



## Original article

## Association of Prenatal Physical Activity and Gestational Weight Gain: Results from the First Baby Study

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### A B S T R A C T

**Background:** In response to increasing rates of excessive gestational weight gain (GWG) and evidence of postpartum weight retention and long-term overweight and obesity, the Institute of Medicine (IOM) revised their guidelines for GWG in 2009. Prenatal physical activity is recommended, although its role in preventing excessive GWG is unclear. We sought to understand the association between prenatal physical activity and GWG in a longitudinal cohort.

**Methods:** During a baseline survey at 34 weeks, women ( $n = 3,006$ ) reported their height, prepregnancy weight, and physical activity during pregnancy. GWG was self-reported at 1-month postpartum. Multivariable logistic regression adjusting for age, race/ethnicity, education, poverty status, marital status, gestational age at the time of delivery, and smoking was used to model the association between adequate physical activity during pregnancy and exceeding the IOM recommendations for GWG.

**Findings:** Overweight women were most likely to exceed the IOM recommendations for GWG (78.7%), followed by obese women and normal weight women (65.0% and 42.4%, respectively). The majority of women participated in some physical activity during pregnancy, with 41.2% engaging in 60 to 149 minutes and 32.1% engaging in at least 150 minutes of physical activity per week. In adjusted analysis, meeting the physical activity guidelines was associated with a 29% (confidence interval, 0.57–0.88) lower odds of exceeding the IOM recommendations for GWG compared with inactive women.

**Conclusions:** Findings of high rates of excessive GWG, especially among women with overweight and obesity, are concerning given the associated health burdens. The association of guideline-concordant physical activity with appropriate GWG suggests this is an important target for future interventions.

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### Introduction

The widespread adverse health and economic effects of the obesity epidemic are well described (Flegal, Carroll, Ogden, &

Curtin, 2010). The majority of women of childbearing age are already overweight or obese, which elevates the risk of gestational diabetes, preeclampsia, eclampsia, cesarean delivery, and macrosomic infants (Baeten, Bukusi, & Lambe, 2001; Institute of Medicine [IOM] & National Research Council [NRC], 2009). Also, nearly half of normal weight women and two thirds of overweight and obese women are exceeding the IOM guidelines for appropriate gestational weight gain (GWG) during pregnancy (Chu, Callaghan, Bish, & D'Angelo, 2009; IOM & NRC, 2009; Martin et al., 2007). Excessive GWG is an important contributor

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to postpartum weight retention and long-term overweight and obesity; one quarter of women with a normal prepregnancy body mass index (BMI) who gain more than 20 kg during pregnancy will move up one BMI category (i.e., from normal weight to overweight) at 6 months postpartum (Nohr et al., 2008; Viswanathan et al., 2008). Even more important, high GWG is independently associated with poor pregnancy outcomes, including premature birth, large-for-gestational age infants, lower breastfeeding initiation rates, and increased risk of cesarean delivery (Viswanathan et al., 2008).

In response to increasing rates of excessive GWG and evidence of associated negative outcomes (Viswanathan et al., 2008), the IOM revised their guidelines for GWG in 2009 (IOM & NRC, 2009). The updated guidelines for GWG are based on prepregnancy BMI, with lower GWG recommended for overweight and obese women compared with normal weight women. Although normal weight (BMI = 18.5–24.9 kg/m<sup>2</sup>) women are recommended to gain 11.5 to 16 kg, women who are overweight (BMI = 25.0–29.9 kg/m<sup>2</sup>) are expected to limit weight gain to 7 to 11.5 kg (IOM & NRC, 2009). Obese women (BMI ≥ 30.0 kg/m<sup>2</sup>) are further restricted, with recommendations to gain only 5 to 9 kg during pregnancy (IOM & NRC, 2009). Although GWG limited to these recommended ranges has been associated with reduced maternal and infant morbidity, little is known about how modifiable prenatal behaviors influence GWG.

