Published in final edited form as:

J Adolesc Health. 2017 November ; 61(5): 626–633. doi:10.1016/j.jadohealth.2017.05.005.

Effect of gestational weight gain and prepregnancy BMI in adolescent mothers on weight and BMI of adolescent offspring

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Abstract

Purpose—To examine the association of the gestational weight gain and prepregnancy BMI of low income adolescent mothers with the risk of their children being overweight and/or obese in late adolescence.

Methods—Study subjects were low-income, primiparous adolescents ($n = 360$) who self-identified as black and participated in the New Mothers Study in Memphis, TN and their children. Gestational weight gain was examined as a continuous variable and also categorized into over-gain, recommended gain, and under-gain following the 2009 Institute of Medicine guidelines. The effects of maternal prepregnancy BMI percentiles and calculated BMI were also considered. Multivariable logistic and linear regression models were used. The main outcome measures were offspring overweight, obesity, and body mass index.

Results—Thirty-nine percent of offspring were overweight or obese. Higher maternal gestational weight gain increased the risk for offspring overweight and obesity. There was an interaction between gestational weight gain and prepregnancy BMI: offspring of mothers with a BMI percentile < 76 were at greater risk of obesity with higher maternal weight gain. If mothers with a BMI percentile between the 29th and 83rd percentiles over-gained, offspring were at greater risk for overweight. Using calculated BMIs, if a mother's BMI was $< 26 \text{ kg/m}^2$ offspring risk for obesity was greater with higher gestational weight gain.

Conclusions—High gestational weight gain had a larger effect on offspring overweight and obesity if maternal prepregnancy BMI percentile was < 76 .

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The gestational weight gain of primiparous adolescents who self-identified as black had an effect on offspring weight

Implications and Contributions: Higher maternal prepregnancy BMI and greater gestational weight gain in primiparous adolescents who identified as black were detrimental to their adolescent offspring. Offspring of underweight and normal weight mothers appeared to have a greater risk of overweight/obesity when their mothers had a higher pregnancy weight gain. Absolute gestational weight gain, as opposed to categories based on prepregnancy BMI, may be a better predictor of offspring obesity.

Conflict of interest: There is no known conflict of interest for any of the authors of this manuscript.

Keywords

gestational weight gain; adolescents; offspring outcomes; prepregnancy body mass index; obesity

High gestational weight gain and maternal prepregnancy body mass index (BMI) contribute to long-term weight retention in women [1, 2]. Evidence is mounting that they also contribute to an unhealthy BMI in offspring [3–5] and consequently the obesity epidemic. Maternal obesity and excessive gestational weight gain result in a state of overnutrition for the fetus [6] and their association with offspring obesity may be through genetic and epigenetic (*in utero* programming) effects [7–9], thus establishing a life-long predisposition to obesity [7, 8]. Such programming, in conjunction with an increased birth weight due to high gestational weight gain and shared genetic and environmental factors (e.g. diet), can influence long-term body weight [8]. Given that gestational weight gain and prepregnancy BMI are modifiable factors that affect risk for overweight or obesity in offspring, it is important that we increase our understanding of how these factors differ depending on maternal factors such as age, racial group and parity.

Studies examining the long-term effects of gestational weight gain have primarily included adult women, although a small percentage of adolescents have been incorporated in some studies [10, 11]. Adolescents are as likely as adults to experience excessive gestational weight gain [12, 13] and if they gain excessively during pregnancy they are also at risk of having large for gestational age infants [13]. In addition, adolescents are at greater risk of preterm births [14], smaller babies, and pregnancy complications compared to adults [2].

Adolescents continue to grow while they are pregnant [15–17]. Bone growth [16, 18], leptin surge [15], and bone loss [17] differences found in pregnant adolescents compared to adult women provide evidence that physiologic changes in pregnancy are different for adolescents than for adults. Hence, it is plausible that excessive gestational weight gain affects the pregnancy and fetal environment differently in adolescents than in adults. Although there appear to be differences, findings are conflicted on whether adolescent continued growth influences fetal outcomes [16, 18]. It is unknown if these apparent differences might alter how prepregnancy BMI and excessive gestational weight gain affect offspring obesity.

