Published in final edited form as:
Womens Health Issues. 2010 ; 20(2): 126–132. doi:10.1016/j.whi.2009.12.002.

PRECONCEPTION PREDICTORS OF WEIGHT GAIN DURING PREGNANCY:

Prospective Findings from the Central Pennsylvania Women's Health Study

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Abstract

Objectives—We examined preconception (prepregnancy) predictors of pregnancy weight gain and weight gain that exceeds the 2009 Institute of Medicine (IOM) recommendations based on pre-pregnancy body mass index (BMI), in a prospective study.

Methods—Data are from a population-based cohort study of 1,420 women who were interviewed at baseline and 2 years later. The analytic sample includes 103 women who were not pregnant at baseline and gave birth to full-term singletons during the follow-up period. Preconception maternal weight category as well as health behaviors, psychosocial stress, parity, and age were examined as predictors of pregnancy weight gain and of weight gain in excess of the IOM recommendations using multiple linear and logistic regression analysis.

Results—Pregnancy weight gain averaged 33.01 pounds, with 51% of women gaining weight in excess of the 2009 IOM recommendations for their preconception weight category. Preconception overweight (BMI = 25–29.9) increased the odds of excessive pregnancy weight gain nearly threefold, whereas preconception physical activity levels meeting activity guidelines reduced the odds of excessive weight gain but was marginally statistically significant.

Conclusion—Although future research examining the role of physical activity in relation to pregnancy weight gain is needed, preconception overweight and physical activity levels are prime targets for interventions to avoid excessive pregnancy weight gain.

Due in part to concerns about the increasing prevalence of obesity in reproductive-age women, the Institute of Medicine (IOM) recently released new guidelines for maternal weight gain during pregnancy (IOM, 2009). There is now sufficient evidence that excessive weight gain during pregnancy is a major contributor to adverse outcomes for both mothers and their infants. For example, high gestational weight gain is the strongest determinant of maternal postpartum weight retention (Gunderson & Abrams, 1999; IOM, 2009; Ohlin & Rossner, 1996; Oken, Kleinman, Belfort, Hammitt, & Gillman, 2009; Walker, 1996), and it is positively associated with long-term weight gain (Amorim, Rossner, Neovius, Lourenco, & Linne, 2007), body adiposity (Butte, Ellis, Wong, Hopkinson, & O'Brian Smith, 2003), and obesity independent of age (Abrams et al., 2000; Harris, Ellison, Holliday, & Lucassen, 1997; Keppel & Taffel, 1993; Rooney, Schauberger, & Mathiason, 2005; Thorsdottir & Birgisdottir, 1998). There are also negative implications for infants of mothers who gain too

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much weight. High gestational weight gain is a strong predictor of high birth weight, and it is associated with macrosomia and overweight during infancy (Cedergren, 2004; Dietz, Callaghan, & Sharma, 2009; Frederick, Williams, Sales, Martin, & Killien, 2008; Hedderson et al., 2006; Kabali & Werler, 2007; Neggers, Goldenberg, Tamura, Cliver, & Hoffman, 1997; Oken et al., 2009). With nearly 60% of overweight and 40% of normal weight women gaining more weight during pregnancy than is recommended (Chu, Callaghan, Bish, & D'Angelo, 2009) the new IOM guidelines propose weight gain ranges based on pre-pregnancy body mass index (BMI) and include a relatively narrow range of recommended weight gain for obese women (IOM, 2009).

Understanding the determinants of pregnancy weight gain is essential for designing clinical and public health interventions to prevent overweight in mothers and their offspring. These interventions should be guided by a conceptual understanding of the relevant determinants of excessive gestational weight gain, which will aid in interpreting effects and translating findings into effective practices (Buckworth & Dishman 2002). The IOM has called for research on how dietary intake, physical activity, and other related health factors affect weight gain during pregnancy in diverse populations (IOM, 2009). The biopsychosocial model (Engel, 1977) provides a flexible framework for examining the determinants of pregnancy weight gain because it considers the complex psychological, social, and biological determinants and outcomes of weight gain, particularly BMI, relevant health behaviors (e.g., nutrition and physical activity), psychosocial stress, and sociodemographic factors that can influence weight during this time.

