interval
No Change	4,809	1.00	
Lost Weight	2,484	1.10	0.77 - 1.56
3-9% Increase	4,662	1.13	0.85 - 1.50
≥10% Increase	4,244	1.59	1.22 - 2.08

* The difference between the number of records analyzed and those eligible for analysis is due to missing values.

† Adjusted for pre-pregnancy weight of last pregnancy (in lbs), gestational age, marital status, previous cesarean section, maternal age, gestational weight gain, gestational diabetes in previous pregnancy.

TABLE V
Relative Risk Estimates for the Association of Weight Change Between Pregnancies with Pregnancy-Induced Hypertension

Weight Change	Number*	Adjusted Relative Risk†	95% Confidence Interval
No Change	5,289	1.00	
Lost Weight	2,679	0.84	0.66 - 1.07
3-9% Increase	5,219	0.98	0.82 - 1.18
≥10% Increase	4,697	1.16	0.96 - 1.40

* The difference between the number of records analyzed and those eligible for analysis is due to missing values.

† Adjusted for pre-pregnancy weight of last pregnancy (in lbs), pregnancy-induced hypertension in previous pregnancy, gestational age, infant sex, difference in parity between initial and last pregnancy, insulin-dependent diabetes, maternal age, smoking during final pregnancy, gestational weight gain, previous cesarean section, and previous low birthweight infant.

developing pregnancy-induced hypertension (RR = 1.16, 95% CI 0.96 - 1.40), independent of weight at the start of the pregnancy, gestational weight gain and other confounders. There was also a suggestion of a protective effect of weight loss between pregnancies on the risk of pregnancy-induced hypertension.

In order to determine if the effect of weight gain (or weight loss) between pregnancies was modified by a woman's initial pre-pregnancy weight, an interaction term including initial pre-pregnancy weight and

weight change between pregnancies was evaluated for each outcome. The interaction term was not statistically significant in any of the three outcomes.

DISCUSSION

Weight gain between pregnancies appeared to be an independent risk factor for gestational diabetes, even after controlling for pre-pregnancy weight of the last pregnancy, maternal age, previous gestational diabetes, and other confounders.

Women in the highest category of weight gain between pregnancies (10% or more of their initial pre-pregnancy weight) were 60% more likely to develop gestational diabetes in the last pregnancy compared to women whose weight did not change. An independent association of weight gain between pregnancy and the occurrence of pregnancy-induced hypertension was suggestive, but based on the upper limit of the confidence interval (1.40), the magnitude of effect is small.

The reasons for the excess risk associated with weight gain between pregnancies and gestational diabetes, independent of a woman's weight, are not obvious. Pre-pregnancy weight of the last pregnancy was analyzed as a continuous variable, so residual confounding from this variable should be minimal. It has been observed that upper body obesity (in particular, abdominal obesity) is a more important risk factor for alterations in carbohydrate metabolism, such as insulin resistance, than a generalized measure of body fat.¹⁰ Women in the highest weight gain category likely increased their abdominal fat more than women who did not gain weight, which could result in increased insulin resistance and an increased risk of gestational diabetes. Further research is warranted to examine the relationship between changes in abdominal fat between pregnancies and its effect on developing gestational diabetes in the subsequent pregnancy.

The results of this study suggest that weight loss between pregnancies may be a protective factor for pregnancy-induced hypertension. Weight loss between pregnancies did not appear to be a protective factor for the other outcomes.

Beazley et al.² found a strong relationship between parity and weight gain across subsequent pregnancy. Williamson et al.³ and Billewicz et al.¹ showed a relationship between the time period of successive pregnancy and postpartum weight changes. In this study, adjustment was made for the difference in parity between the first and last recorded pregnancy as well as maternal age at the time of the first and last recorded pregnancy.

A strength of this study was the availability of data from the Atlee Perinatal Database which includes information on

all births in the province. The ability to link information from one pregnancy to another on a population basis and over a nine-year period is a unique feature of this study. Data quality checks are ongoing and have included a re-abstraction study, which showed little discrepancy for the variables used in this study.

Several limitations of this study should be noted. Approximately 16% of the subjects had missing information on either their initial pre-pregnancy weight or their last pre-pregnancy weight. There were no differences in the rate of occurrence of the three outcomes between the 19,932 women included in this study and the 3,806 women who were excluded because of missing information on the weight variables. There were slight differences between these two groups on several of the confounding variables (e.g., marital and smoking status).

Some women may have been excluded because their pregnancies could not be linked and we did not have information on two or more pregnancies. This could happen if women moved in or out of the province between deliveries or if there were data errors on the unique identifiers needed to link pregnancies.

Other measures (such as waist circumference, waist to hip ratio and BMI) which have been shown to be more useful than weight alone in predicting outcomes such as diabetes and hypertension¹¹ could not be

evaluated in this study because height and other measurements are not recorded in the database. As well, information on ethnicity is not in the database. The results of this study may not be generalizable to all populations since the Nova Scotia population is predominantly Caucasian.

Pre-pregnancy weights (for both the initial and last pregnancy) were based on self-reports. Data from Sweden suggest that, on average, women under-report their pre-pregnancy weight by 0.8 kg.¹⁰ Assuming the amount of under-reporting in this cohort is consistent between pregnancies, the weight change variable used in this study should have minimal misclassification.

This study examined the relationship between weight change between pregnancies and delivery by cesarean section, developing gestational diabetes or pregnancy-induced hypertension, independent of pre-pregnancy weight and other confounders. An increased risk among women who experienced a large weight gain between pregnancies was seen with gestational diabetes. Weight loss between pregnancies may decrease the risk of pregnancy-induced hypertension. Further investigation is warranted to examine how initial pre-pregnancy weight might modify the relationship with weight gain (or loss) between pregnancies and to clarify the benefits, if any, of weight loss between pregnancies.

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