The effects of maternal gestational weight gain differ by race [19]. While race and ethnicity have been adjusted for in some studies that examined offspring outcomes [9, 10, 20] none have specifically considered a minority group. Fetal growth differs depending on racial group, with black women delivering smaller infants [21] and small infants are at increased risk for adult obesity and metabolic diseases [22]. Whether the effect of excessive gestational weight gain on offspring outcomes later in life differs by racial group has not been reported.

Although there are inconsistencies, it appears as though a first pregnancy contributes to maternal weight retention more than subsequent pregnancies [23, 24]. Whether the uterine environment, which appears to influence offspring outcomes, is different in an initial pregnancy as opposed to subsequent pregnancies is unknown. Thus, parity is an important

consideration when examining the effects of maternal gestational weight gain and prepregnancy BMI.

Gestational weight gain is typically categorized into under-, recommended, and over-gain, using prepregnancy BMI categories as specified in the 2009 IOM recommendations [2]. The IOM indicates that during pregnancy women who are underweight (BMI < 18.5 kg/m²) should gain 28–40 pounds; women who are a healthy weight (BMI > 18.5 to 24.9 kg/m²) should gain 25–35 pounds; women who are overweight (BMI > 25 – 29.9 kg/m²) should gain 15–25 pounds; and women who are obese (BMI > 30 kg/m²) should gain 11–20 pounds.

Alternatively, gestational weight gain can be used as a continuous measure assessing the effect of increasingly higher weight gain. The 2009 IOM guidelines do not differentiate between adolescents and adults [2]. However, some adolescents will be misclassified into a lower BMI category if adult BMI categories are used as opposed to adolescent age-sex specific BMI percentile ranges [12, 25]. Consequently, those adolescents are advised to gain more than recommended for their true BMI category. The finding that most adolescents gain excessively and have greater postpartum weight retention than adults, even if BMI percentiles are used, suggests that utilizing adult cut points may be a disservice to adolescents. The objective of this study was to examine the association of the gestational weight gain and prepregnancy BMI of black adolescent mothers, using age-sex adjusted BMI percentiles and adult calculated BMI, with the risk of overweight and/or obesity in their adolescent children. This study was approved by the University of Rochester Institutional Review Board.

METHODS

Secondary data analysis was conducted utilizing data from the New Mothers Study that began in 1990 and was conducted in Memphis, TN [26]. Eighteen-year follow-up data were collected from 2009–2014. The New Mothers Study was a randomized controlled trial of the Nurse-Family Partnership home visiting program for primiparous mothers seeking prenatal care at a clinic primarily serving Medicaid-covered women. The nurse visiting period was from intake before 28 weeks of pregnancy through the child's 2nd birthday. To participate in the New Mothers Study, mothers had to enroll before the 27th week of pregnancy and meet two of the following three high-risk criteria: less than high school education, unmarried, and unemployed. Women with chronic medical conditions related to fetal growth restriction or preterm birth were excluded. The resulting sample was primarily black (92%) and young (mean age of 18). Eighty-eight percent of the eligible women obtaining care at the Regional Medical Center in Memphis, TN were enrolled in the original study.

For these analyses, we used only the adolescents (< 20 years old) who self-identified as black. We limited the sample to these adolescents because differences in gestational weight gain and health outcomes between racial groups have been reported [27, 28], plus there were few white adolescents in the sample. We limited the sample to adolescents because if these mothers were still growing the impact of gestational weight gain could be different from

adult mothers: it has been documented that 35–50% of adolescent pregnant females between 14 and 18 years of age continue to grow during pregnancy [18, 29].