In addition, it is important for study designs to incorporate preconception measures of BMI, rather than relying on retrospective reports of BMI provided by women who are already pregnant or have given birth. Findings from existing studies of women enrolled midway through their pregnancies or after childbirth suggest that excessive gestational weight gain may be associated with elevated BMI before pregnancy (Chasan-Taber et al., 2008; Lof, Hilakivi-Clarke, Sandin, & Weiderpass, 2008; Olson & Strawderman 2003; Wells, Schwalberg, Noonan, & Gabor, 2006), older maternal age (Chasan-Taber et al. 2008), first births compared with higher parity (Chasan-Taber et al., 2008; Wells et al., 2006), low reported pre-pregnancy physical activity level (Lof et al., 2008), lower maternal education (Wells et al., 2006), and lower income (Olson & Strawderman, 2003). Although none of these studies conducted interviews with women before pregnancy, one study of pregnant women who were receiving prenatal care included pre-pregnancy BMI from medical chart review and found that those who were overweight before pregnancy were over twice as likely as other women to gain excessive weight during pregnancy, based on the 1990 IOM recommendations (Brawarsky et al., 2005).

The objective of this study is to examine the preconception predictors of pregnancy weight gain that exceeds the new IOM recommendations for total weight gain based on pre-pregnancy BMI. In addition to preconception weight category, other preconception variables that we hypothesized would impact pregnancy weight gain include health behaviors presumed to affect weight status (nutritional intake, physical activity levels, and smoking) as well as psychosocial stress, which is hypothesized to affect health behaviors and also exert direct physiological effects on weight status before and during pregnancy (Webb, Seiga-Riz, & Dole, 2008). We hypothesized that healthier behaviors (higher physical activity levels, greater vegetable consumption, and not smoking) are associated with pregnancy weight gain within the IOM guidelines (i.e., not exceeding the guidelines). This study is the first, to our knowledge, to examine these variables assessed before pregnancy, rather than retrospectively during pregnancy or after birth, in relation to the 2009 IOM guidelines.

Methods

Study design and sample

Data are from a population-based cohort study of 1,420 women who were ages 18 to 45 years at the baseline interview and who were re-interviewed 2 years later as part of the Central Pennsylvania Women's Health Study. The baseline random-digit dial telephone survey was conducted between September 2004 and March 2005; the follow-up telephone interview was conducted at the 2-year anniversary of the baseline interview. Details of the study design, sampling frame, response rates, and sample representativeness have been published previously (Weisman et al., 2006, 2009). Among women who gave birth during the 2-year follow-up period, 90% consented to accessing their electronic birth records from the Pennsylvania Department of Health.

The analytic sample is 103 women who had full-term singleton births during the study period and were not pregnant at the time of the baseline interview. Although 172 live births occurred during the follow-up period, we limited this analysis to singleton full-term births (≥37 weeks gestation). This is because the length of pregnancy is associated with weight gain and the IOM guidelines refer to total pregnancy weight gain; in addition, pregnancy weight gain is influenced by the number of fetuses, and the IOM issued only provisional guidelines for women with multiple fetuses.

The independent variables for this analysis were measured in the baseline interview, when the woman was not pregnant. Pregnancy weight gain was measured in the follow-up interview for the pregnancy and birth that occurred during the follow-up period.

Measures

Dependent variables—Two dependent variables related to gestational weight gain are examined. The first is a continuous measure of pregnancy weight gain (in pounds) based on self-report in the follow-up interview. Self-reported weight gain was strongly correlated with weight gain reported on the birth record; because birth records were not available for 14% of respondents, self-reported weight gain is used in this analysis. Mean weight gain was 33.01 pounds, with a standard deviation of 15.89.

The second dependent variable is categorical, created by computing whether the woman's pregnancy weight gain exceeded the 2009 IOM recommendation for her baseline (preconception) BMI, met the recommendation, or fell below the recommendation. Baseline BMI was computed from the woman's report of her height and weight at baseline. The IOM (2009) recommends the following weight gain ranges based on preconception BMI:

BMI	Recommended weight gain (lbs)
<18.5	28–40
18.5–24.9	25–35
25.0–29.9	15–25
≥30.0	11–20

In our sample, 51% exceeded the recommendation based on preconception BMI; 33% met the recommendation; and 16% were below the recommendation. Because too few cases were below the recommendation for detailed analysis (n = 16), we dichotomized this variable to contrast those who exceeded the recommendation (51%) with all others (49%).

