Journal of Perinatology
https://doi.org/10.1038/s41372-018-0051-9

ARTICLE

Stress during pregnancy and gestational weight gain

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Received: 14 September 2017 / Revised: 11 December 2017 / Accepted: 2 January 2018

Abstract

Objective To evaluate the association between prenatal stress and gestational weight gain (GWG).

Study design This was an analysis of women recruited between 2013–2015 from four sites in the US. We tested associations between responses at 32–35 weeks to the Life Experiences Survey (LES), a 37-item measure of events and perceived stress, and GWG categories. Bivariable comparisons and logistic regression were used to estimate the association between the total LES score and the odds of achieving adequate GWG.

Result Among the 725 women, those with adequate GWG had lower median LES scores (5) compared to women with inadequate (7) and excessive (7) GWG, $p = 0.02$. After adjusting for age, initial BMI, income, education, marital status and gestational diabetes, lower LES scores (multiples of the median) were associated with adequate GWG (aOR 0.81, 95% CI 0.67–0.98).

Conclusion Lower reported stress, as measured by the LES, was associated with a greater chance of women achieving adequate GWG. This relationship highlights the potential for interventions directed toward psychosocial support to have salutary effects upon GWG.

Introduction

In 2009, the Institute of Medicine (IOM) updated the guidelines for gestational weight gain (GWG) and highlighted the importance of meeting goals for appropriate GWG so as to improve perinatal outcomes [1] The recommended GWG ranges for underweight (28–40 pounds), normal weight (25–35 pounds), and overweight (15–25 pounds) women were similar compared to the prior recommendations, but were more defined for women with obesity (11–20 pounds). Nonetheless, according to a national study, only 32% of all women met these goals and 47% exceeded them in 2010–2011 [2]. Although inadequate GWG is less common (21%) than excessive GWG, it is also significantly associated with adverse perinatal outcomes, such as low birth weight [1, 2].

Given that such a high proportion of women fail to meet GWG goals, achieving a better understanding of modifiable factors related to GWG is a public health priority. The majority of studies to date have primarily evaluated socio-demographic (race, ethnicity, socioeconomic status), behavioral (physical activity, dietary intake) and physiological characteristics (height, weight, age). Although these characteristics are important, psychosocial factors such as stress have been shown to be associated with a variety of adverse behaviors, including those related to eating, and should therefore be further studied in the context of GWG [3, 4].

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Published online: 29 January 2018

The limited number of prior studies that have evaluated the relationship between stress and GWG have reported inconsistent results and used differing measures of stress, such as the Perceived Stress Scale (PSS) and the Prenatal Social Environment Inventory [5–9]. The Life Experiences Survey (LES) measures life changes that could be potentially stressful as either "negative" or "positive" events [10]. Many of these changes are common in pregnancy (e.g., relocating to accommodate new family members, appetite changes due to nausea and vomiting, and changes in family due to marriage or separation), yet are typically all measured as "negative" events in surveys of stress during pregnancy. The LES could therefore be potentially more informative about stress during pregnancy as it allows women to rank events as "negative" or "positive". When the IOM summarized the findings regarding the relationship between stress and GWG, they stated that stress appeared to have a modest association with either inadequate or excessive GWG, but further research was needed to clarify the relationship [1]. Indeed, because many of these studies were performed before the updated GWG guidelines and one of them excluded women with a pre-pregnancy body mass index (BMI) >26 kg/m^2, a more contemporary study of the relationship is needed. Therefore, the objective of this study was to evaluate the association between prenatal stress, as quantified by a validated survey instrument, and GWG.

Materials and methods

This is an analysis of data from a prospective observational study, the Measurement of Maternal Stress (MOMS) Study, of 744 pregnant women, in which participants were enrolled between 2013–2015 from four sites: Northwestern University, University of Texas Health Science Center at San Antonio, University of Pittsburgh, and Children's Hospital of Philadelphia between 12 and 0/7 weeks and 20 and 6/7 weeks gestation. The overall goal of the study was to determine reliable, acceptable, and cost-efficient approaches for the assessment of self-reported and biological markers of maternal stress. The inclusion criteria were ≥18 years, singleton pregnancy, <21 weeks pregnant, and English speaking. Women were excluded if they had known fetal congenital or chromosomal anomalies, progesterone treatment, or chronic corticosteroid use.