There were 516 black adolescent mothers in the original sample. We excluded those with preterm births ($n=83$), because their gestational weight gain would be different due to the shorter gestation. One mother had an initial BMI $> 45 \text{ kg/m}^2$ and was excluded from these analyses, because the impact of gestational weight gain on someone already so obese may be different from those with lower BMIs. We also excluded mothers who were missing gestational weight gain data ($n=31$), leaving a final sample of 399 adolescents. Data were collected on 360 of their children (90.2%) at an average age of 18 years old (range = 17.5–23.3; table 1). Of these, 328 had sufficient information to calculate BMI. Only Aid to Families with Dependent Children receipt was missing in more than 5% of the observations (7%), so we dropped cases with missing data, resulting in a final sample size of 295.

Gestational Weight Gain and Prepregnancy BMI

Gestational weight gain was calculated from the self-reported prepregnancy weight and the last weight prior to delivery. Self-reported weight has been found to be a valid estimate of body weight for prepregnant weights in adolescents [30] and in the general population [31], although it is less accurate for overweight women who tend to underreport their weight. We analyzed gestational weight gain both as a continuous variable, and also categorized into: over-gain, recommended gain, and under-gain, following the current IOM guidelines [2].

Body mass index was determined in two different ways. First, since our sample was less than 20 years old at the estimated time of conception, maternal prepregnancy BMI was converted to a sex- and age-adjusted percentile rank using a SAS macro from the Centers for Disease Control and Prevention [32], specifically developed for children ages 2–20 years old. Body mass index was categorized as overweight if the age and sex-adjusted BMI percentile rank was $> 85^{\text{th}}$ percentile, and as obese if the adjusted BMI percentile was $> 95^{\text{th}}$ percentile. A separate category for underweight was not created due to the limited number of underweight adolescent mothers in this sample (2.5%). Second, consistent with the IOM guidelines, standard adult BMI categories were used for classification as calculated BMI: underweight (BMI $< 18.5 \text{ kg/m}^2$); normal weight ($> 18.5 \text{ kg/m}^2$ and $< 25 \text{ kg/m}^2$); overweight (BMI $> 25 \text{ kg/m}^2$ and $< 30 \text{ kg/m}^2$); and obese (BMI $> 30 \text{ kg/m}^2$).

Outcomes

Child BMI was based on measured height and weight when possible; nine participants provided self-report height and/or weight. For children who were under the age of 20, the SAS macro from the Centers for Disease Control [32] was used to calculate the BMI percentile, and BMI was categorized as described above for mother's age-sex adjusted prepregnancy BMI percentile. For children 20 years of age and over, adult BMI category cutoffs were used; BMI was categorized as normal weight if BMI was $< 25 \text{ kg/m}^2$, overweight if the BMI was $> 25 \text{ kg/m}^2$ and $< 30 \text{ kg/m}^2$, and as obese if the BMI was $> 30 \text{ kg/m}^2$.

Covariates

We included the following pregnancy and birth characteristics as covariates because they can have an effect on offspring weight: maternal age at conception of the first child [13]; if the mother smoked during pregnancy [33]; and sex of the child. Later covariates that could influence offspring weight were also included: if the child was breastfed [34]; the percentage of months the family received welfare (Aid to Families with Dependent Children) [35]; and if the offspring had any live births (to account for weight gain due to pregnancy; this is only relevant for female children of the adolescent mothers).

The intervention (home visiting program) was included, because it was intended to improve health practices. We also included two interactions based on previous work: the sex of the child and the intervention, and gestational weight gain and the intervention [36]. Models were run with and without an interaction between gestational weight gain and the mother's prepregnancy BMI, based on a previous study [36]. Interactions between gestational weight gain and both smoking and age were examined because each of these covariates could potentially moderate the relationship between gestational weight gain and later child BMI: smoking could impact the relationship because it increases the risk of a lower birth weight infant; maternal age could impact the relationship because young mothers who are still developing physically might gain differently.