Independent variables—Pre-pregnancy BMI category was calculated based on self-reported height and weight in the baseline interview. Self-reported height and weight have been found to accurately represent BMI abstracted from medical records for reproductive-age women (Huber, 2007). Too few cases in the analytic sample were classified as underweight to permit analysis as a separate weight category; accordingly, underweight and normal categories were combined for analysis. Thus, 50% of women were classified as underweight or normal (BMI < 25), 34% were overweight (BMI = 25–29.9), and 16% were obese (BMI ≥ 30).

A large number of other plausible independent (preconception) variables in the categories of health-related behaviors, psychosocial stress, reproductive history, and sociodemographics were explored for this analysis. Although the Central Pennsylvania Women's Health Study provides a comprehensive set of health-related variables and reproductive history variables, the small sample size for this analysis limits the number of predictors that can be included. The set of independent variables included here represents the most theoretically relevant potential determinants of pregnancy weight gain in the selected categories based on the biopsychosocial framework.

Three health-related behaviors are included. Preconception physical activity level was measured using items adapted from the Behavioral Risk Factor Surveillance System (2009), and was categorized as 30 minutes or more of moderate or strenuous exercise on 4 or more days per week (21% of respondents) versus less physical activity (79%). This categorization was based on prevailing guidelines (American College of Sports Medicine, 2000; American College of Obstetricians and Gynecologists, 2002). Preconception vegetable consumption was measured using an item from the Behavioral Risk Factor Surveillance System and was categorized as at least one serving per day in a typical week of vegetables "not counting carrots, potatoes, or salad" (43% of respondents) versus less than daily vegetable consumption (57%). Vegetable consumption was selected among the all of the dietary intake measures in the survey because it has been found in our previous analyses to predict birthweight and fetal growth, whereas other nutritional measures did not (Weisman et al., 2009). Preconception cigarette smoking was measured as any cigarette smoking (22% of respondents) versus no cigarette smoking (78%).

Psychosocial stress was measured using the 12-item Psychosocial Hassles Scale that assessed the degree to which common hassles (such as money worries, problems with friends) were perceived as stressful (on a 4-point scale ranging from "no stress" to "severe stress") during the past 12 months. The scale was adapted from the Prenatal Psychosocial Profile Hassles Scale, which referred to stress during pregnancy (Misra, O'Campo, & Strobino, 2001), which in turn was adapted from the stress subscale of the Prenatal Psychosocial Profile developed by Curry Campbell, and Christian (1994). Because the summed scale scores were skewed, they were dichotomized at the median for analysis, with 44% of respondents classified as high stress. We hypothesized that lower psychosocial stress is associated with pregnancy weight gain within the IOM guidelines (i.e., not exceeding the guidelines).

Parity was measured as having any live birth before the index live birth. Sixty-eight percent of respondents had a prior live birth. We hypothesized that nulliparity is associated with greater likelihood of exceeding the IOM guidelines for pregnancy weight gain.

The only sociodemographic variable included is age, because older women are likely to weigh more and to be at elevated risk for exceeding IOM guidelines. Indicators of socioeconomic status (educational level, poverty status, and minority status) were explored

but dropped from analysis because they were not associated with pregnancy weight gain in this sample.

Analysis

Bivariate associations between independent and dependent variables were examined using parametric (analysis of variance) and non-parametric (Wilcoxon Rank Sum or Kruskal-Wallis) methods, as appropriate for pregnancy weight gain in pounds, and Pearson chi-square test for exceeding the IOM recommendations for pregnancy weight gain. Before conducting regression analysis, multicollinearity among independent variables was assessed and no evidence of multicollinearity was found, with tolerance values ranging from 0.43 to 0.93. Multiple regression analyses were conducted to assess the relative importance of the predictors on the dependent variables; multiple linear regression was used to model pregnancy weight gain in pounds, and multiple logistic regression was used to model exceeding IOM guidelines (a dichotomous variable).