Describing characteristics and behaviors associated with excessive GWG may offer important clinical insights on how to limit the increasing problem of excessive weight gain during pregnancy. Identifying modifiable factors influencing GWG may provide useful targets for intervention and prevention. For example, physical activity during pregnancy is recommended by both the American College of Obstetricians and Gynecologists and United States Federal Guidelines, but whether prenatal physical activity has an important role in preventing excessive GWG is unclear (American College of Obstetricians and Gynecologists, 2002; Physical Activity Guidelines Advisory Committee, 2008). In fact, the 2009 IOM report specifically recommended that studies be conducted on the effect of physical activity on weight gain during pregnancy (IOM & NRC, 2009). Subsequent studies have suggested that physical activity, both preconception and prenatal, is inversely associated with excessive GWG (Stuebe, Oken, & Gillman, 2009; Weisman, Hillemeier, Downs, Chuang, & Dyer, 2010). We hypothesize that adequate physical activity during pregnancy helps women to avoid excessive GWG. This benefit may be even greater for women with overweight and obesity, given tighter restrictions on appropriate weight gain. Using a unique longitudinal cohort of women having their first child, the aim of this study was to understand the association between prenatal physical activity and GWG, using data collected at the baseline and 1-month postpartum time points.

## Methods

### Study Design

Data for these analyses are from the First Baby Study (R01 HD052990, PI: Kjerulff), a longitudinal cohort study of women having a first, singleton birth. The First Baby Study was approved by the Institutional Review Board of the Penn State College of Medicine. The primary purpose of the parent project is to investigate the association between mode of first delivery (vaginal vs. cesarean) and subsequent childbearing. Participants were

recruited with flyers between January 2009 and April 2011 from numerous locations, such as hospitals, obstetricians' offices and clinics, and targeted mailings to potentially eligible women obtained from marketing lists. Women were eligible to participate if they were residents of Pennsylvania, aged 18 to 35 at the time of the baseline interview, nulliparous, currently pregnant with a singleton pregnancy, and able to speak/read English or Spanish. Details regarding recruitment are described elsewhere ([reference blinded by WHI editors for peer review]). The majority of participants delivered at 7 hospitals, although women delivered at a total of 69 hospitals throughout Pennsylvania. Participants of the First Baby Study completed the baseline telephone interview during the third trimester (≥34 weeks gestation), and will continue to be followed with subsequent telephone interviews until 3 years postpartum.

A total of 3,006 women were recruited, consented, and completed both the baseline interview and 1-month postpartum interview and comprise the sample for the current analysis. Because the characteristics and risks associated with prepregnancy weight and GWG differ significantly for underweight women, the 100 women who were underweight (BMI < 18.5 kg/m<sup>2</sup>) before pregnancy were excluded from this analysis. We also excluded 118 women who delivered before 37 weeks' gestation, because the IOM recommendations are intended for women with full-term gestations. Finally, 21 women did not provide information on height, prepregnancy weight or GWG. The final analytic sample, therefore, consisted of 2,767 women (91% of the recruited cohort).

### Definition of Variables

#### GWG

Using self-reported height and prepregnancy weight collected during the baseline survey, women were classified into prepregnancy BMI categories as follows: Normal weight (BMI 18.5–24.9 kg/m<sup>2</sup>), overweight (BMI 25.0–29.9 kg/m<sup>2</sup>), and obese (BMI ≥ 30.0 kg/m<sup>2</sup>). During the 1-month postpartum survey, women self-reported how much weight they gained during pregnancy. Using the IOM recommendations for GWG defined above (IOM & NRC, 2009), women were then categorized as exceeding or not exceeding the recommended GWG for their respective prepregnancy BMI category. GWG was analyzed both as a continuous variable (in kilograms) and as a dichotomized variable (exceeding or not exceeding IOM recommendations).

#### Physical activity during pregnancy

In the baseline survey, women were given a definition for regular physical activity based on the U.S. Department of Health and Human Services guidelines (i.e., ≥150 minutes of moderate-intensity physical activity, such as brisk walking, hiking or bicycling, per week; Physical Activity Guidelines Advisory Committee, 2008), and then asked how many days per week and minutes per day they were engaging in regular physical activity since becoming pregnant. A three-level variable describing physical activity during pregnancy was created, defined as inactive (<60 min/week), minimally active (60–149 min/week), and active (150 min/week or more). Women were also asked the type of physical activity they engaged in during pregnancy.