Statistical Analysis

Associations between gestational weight gain and the dichotomous outcomes overweight and obesity were analyzed with multivariable logistic regression. Both unadjusted and adjusted models (including all covariates described above) are reported. BMI percentile was analyzed with multivariable linear regression. To allow comparison with previous literature, we repeated these analyses using gestational weight gain categorized into over- and under-gaining compared to recommended gain per the IOM guidelines and also with the calculated BMI instead of BMI percentile. Interactions between gestational weight gain and both smoking and age were not significant in any models, and therefore not included in the final models. All analyses were conducted using Stata 14.

RESULTS

Descriptive statistics are depicted in Table 1. The majority of adolescent mothers (74%) had a normal prepregnancy BMI. Their overall gestational weight gain was relatively equally distributed among the three groups identified in the IOM guidelines; over-gain, recommended gain, and under-gain. Thirty-nine percent of the adolescent children were overweight or obese.

Nearly 53% of the children born to adolescent mothers who were in the normal or underweight range prior to pregnancy and over-gained during pregnancy were overweight or obese as adolescents (Figure 1). Approximately 31% of the children of normal/underweight mothers who gained within the IOM guidelines were also overweight or obese as adolescents. If adolescent mothers were overweight or obese prior to pregnancy and over-gained during pregnancy nearly 47% of their offspring were overweight or obese as

adolescents. Approximately 58% of the children of overweight and obese mothers who gained within the IOM guidelines were also overweight or obese.

The multivariable models were similar in both magnitude and significance whether the covariates were included or not (Table 2). Therefore, we will focus on the adjusted models for the remainder of the manuscript. For each outcome (child overweight, obesity, BMI percentile), higher maternal prepregnancy BMI percentile was associated with higher child weight (Table 2). An interaction between prepregnancy BMI percentile and gestational weight gain was associated with child weight status (Table 2 and Figure 2): gestational weight gain had a greater impact on the child's weight status for mothers who had a lower prepregnancy BMI for all outcomes.

In the case where gestational weight gain was categorized according to IOM guidelines the children of mothers who over-gained were more likely to be overweight (Table S1). In models using categorized gestational weight gain, over-gain predicted offspring overweight if the maternal prepregnancy BMI was between the 29th and 83rd percentiles (Table S1 and Figure S1 & S2). The impact of over-gain was higher on offspring BMI percentile when maternal prepregnancy BMI was lower, especially when maternal BMI percentile was less than 68%.

In analyses using prepregnancy BMI as the calculated measure the BMI influence on offspring weight was similar to that of prepregnancy BMI percentile (Table S2). There was also an interaction between prepregnancy calculated BMI and gestational weight gain. The mothers with a BMI < 28 kg/m² and with higher gains during pregnancy were more likely to have overweight children and mothers with a BMI < 26 kg/m² and higher gains during pregnancy were more likely to have children who were obese.

DISCUSSION

For primiparous adolescent mothers who self-identified as black, whether age-adjusted BMI percentiles or calculated BMI were used to delineate maternal BMI, prepregnancy BMI was consistently a predictor of child weight status as adolescents. Absolute gestational weight gain was also a predictor, with higher gestational weight gain increasing the risk of offspring overweight and obesity. There was an interaction between gestational weight gain and prepregnancy BMI percentile: for mothers whose BMI percentile was <85 or < 76, gestational weight gain had a stronger effect on offspring overweight and obesity respectively, than that of overweight or obese mothers. Similarly, for mothers whose calculated BMI was < 28 or < 26 kg/m² the risk of child overweight or obesity was significantly greater. Finally, the children of women who over-gained per the IOM guidelines were at risk of overweight if maternal prepregnancy BMI was between the 29th–83rd percentiles.