The LES, administered from 32 0/7 to 35 6/7 weeks, was adapted from a 57-item measure of potentially stressful life changes as originally proposed by Sarason et al. [10]. The survey used in the MOMS study included a subset of 37 questions from the LES selected by expert opinion (PW, BC, SE) following a pilot trial of the questionnaire in a pregnant study population to measure stress during pregnancy. The survey asked participants about events that occurred since becoming pregnant, such as marriage, death of partner or close family member/friend, change in sleeping or eating habits, law violation, change in work situations, close family member or friend with serious illness, sexual difficulties, gaining a new family member, new home, separation or divorce from partner, change in church activities, or if they had borrowed money. Response options included "yes", "no", or "don't know." For responses answered as "yes", the participants were asked to rate the impact of the event as either negative (−1, −2, −3, with lower numbers indicating more negative events) or positive (1, 2, 3, with higher numbers indicating more positive events). The responses were summed using the absolute value of the negative and positive scores to calculate a total life stress score.

Maternal sociodemographic information was obtained from either interview or the participants' medical record. Information about nutrition (e.g., number of daily servings from four food groups) and whether or not women participated in regular exercise were obtained from responses to questions at study enrollment. The BMI was calculated based on self-reported height and measured weight at the first prenatal visit. GWG was defined as the difference between the weight at the first prenatal visit and either the weight at delivery or the weight most proximate to delivery. For the current analysis, participants were included if weight at first prenatal visit, height, and total GWG were available in the database ($n = 684$). The mean gestational age at the first visit was 8 weeks. In order to standardize the GWG regardless of the length of gestation, the weekly rate of change was calculated and then multiplied by 40 to estimate the amount of GWG had the pregnancy lasted 40 weeks [11]. GWG was analyzed as a continuous (mean ± standard deviation) and a categorical variable (inadequate, adequate, or excessive), according to the 2009 IOM guidelines (28–40 pounds for BMI <18.5 kg/m^2, 25–35 pounds for BMI 18.5–24.9 kg/m^2, 15–25 pounds for BMI 25.0–29.9 kg/m^2, and 11–20 pounds for BMI ≥ 30 kg/m^2) [1]. Maternal demographics and characteristics (parity, current smoker, BMI, pregestational hypertension or diabetes) were compared according to GWG category (inadequate, adequate, or excessive) with either ANOVA for continuous measures or X^2 tests for categorical measures. The LES scores were not normally distributed as determined by the Shapiro–Wilk normality test ($p < 0.001$), so the medians were compared among the GWG categories with a nonparametric k-sample test. A two-sided p-value < 0.05 was considered statistically significant, and all tests were two-tailed. Multivariable logistic regression analysis was used to estimate the association between the LES scores expressed as multiples of the median and the odds of adequate GWG with 95% confidence intervals (CI). The

sample size for the entire MOMS study was powered for the outcomes of preterm birth and small for gestational age infants, estimated at 12–15% of births in the entire cohort. All statistical analyses were performed with STATA software (College Station, TX; Version 14). IRB approval was obtained at each participating site prior to enrollment of participants, all of whom signed written informed consent prior to participation.

Results

Of 684 women eligible for this analysis, 17% were black, 59% were non-Hispanic white, and 19% were Hispanic white, while 36% had Medicaid-funded prenatal care. Overall, 24, 30, and 46% of women had inadequate, adequate, or excessive GWG, respectively. Women with adequate GWG were older, had a lower BMI, had higher education and income, and were more frequently married and without gestational diabetes compared to women with inadequate or excessive GWG (all $p <$ or $= 0.04$). (Table 1) Conversely, GWG did not vary by race-ethnicity, with 28% of blacks, 31% of non-Hispanic whites, and 26% of Hispanic whites achieving adequate GWG ($p > 0.05$). Women with adequate GWG had lower total median LES scores [5] compared to women with inadequate [7] and excessive [7] GWG, $p = 0.02$. After adjusting for age, race-ethnicity, parity, BMI, income, education, marital status, and gestational diabetes in a logistic regression analysis, lower LES scores expressed as multiples of the median were associated with adequate GWG (aOR 0.81, 95% CI 0.67–0.98). Among the variables included in the model, BMI > 30 kg/m^2 (aOR 0.25 95% CI 0.07–.89) and gestational diabetes (aOR 2.1, 95% CI 1.03–4.27), were also significantly associated with adequate GWG. (Table 2)