#### Covariates

Covariates were self-reported during the baseline telephone interview and were chosen to reflect variables that have been

demonstrated in the literature to be associated with GWG (IOM & NRC, 2009). Sociodemographic variables included age group (18–24, 25–29, and 30–36 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, or other), education (high school degree or less, some college or technical school, or college graduate or higher), poverty status (poverty, near poverty, or not poverty), and marital status (married, partnered/living together, partnered/not living together, or not partnered). We also included continuous variable to indicate gestational age at the time of delivery (in weeks) and a variable to indicate if women were smoking daily during pregnancy, which has been shown to be associated with lower GWG (Furuno, Gallicchio, & Sexton, 2004).

### Statistical Analysis

Frequencies of the study variables were determined. GWG (in kilograms) was compared between the normal weight, overweight, and obese women using analysis of variance (Tukey procedure) for multiple comparisons. Bivariate analyses assessed the association between adequate physical activity and exceeding the IOM recommendations for GWG, using chi-square tests. Bivariate associations between the other independent variables and exceeding GWG recommendations were also performed, using chi-square tests or *t*-tests for continuous variables. We then used multivariable logistic regression to model the

association between adequate physical activity during pregnancy and exceeding the IOM recommendations for GWG (IOM & NRC, 2009), controlling for the covariates described. All analyses were performed using SAS Version 9.3 (SAS Institute, Inc., Cary, NC).

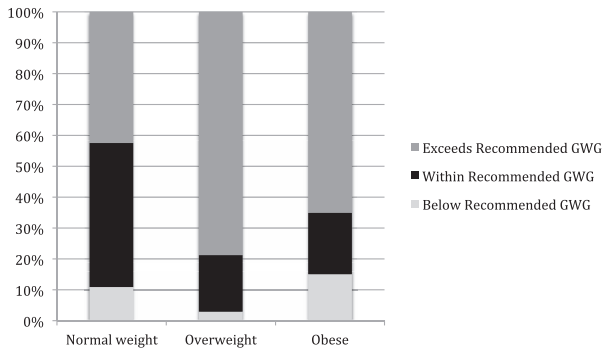
### Results

As shown in Table 1, almost half of the First Baby Study participants were either overweight or obese before pregnancy (22.9% and 21.5%, respectively). Overall, the majority of women (55.6%) gained more weight during pregnancy than recommended by the IOM guidelines for GWG, as shown in the top panel of Figure 1. As shown in the bottom panel of Figure 1, the mean  $\pm$  standard deviation GWG was  $15.6 \pm 6.2$  kg. Obese women gained significantly less weight (in kg) than each of the other weight categories ( $p < .05$ ), but there was no difference in GWG between the normal weight and overweight women. Overweight women were most likely to exceed the IOM recommendations for GWG (78.7%), followed by obese women and normal weight women (65.0% and 42.4%, respectively).

The majority of the women participated in at least some physical activity during pregnancy, with 41.2% engaging in 60 to 149 minutes and 32.1% engaging in at least 150 minutes of physical activity per week, although 26.8% engaged in less than 60 minutes of physical activity per week. The most common