We are unaware of any other studies specific to primiparous adolescent mothers who self-identified as black that report gestational weight gain and prepregnancy BMI effects on offspring weight in late adolescence. Our findings are consistent with a systematic review [3] and two meta-analyses [4, 5] that concluded gestational weight gain can be a risk factor

for childhood obesity from early childhood through 19 years of age [3], and that excessive gestational weight gain affects short and long-term offspring obesity [4, 5].

In our sample, gestational weight gain had a greater effect on children if maternal prepregnancy BMI percentiles were <85 (or < 76) compared to children of overweight/obese mothers, even though overall higher maternal BMIs were associated with higher child weights. This is consistent with other studies that have examined adolescent offspring [8, 20]. Diesel et al. (2015) observed that for adult mothers the risk of offspring obesity as a consequence of gestational weight gain varied by maternal prepregnancy BMI, with the risk specific to children of lean mothers [20]. In that study (n=514), the effect of gestational weight gain was not evident until lean women gained around 16 kg, which is the cut point for over-gain per the IOM guidelines. Conversely, Stuebe et al. (2009) in a sample of mothers and daughters (n = 26,506), used maternal recalled prepregnancy BMI of 29 kg/m², compared to a recalled prepregnancy BMI of 21 kg/m², and found that higher prepregnancy BMI and high (> 40 pounds) or low (< 10 pounds) gestational weight gain increased the risk of offspring obesity [37]. In this case, the association of gestational weight gain with child weight was stronger in overweight women. These differing results may be explained by: our sample being entirely adolescent, primiparous and homogeneous in terms of race compared to women of mixed parity, race, and age; the use of different methods of categorizing gestational weight gain or categorizing vs. using continuous values; and a differing prevalence of offspring obesity in study samples (Stuebe et al. (2009) –2.1%; Diesel et al. (2015) –22%; our sample –21%).

The interaction between gestational weight gain and prepregnancy BMI in this study is also consistent with studies of pre-adolescent offspring [7, 9]. Sridhar et al. (2014) reported a significant interaction of gestational weight gain with prepregnancy BMI, in which case the association between gestational weight gain and a higher child weight was stronger if maternal prepregnancy BMI was < 25 kg/m² [38]. Hinkle et al. (2012) reported slightly different results: over-gain was associated with an increase in child BMI among both normal and overweight mothers [7].

The long-term effect of maternal gestational weight gain on offspring overweight and obesity in primiparous black adolescent mothers appears to be similar to adult multiparous women of varied racial groups. The 2009 IOM report indicated that there is limited data linking gestational weight gain to long-term health outcomes beyond the neonatal period, and that there is inadequate evidence to reject possible racial/ethnic modifications of an association [2]. Our study contributes to understanding in both of these areas, as well as providing an added refinement by including only primiparous mothers.

Recent studies, including ours, provide evidence that an interaction between prepregnancy BMI and gestational weight gain in relation to offspring weight, although there is variation in terms of the prepregnancy BMI level at which the interaction becomes evident. We found slight differences depending on whether age-sex adjusted BMI percentiles or calculated BMI was used. The increased effect of gestational weight gain on child overweight and obesity occurred if mothers were within a normal weight range when BMI percentiles were used. With the calculated BMI maternal overweight prior to pregnancy also contributed to child

overweight or obesity. Given that adolescents may be misclassified when calculated BMI values are used [25], the age-sex adjusted BMI percentiles may be the more precise option for adolescent mothers.

As evidence for an interaction effect builds, questions of mechanism and implications for clinical practice arise. Lawlor et al. (2011) proposed that the impact of gestational weight gain on offspring of overweight/obese women is through intrauterine environmental programming, potentially via developmental over-nutrition and/or epigenetic changes, while for normal weight women it is predominantly because of shared genetic and environmental characteristics [8]. It could be that underweight and normal weight mothers with higher gestational weight gain are ‘taking on’ a larger proportion of weight relative to their prepregnancy body size than occurs for overweight and obese women. It is plausible that with a more extreme change of the pregnancy milieu, biological effects have a more profound effect on the intrauterine environment and therefore the offspring.