In order to evaluate behavioral factors such as diet and exercise that might have been related to differences in stress levels and also be associated with GWG, we compared self-reported responses to questions about daily servings of four food groups and whether or not women participated in regular exercise across the three GWG categories. Exercise and daily servings of vegetables, fruit, dairy, and fish did not vary across the GWG groups ($p > 0.05$ for all; Table 3)

Table 1 Sociodemographic and other maternal characteristics

Variable (n,% vs. mean ± standard deviation)	Inadequate GWG $n =$ 164	Adequate GWG $n =$ 205	Excessive GWG $n =$ 315	P-value
Age (years)	29.4 ± 5.8	30.2 ± 6.1	28.8 ± 5.4	**0.02**
Race				0.06
White	84(51)	124(60)	193(62)	
Hispanic	37(22)	34(17)	58(19)	
Black	30(18)	32(15)	51(16)	
Other	15(9)	16(8)	10(3)	
Married	138(83)	176(86)	238(76)	**0.01**
Education level				**0.02**
<High school	49(30)	47(23)	81(26)	
=High school	59(36)	57(28)	118(38)	
>High school	57(34)	101(49)	113(36)	
Total income				**0.04**
<$15,000	21(13)	25(12)	46(15)	
$15–50,000	61(37)	53(25)	98(32)	
$50–100,000	36(22)	54(26)	87(28)	
>$100,000	29(17)	57(28)	49(16)	
Unknown	19(11)	17(8)	30(10)	
Private insurance	83(50)	133(65)	185(59)	0.14
Nullipara	60(36)	84(41)	152(49)	0.22
Current smoker	18(11)	18(9)	35(11)	0.66
Gestational age at first visit	8.9 ± 2.8	8.3 ± 2.6	8.5 ± 2.8	0.07
Initial body mass index (kg/m^2)				
Underweight	7(1.5)	7(3.4)	1(0.32)	**0.002**
Normal	187(39)	114(55)	104(33)	
Overweight	120(25)	42(20)	98(32)	
Obese	163(34)	43(21)	108(35)	
Mean	28.4 ± 9.1	26.2 ± 6.7	28.3 ± 6.5	<0.001
Co-morbid conditions				
Hypertension	4(2.4)	9(4.4)	6(1.9)	0.23
Pregestational diabetes	4(2.4)	4(2.0)	21(6.7)	**0.01**
Gestational age at delivery (weeks)	38.4 ± 2.5	39.0 ± 1.7	39.1 ± 2.1	**0.003**
Preterm delivery	22(13)	16(8)	19(6)	**0.02**
Gestational diabetes	24(14)	12(5.8)	44(14)	**0.007**
Preeclampsia	12(7.2)	9(4.4)	15(4.8)	0.42

Data presented as mean ± standard deviation or n(%)

Bold values denote statistical significance

Discussion

In this study, we have documented that women with lower LES total scores in the third trimester of pregnancy were more likely to have adequate GWG, as quantified by a validated instrument in which higher scores are associated with a greater amount of "life change" and greater stress. Our distribution of GWG was similar to that reported in national observational studies on GWG patterns, with only 30% of women meeting their GWG goals. These findings highlight that stress, as measured by life changes that frequently occur in pregnancy (e.g., changes in address, job, sleep, and marital status, etc.) is an important factor to consider in the risk assessment of women with regard to their GWG.

In prior studies, greater reported stress has been primarily associated with inadequate GWG, but these findings are inconsistent. Picone et al. examined the association of psychological stress, measured by the Holmes–Rahe life events questionnaire, with GWG in a prospective study of 60 women. The investigators found a correlation between higher stress scores and lower GWG, independent of nutrient or caloric intake [8]. Brawarsky et al. found a similar pattern in that women with higher reported stress during pregnancy, as measured by the PSS, tended to have low GWG [5]. Likewise, Orr et al. reported that higher stress, according to the 41-item Prenatal Social Environment Inventory, was related to inadequate GWG [7]. Conversely, two other studies, in which the PSS and the Subjective Stress Scale were used, found no association between low GWG and stress [6, 9].