**Table 1**  
Characteristics of First Baby Study Participants by Gestational Weight Gain (GWG;  $n = 2,767$ )

Factor/Variable Name	Total	Exceeded Recommended GWG ( $n = 1,538$ ; 55.6%)	Did Not Exceed Recommended GWG ( $n = 1,229$ ; 44.4%)	<i>p</i> Value
Physical activity during pregnancy				<.01
Inactive (<60 min/wk)	741 (26.8)	444 (28.9)	297 (24.2)	
Minimally active (60–149 min/wk)	1,139 (41.2)	657 (42.7)	482 (39.2)	
Active ( $\geq 150$ min/wk)	887 (32.1)	437 (28.4)	450 (36.6)	
Prepregnancy weight category				<.01
Normal weight	1,537 (55.5)	651 (42.3)	886 (72.1)	
Overweight	635 (22.9)	500 (32.5)	135 (11)	
Obese	595 (21.5)	387 (25.2)	208 (16.9)	
Age group (y)				.98
18–24	704 (25.4)	389 (25.3)	315 (25.6)	
25–29	1,106 (40)	617 (40.1)	489 (39.8)	
30–36	957 (34.6)	532 (34.6)	425 (34.6)	
Race/ethnicity				.02
White	2,313 (83.6)	1,301 (84.6)	1,012 (82.3)	
Black	200 (7.2)	113 (7.3)	87 (7.1)	
Hispanic	151 (5.5)	78 (5.1)	73 (5.9)	
Asian	54 (2)	18 (1.2)	36 (2.9)	
Other	49 (1.8)	28 (1.8)	21 (1.7)	
Education				<.01
High school degree or less	440 (15.9)	259 (16.8)	181 (14.7)	
Some college	743 (26.9)	441 (28.7)	302 (24.6)	
College degree or higher	1,584 (57.2)	838 (54.5)	746 (60.7)	
Poverty status				.96
Poverty	223 (8.6)	125 (8.6)	98 (8.5)	
Near poverty	224 (8.6)	127 (8.7)	97 (8.4)	
Not poverty	2,157 (82.8)	1,201 (82.7)	956 (83.1)	
Marital status				.03
Married	1,962 (70.9)	1,057 (68.8)	905 (73.6)	
Living with partner	494 (17.9)	299 (19.5)	195 (15.9)	
Not living with partner	173 (6.3)	100 (6.5)	73 (5.9)	
Not partnered	137 (5)	81 (5.3)	56 (4.6)	
Gestational age at delivery, weeks—mean (SD)	39.4 (1.1)	39.5 (1.2)	39.4 (1.1)	.34
Smokes daily				<.01
Yes	102 (3.7)	70 (4.6)	32 (2.6)	
No	2,665 (96.3)	1,468 (95.4)	1,197 (97.4)	



Pre-pregnancy Weight Category	GWG in kg—mean (SD)
Normal weight	16.4 (5.3)
Overweight	16.7 (6.4)
Obese <sup>a</sup>	12.5 (7.2)
Overall	15.6 (6.2)

<sup>a</sup> Obese women had significantly lower GWG (in kg) than either normal weight or overweight women ( $p < 0.05$  for both comparisons). There was no significant difference between normal weight and overweight women.

**Figure 1.** Proportions of women who are below, within, and exceed IOM recommended gestational weight gain (GWG), by prepregnancy weight category ( $n = 2,767$ ).

physical activity women reported engaging in was walking, with 81.6% reporting walking slowly and 60.0% reporting brisk walking. Smaller percentages of women reported swimming (18.9%), dancing (11.8%), participating in prenatal exercise classes (11.0%), and jogging (8.2%) during pregnancy (data not shown). Women who were inactive (<60 min/week), minimally active (60–149 min/week), and active (150 min/week or more) gained a mean  $\pm$  standard deviation of  $16.2 \pm 6.9$ ,  $15.6 \pm 6.0$ , and  $15.2 \pm 5.9$  kg, respectively; the difference in mean weight gain between the inactive and active women was significant ( $p < .05$ ). Physical activity level was also associated with exceeding/not exceeding the IOM GWG recommendations by weight category—as shown in Table 1, physical activity level was associated with not exceeding recommended GWG ( $p < .01$ ) in bivariate analysis. Women who were active were more likely to gain the recommended weight (51%) than those who were minimally active (43%) or inactive (40%). When examined within each BMI category, women who were active were less likely to have excessive GWG compared with women who were inactive, although the results were not significant. There was no interaction between BMI category and physical activity. Other significant bivariate predictors of exceeding GWG recommendations included lower educational attainment and smoking daily during pregnancy. Race/ethnicity was also significantly associated with GWG, with Asian women less likely to exceed GWG recommendations.