Another possible mechanism is through fat accrual: non-overweight women accrue significantly more adipose tissue during pregnancy than obese women, even when gaining the same amount of weight, which could affect the pregnancy environment by decreasing insulin sensitivity [38, 39]. Specific to adolescents, it has been suggested that in growing adolescents there is reduced lipolysis of pregnancy-accrued fat deposition late in pregnancy, which decreases availability of glucose to the fetus, thus limiting fetal growth [15] and consequently increasing the risk of obesity across the lifespan [40].

There are several strengths and limitations to this study. The original study was a randomized controlled trial that enrolled 88% of those eligible, representing the Memphis population of low-income pregnant women. This is the first study examining the pregnancy outcome of adolescent offspring overweight and obesity using a sample of black, low-income primiparous adolescent mothers, a unique and important population. However, the sample is from one city in the US and therefore generalizability is limited. Furthermore, the analyses were not extended to include environmental factors that could affect growth and weight in children, nor did it include behavioral factors (e.g. diet and physical activity), which could have added further information on offspring weight.

CONCLUSION

In conclusion, the findings provide evidence that higher maternal prepregnancy BMI and greater gestational weight gain in black adolescent mothers are both detrimental for the weight of adolescent offspring. Furthermore, the offspring of underweight and normal weight adolescents appear to have a greater risk of overweight and/or obesity if their mothers have a high gestational weight gain. Adolescent mothers in these BMI categories should be encouraged to gain within the IOM guidelines and/or attempt to stay within the mid-lower range of the guidelines. Absolute gestational weight gain, as opposed to categories, may be a better predictor of offspring obesity in black adolescents.

Additional research is needed to expand our understanding of what occurs differently for underweight and normal weight adolescent mothers compared to those who are overweight

or obese. Such research would inform how to advise pregnant adolescents regarding gestational weight gain. Exploration of epigenetic effects during pregnancy would contribute to an understanding of mechanisms of maternal gestational weight gain and prepregnancy BMI effects on offspring long-term health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This work was supported by the National Institute on Drug Abuse (R01 DA021624, 2008–2015).

Abbreviations

BMI	body mass index
IOM	Institute of Medicine
TN	Tennessee

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Figure 1.
 Relationship between mothers' gestational weight gain and their first child's BMI categories in late adolescence.

Figure 2.

Average marginal effect of interaction between mother's gestational weight gain (GWG; continuous) and prepregnancy BMI on child's body weight in late adolescence. Dotted lines indicate 95% confidence interval.

Table 1

Adolescent mothers and their offspring: sample description (N=295)

Variable	%	Mean (SD)	Range
Mother Variables^a			
Underweight preconception (<5 th %ile)	1.7%		
Normal preconception (5 th to <85 th %ile)	75.6%		
Overweight preconception (85 th to <95 th %ile)	15.3%		
Obese preconception (95 th %ile)	7.5%		
Gestational weight gain in pounds, overall mean		30.8 (15.7)	−14, 96
Gestational weight gain if underweight (<5 th %ile)		30.1 (14.2)	14, 46
Gestational weight gain if normal (5 th to <85 th %ile)		30.8 (13.6)	−7, 90
Gestational weight gain if overweight (85 th to <95 th %ile)		32.0 (19.0)	−4, 96
Gestational weight gain if obese (95 th %ile)		29.2 (25.5)	−14, 91
% who over-gained ^b	38%		
% within recommended gain ^b	29%		
% who under-gained ^b	33%		
Child Variables^c			
Body mass index overall mean (kg/m ²)		26.1 (6.2)	15.0, 55.1
Overweight	17.3%		
Obese	21.4%		
Covariates (Mother)			
Smoking: ever heavy	12.2%		
Smoking ever, but not heavy	26.4%		
Prepregnancy BMI (kg/m ²)		22.7 (4.4)	15.7, 42.3
Age at conception of first child (years)		16.2 (1.6)	12–19
Age <16 years	31.5%		
Age 16–17 years	42.7%		
Age 18–19 years	31.2%		
% of months on AFDC ^e at 18 years (SES) ^f		31 (27)	0–90
Ever breastfed study child ^d	12%		
Covariates (Child)^c			
Age at time of 18 year interview (years)		18.4 (0.5)	17.5, 19.9
Smoked in last 30 days	14.6%		
Female	51%		
If female, ever pregnant (N=45)	30%		
Live births=0	36%		
Live births=1	51%		
Live births=2	11%		
Live births=3	2%		
Birthweight (g)		3193 (463)	1639, 4540