Results

Table 1 shows the bivariate (unadjusted) associations between preconception variables and the two dependent variables (pregnancy weight gain in pounds, and meeting or exceeding the IOM guidelines for pregnancy weight gain, based on pre-pregnancy BMI). Although many of the associations in this table trend in the hypothesized direction, there are only three statistically significant associations ($p < .05$). Preconception weight category is associated with pregnancy weight gain in pounds ($p = .04$), but marginally associated ($p = .08$) with meeting or exceeding the IOM guideline. Physical activity level is associated with meeting or exceeding the IOM guideline ($p = .04$): women who exercise 30 minutes or longer on most days of the week are more likely to have pregnancy weight gain within the guidelines. Age is significantly associated with pregnancy weight gain measured continuously ($p = .01$).

Multiple linear regression analysis of the predictors of pregnancy weight gain measured in pounds revealed no statistically significant predictors (data not shown). Results of the multiple logistic regression analysis of the predictors of exceeding the IOM guidelines for pregnancy weight gain are shown in Table 2. Preconception BMI indicating overweight substantially increases the odds of exceeding the IOM guidelines, compared with normal preconception weight category (adjusted odds ratio [AOR], 2.84) and is the strongest predictor in the model. Preconception obesity does not significantly impact exceeding the IOM guidelines. Physical activity levels meeting the guidelines substantially reduces the odds of exceeding the IOM guidelines (AOR = 0.34), although statistical significance is marginal ($p = .07$). Neither vegetable consumption, smoking, psychosocial stress, parity, nor age predicted pregnancy weight gain.

Discussion

This study examined preconception predictors of pregnancy weight gain using a population-based prospective data set in which pre-pregnancy status, including weight category, was measured before the index pregnancy rather than retrospectively. Overweight, defined as BMI between 25 and 29.9, was the strongest predictor of exceeding the 2009 IOM recommendations for pregnancy weight gain, increasing the odds of excessive weight gain nearly threefold. Preconception physical activity levels consistent with prevailing guidelines lowered the risk of excessive weight gain ($p = .07$) and possibly would have been a stronger predictor in a larger sample. Although nutrition (vegetable consumption), smoking, psychosocial stress, parity, and age were not significant predictors of pregnancy weight gain in this analysis, their potential importance cannot be dismissed owing to the small sample size in this study. Several findings warrant further discussion.

Although the finding that preconception overweight predicts excessive pregnancy weight is expected and consistent with prior research using the older IOM guidelines (Brawarsky et al., 2005), these findings are novel in that they apply the 2009 IOM guidelines and represent preconception weight status measured before pregnancy rather than retrospectively. Confirming prior findings using a prospective study design is important and further illustrates the need for intervention efforts aiming to promote healthy weight status before pregnancy. Although we observed no significant differences in absolute weight gain by preconception weight category, it is not surprising that overweight women were more likely to exceed the recommended IOM pregnancy weight gain guidelines because of the more restrictive guidelines for overweight women compared with normal weight women. This highlights the importance of specific counseling about weight gain recommendations for overweight women who may be unaware that they are overweight and that they should limit their pregnancy weight gain.

Although we expected some health-related behaviors (i.e., nutritional intake, physical activity level, or smoking) and psychosocial stress to predict pregnancy weight gain, only preconception physical activity level was marginally significant in multivariable analysis. This finding suggesting that women who meet physical activity guidelines before pregnancy are less likely to exceed the IOM (2009) guidelines is new. Few studies have examined the role of preconception physical activity on pregnancy and postpartum outcomes. Symons Downs, DiNallo, and Kirner (2008) prospectively examined the moderating influence of preconception physical activity (meeting or not meeting activity guidelines) for predicting depressive symptoms across pregnancy and found that women who were meeting the guidelines before pregnancy had less depressive symptoms during early pregnancy. In addition, Stuebe, Oken, and Gillman (2009) examined the associations between diet and physical activity during pregnancy with the risk for excessive weight gain in pregnancy and found that second trimester walking and vigorous physical activity were inversely associated with high gestational weight gain. Although these studies, along with the current study findings, suggest that preconception physical activity may offer women protective effects against poor health outcomes and excessive weight gain in pregnancy, they are nonetheless limited by their observational nature to preclude causal inferences at this time. Future research is needed to replicate these study findings and further examine whether physical activity in itself plays an integral role for preventing high weight gain—or whether physical activity is a marker for other preconception health behaviors.