In the adjusted analysis (Table 2), meeting the physical activity guidelines during pregnancy was associated with a 29% lower odds of exceeding the IOM recommendations for GWG compared with inactive women. Women who were minimally active (60–149 min/week) had the same odds of exceeding GWG recommendations as inactive women. Overweight and obese women had increased odds of exceeding GWG recommendations compared with women with normal weight women (5.11 and 2.35, respectively). Women who were 30 to 36 years old (compared with women 18–24), women who were not college graduates (compared with college graduates), and unmarried women living with their partners were also significantly more likely to exceed the GWG recommendations. Asian women had significantly lower odds of exceeding the GWG recommendations.

**Table 2**  
Logistic Regression Modeling Exceeding Gestational Weight Gain (GWG) Recommendations ( $n = 2,603$ )

Factor/Variable Name	Exceeds GWG Recommendations Adjusted Odds Ratio (95% Confidence Interval)
Physical activity during pregnancy	
Inactive (<60 min/wk)	Reference
Minimally active (60–149 min/wk)	0.97 (0.79–1.2)
Active ( $\geq 150$ min/wk)	0.71 (0.57–0.88)
Prepregnancy weight category	
Normal weight	Reference
Overweight	5.11 (4.08–6.4)
Obese	2.35 (1.91–2.89)
Age group (y)	
18–24	Reference
25–29	1.28 (0.96–1.7)
30–36	1.45 (1.07–1.96)
Race/ethnicity	
White	Reference
Black	0.86 (0.58–1.27)
Hispanic	0.68 (0.45–1.02)
Asian	0.51 (0.27–0.96)
Other	1.02 (0.55–1.88)
Education	
High school degree or less	1.46 (1.05–2.03)
Some college	1.23 (0.98–1.53)
College degree or higher	Reference
Poverty status	
Poverty	0.85 (0.6–1.2)
Near poverty	0.86 (0.62–1.19)
Not poverty	Reference
Marital status	
Married	Reference
Living with partner	1.48 (1.13–1.94)
Not living with partner	1.37 (0.88–2.14)
Not partnered	1.46 (0.91–2.34)
Gestational age at delivery (wks)	1.02 (0.95–1.1)
Smokes daily	
Yes	1.49 (0.9–2.49)
No	Reference

## Discussion

Our main finding was that more than 150 minutes per week of physical activity during pregnancy, in concordance with national guidelines (Physical Activity Guidelines Advisory Committee, 2008), was associated with 29% lower odds of exceeding GWG recommendations. Interestingly, lower levels of physical activity (60–149 minutes per week) were not protective against excessive GWG. Several studies, including randomized, controlled trials, have demonstrated the inverse relationship between exercise and GWG, supporting the role of IOM recommendations that prenatal care providers offer counseling on physical activity (IOM & NRC, 2009; Phelan, 2010; Stuebe et al., 2009). For example, Stuebe and colleagues (2009) demonstrated that vigorous physical activity in the second trimester resulted in a 24% lower odds of exceeding GWG. Unfortunately, pregnancy is a time of decreased physical activity for most women (Pereira et al., 2007). Pregnancy may serve as an ideal time for prenatal care providers to target weight control and healthful activities, such as meeting physical activity guidelines, given its characterization as a “teachable moment” (Phelan, 2010). However, our current understanding of prenatal provider counseling patterns suggests more than one third of women do not receive any advice regarding GWG (Ferrari &



Siega-Riz, 2013; Stotland et al., 2005). Further, pregnant women who do receive counseling may not be advised to meet federal guidelines for physical activity; a recent survey found that more than one quarter of obstetricians did not believe moderate intensity exercise was beneficial (Evenson & Pompeii, 2010). Our study findings highlight the importance of meeting the physical activity guidelines to moderate GWG and suggest that healthcare providers encourage their prenatal patients to meet the guidelines and emphasize that engaging in only “some activity” may not be sufficient to control GWG.