^aPreconception weight self-report at intake interview; gestational weight gain calculated from last measured weight before delivery.

^bWeight gain categories based on the 2009 IOM guidelines.

^cInterview scheduled near the study child's 18th birthday.

^dInterview scheduled near the study child's 1st birthday

^eAid to Families with Dependent Children

^fInterviews were conducted during pregnancy at enrollment and at 28 and 36 weeks; and through the child's life at 6, 12, and 24 months, 4.5, 6, 9, 12, and 18 years.

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Table 2

Predicting child weight outcomes with gestational weight gain (continuous measure) and mother's prepregnancy BMI percentile. An interaction between gestational weight gain and prepregnancy BMI percentile was included in a second model

Unadjusted models	Child Overweight		Child Obesity		Child BMI percentile	
	Interaction not included	Interaction model	Interaction not included	Interaction model	Interaction not included	Interaction model
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	beta (95% CI)	beta (95% CI)
Gestational weight gain	1.04 (1.004, 1.08) *	1.10 (1.05, 1.16) *	1.03 (0.99, 1.07)	1.13 (1.06, 1.21) *	0.37 (-0.05, 0.78)	1.30 (0.77, 1.83) *
Prepregnancy BMI percentile	1.02 (1.01, 1.03) *	1.02 (1.01, 1.03) *	1.02 (1.01, 1.04) *	1.03 (1.02, 1.04) *	0.26 (0.16, 0.37) *	0.26 (0.16, 0.36) *
Gestational weight gain $\times$ Prepregnancy BMI		0.998 (0.996, 0.999) *		0.997 (0.99, 0.999) *		-0.04 (-0.06, -0.0271) *
Range of Prepregnancy BMI where Gestational weight gain is significant ^a		76 *		75 *		70 *
Adjusted models^b						
Gestational weight gain	1.08 (1.03, 1.13) *	1.13 (1.06, 1.20) *	1.04 (0.996, 1.09)	1.14 (1.06, 1.22) *	0.60 (0.12, 1.08) *	1.36 (0.80, 1.93) *
Prepregnancy BMI percentile	1.02 (1.01, 1.03) *	1.02 (1.01, 1.03) *	1.03 (1.02, 1.04) *	1.03 (1.02, 1.05) *	0.29 (0.18, 0.39) *	0.29 (0.18, 0.39) *
Gestational weight gain $\times$ Prepregnancy BMI		0.998 (0.996, 0.9996) *		0.997 (0.995, 0.999) *		-0.04 (-0.05, -0.02) *
Range of Prepregnancy BMI where Gestational weight gain is significant ^a		85 *		76 *		72 *

* $P < .05$

Exclusions: Pre-term births, prepregnancy BMI > 45 , mother's age during pregnancy > 19

^aSignificance calculated based on estimation of marginal effects across levels of prepregnancy BMI.

^bAdjusted models include: sex of child, percent of months on welfare (AFDC), intervention, gestational weight gain $\times$ intervention, sex of child $\times$ intervention, child breastfed, mother smoker during pregnancy, parity of study child ($=0$ if male), maternal age (<16 , $16-17$, $18-19$)