The main limitation of this study is the small sample size of women with full-term, singleton, live births. Despite the strength of the longitudinal design, the number of incident pregnancies observed over the 2-year follow-up period was limited by the baseline sample size, and not all incident pregnancies could be included in this analysis because of the necessity of including only singleton, full-term births to assess pregnancy weight gain exceeding the IOM recommendations. In addition, the small sample size precluded examining the rarer outcome of pregnancy weight gain lower than recommended by the IOM. It is important that future research use larger prospective studies in which women are followed from preconception through delivery.

In sum, using the 2009 IOM recommendations for pregnancy weight gain, this study has shown that preconception overweight and physical activity levels are prime targets for interventions to avoid excessive pregnancy weight gain.

Acknowledgments

Funded, in part, under grant number 4100020719 with the Pennsylvania Department of Health. The Department specifically disclaims responsibility for any analyses, interpretations or conclusions. The Penn State Survey

Research Center conducted the telephone surveys. The Study was approved by the Institutional Review Board at the Penn State College of Medicine.

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Table 1

Associations Between Preconception Variables, Pregnancy Weight Gain, and Meeting or Exceeding IOM Pregnancy Weight Gain Guidelines (base *n* = 103)

	Pregnancy Weight Gain(pounds)				
	(mean, SD)	***p****	**Does Not Exceed IOM Guidelines (*n* = 50)**	**Exceeds IOM Guidelines (*n* = 53)**	***p**†*
Body mass index (BMI)					
Normal and underweight (BMI < 25)	35.13 (14.59)		60% (31)	40% (21)	
Overweight (BMI = 25–29.9)	32.43 (14.46)		37% (13)	63% (22)	
Obese (BMI ≥ 30)	27.38 (21.67)	.04	38% (6)	62% (10)	.08
Physical activity level					
≥30 min on most days of week	29.68 (14.13)		68% (15)	32% (7)	
<30 min on most days of week	33.91 (16.30)	.27	43% (35)	57% (46)	.04
Vegetable consumption					
≥1 serving daily	29.52 (11.69)		55% (24)	45% (20)	
Less than daily	35.61 (18.07)	.11	44% (26)	56% (33)	.29
Cigarette Smoking					
Yes	37.43 (16.47)		39% (9)	61% (14)	
No	31.74 (15.59)	.13	51% (41)	49% (39)	.31
Psychosocial Hassles Scale					
High stress	32.33 (18.80)		47% (21)	53% (24)	
Low stress	33.53 (13.35)	.72	50% (29)	50% (29)	.74
Previous live birth					
Yes	32.20 (13.98)		49% (34)	51% (36)	
No	34.73 (19.47)	.51	48% (16)	52% (17)	.99
Age (yrs)					
18–24	37.18 (16.94)		41% (9)	59% (13)	
25–34	30.03 (13.97)		53% (37)	47% (33)	
35–45	43.64 (20.06)	.01	36% (4)	64% (7)	.90

*Based on F-test for one-way ANOVA, Wilcoxon Rank Sum, or Kruskal-Wallis tests, as appropriate.

†Based on chi-square test.

Table 2

Preconception Predictors of Exceeding the IOM Pregnancy Weight Gain Guidelines: Results of Multiple Logistic Regression Analysis (n = 103)

	Adjusted Odds Ratio	95% Confidence Interval	*p*
Body mass index			
Normal and underweight	Reference		
Overweight	2.84	1.11, 7.29	.03
Obese	2.84	0.81, 9.96	.10
Physical activity level			
≥30 min on most days of week	0.34	0.11, 1.07	.07
<30 min on most days of week	Reference		
Vegetable consumption			
≥1 serving daily	0.75	0.31, 1.78	.51
Less than daily	Reference		
Cigarette smoking			
Yes	2.45	0.80, 7.48	.12
No	Reference		
Psychosocial Hassles Scale			
High stress	0.95	0.39, 2.32	.91
Low stress	Reference		
Previous live birth			
Yes	0.73	0.27, 1.97	.54
No	Reference		
Age (yrs)	0.97	0.89, 1.06	.54

Likelihood ratio test statistic = 12.80 (p = .12).