The majority of first-time mothers (55.6%) in our study exceeded the current IOM guidelines for GWG. These findings are comparable with other recent studies examining guideline-concordant weight gain (Ferrari & Siega-Riz, 2013; Stuebe et al., 2009). Stuebe and colleagues (2009) found 51% of women in their prospective cohort ( $n = 1,388$ ) experienced excessive GWG. Ferrari & Siega-Riz (2013) demonstrated that 78% of women in their prospective cohort ( $n = 1,454$ ) had exceeded recommended weight gain. We found that although normal weight and overweight women gained similar amounts of weight in pregnancy, obese women gained significantly less weight in comparison. However, the mean weight gain in all three BMI categories exceeded IOM guidelines. Particularly concerning is the finding that overweight women were at significantly increased risk of excessive GWG, with more than five times the odds of excessive GWG compared with normal weight women. This elevated risk is particularly concerning because excessive GWG is known to increase postpartum weight retention (Callaway et al., 2007; Linne, Dye, Barkeling, & Rossner, 2003, 2004). Therefore, higher rates of weight gain in overweight women further threatens their post-pregnancy health. As the second most preventable cause of death (Mokdad et al., 2001), obesity is a risk factor for cardiovascular disease, stroke, several types of cancer, and diabetes mellitus (Thompson, Edelsberg, Colditz, Bird, & Oster, 1999). Also of concern is the limited intervention evidence for moderating GWG among overweight and obese pregnant women. That is, although interventions have been able to modify GWG among normal weight women (Phelan et al., 2011; Polley, Wing, & Sims, 2002; Ruchat et al., 2012), few, if any, interventions have effectively moderated GWG in overweight/obese women. This remains an important area of future research.

This study has several limitations. First, participant height, weight, and GWG were obtained by self-report. However, women's self-report of prepregnancy weight has been validated (Oken, Taveras, Kleinman, Rich-Edwards, & Gillman, 2007). Further, as self-report has been shown to underestimate weight when compared with objective measures, this would suggest even greater rates of excessive GWG than demonstrated (Elgar & Stewart, 2008; Stommel & Schoenborn, 2009). Another limitation is that physical activity was obtained by participant self-report; however, this methodology remains widely used despite overestimating activity when compared with objective measures (Chasan-Taber, Evenson, Sternfeld, & Kengeri, 2007). Although the physical activity questionnaire used was not validated, it parallels the Leisure-Time Exercise Questionnaire, a validated measure of physical activity. The Leisure-Time Exercise Questionnaire and other physical activity measures have been similarly adapted in recent years to convert metabolic equivalents to bouts and minutes of physical activity, to parallel the federal physical activity guidelines. An additional limitation is the potential for residual confounding not controlled for in our analysis. For example, prepregnancy physical activity and dietary

intake were not assessed, which may predict GWG and gestational physical activity, respectively. We also did not account for the specific types or levels of physical activity in which women engaged, outside of “moderate.” However, the IOM report concluded that the evidence base remains too limited to draw conclusions for these factors (IOM & NRC, 2009). Last, our study is limited in its ability to generalize these results to other populations. Women in the First Baby Study were older, more likely to be White, have more education, more likely to have private insurance, and less likely to smoke than the general population of women having their first, singleton birth (Kjerulff et al., 2012).

Our study also has important strengths. The First Baby Study is a large, observational study, which allows for the determination of associations limited by smaller studies. Further, the study design allowed weight and physical activity data to be obtained during pregnancy, thereby limiting participant recall bias. Our finding that guideline-concordant physical activity was associated with decreased GWG in this population further supports that real-world activity, outside of clinical interventions, is effective.

### Implications for Practice and/or Policy

Our findings reveal high rates of excessive GWG, especially among women with overweight and obesity. We also demonstrated that only guideline-concordant levels of physical activity, and not less, were inversely associated with GWG. The association of guideline-concordant physical activity with appropriate GWG suggests this is an important target for future interventions. Provider-based interventions during pregnancy may be particularly relevant given pregnancy is a particularly “teachable” moment for weight control (Phelan, 2010). Appropriate GWG and physical activity should be encouraged among all pregnant women, in accordance with current guidelines (IOM & NRC, 2009), to reduce both short-term pregnancy complications and the long-term risks of overweight and obesity.

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