Table 2 Logistic regression analysis for adequate gestational weight gain reporting adjusted odds ratios and 95% CI

Variables	Adjusted OR for adequate GWG	95% CI
LES score multiples of the medians	**0.81**	**0.67–0.98**
Maternal age	1.01	0.97–1.05
Nullipara	0.79	0.53–1.18
Prepregnancy BMI		
Underweight	Ref	Ref
Normal	0.59	0.18–1.96
Overweight	0.39	0.11–1.34
Obese	**0.25**	**0.07–0.89**
Income		
<$15,000	Ref	Ref
$15–50,000	0.86	0.44–1.69
$50–100,000	1.01	0.42–2.16
>$100,000	1.41	0.61–3.31
Unknown	0.91	0.39–2.09
Education		
<High school	Ref	Ref
=High school	0.76	0.44–1.30
>High school	0.87	0.46–1.65
Married	0.71	0.40–1.26
Gestational diabetes	2.10	1.03–4.27
Race		
White	Ref	Ref
Hispanic	1.56	0.88–2.77
Black	1.22	0.71–2.09
Other	0.99	0.46–2.13

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *GWG* gestational weight gain, *LES* Life experiences survey

Bolded values denote statistical significance

One potential reason for the inconsistent results that have been documented in prior studies is the multiple different instruments that have been used to quantify stress exposure. We specifically chose the LES survey because it focuses on the changes in important life events that women frequently experience during pregnancy and also allows them to rate the quality (good vs. bad) of the change. We are unaware of prior studies that used this survey to evaluate stress and GWG, but associations between higher scores on this survey and preterm birth and other pregnancy complications have been reported [12, 13].

The aim of a recent systematic review was to provide a summary of the available evidence examining psychological determinants of GWG. This review focused on three broad psychological domains, namely, affect, cognition, and personality. In the 35 studies (25 cohort, 8 cross sectional, 2 case control) that met the inclusion criteria, the summary estimates of the association of depression, anxiety, and stress with excessive GWG were not significant [14]. This finding was considered to be robust, given that most of the scales had been validated for use during pregnancy, two studies were large and population-based, and four studies included women from diverse ethnic backgrounds. Another recent systematic review of other psychosocial risk factors (psychological distress, body image dissatisfaction, social support, self-efficacy and self-esteem)

Table 3 Health behaviors and gestational weight gain

Variable (*n*,% vs. mean ± standard deviation)	Inadequate GWG *n* = 164	Adequate GWG *n* = 205	Excessive GWG *n* = 315	*P*-value
Participated in regular exercise	92(55)	113(55)	179(57)	0.82
Nutrition				
Fruit (daily servings)	3.2 ± 1.1	3.3 ± 1.0	3.3 ± 1.1	0.26
Vegetables (daily servings)	3.0 ± 1.1	3.1 ± 1.0	3.2 ± 1.1	0.28
Dairy (daily servings)	3.3 ± 1.2	3.5 ± 1.1	3.8 ± 4.9	0.34
Fish (monthly serving)	3.7 ± 9.4	2.8 ± 1.5	2.9 ± 5.1	0.21

Data presented as mean ± standard deviation or *n* (%)

GWG gestational weight gain

found significant associations of depression, body image dissatisfaction, and social support with excessive GWG, but no significant relationships of anxiety, stress, self-efficacy, and self-esteem with excessive GWG [15]. According to the available evidence, there are mixed findings regarding the relationship between stress and GWG. Our study of stress, measured according to changes in life events during pregnancy, suggests that the lowest stress scores are associated with adequate GWG. This further substantiates the association between stress and abnormal GWG.

Among non-pregnant populations, a consistent body of evidence demonstrates that higher levels of stress are associated with increased weight gain [16–18], possibly due to activation of the HPA axis, with higher glucocorticoid levels leading to increased adiposity [19, 20]. Of note, this mechanism is independent of changes in exercise or eating per se, but related to endocrine changes associated with greater stress [20]. Pregnancy is also associated with increased HPA axis function beginning as early as the 11th week of gestation. By the third trimester, blood cortisol levels are more than two-fold higher among pregnant women compared to non-pregnant women [21]. In concordance with the possibility that stress-associated endocrine changes, rather than behavioral factors, may underlie inappropriate weight gain in association with pregnancy stress, in the current study nutrition or physical activity were not associated with GWG differences and thus could not explain the inadequate GWG in women who experienced high stress during pregnancy.

We recognize several limitations to this study. There is no single validated measure of stress during pregnancy and LES measures one component of maternal stress. Also, we do not currently know the etiology or mechanism behind the relationship between stress and GWG, or whether that relationship is causal. Although we assessed measures of servings per day of different food groups and whether or not participants engaged in regular exercise, there were no additional measures of dietary intake and physical activity to associate with the GWG findings. The weight measured at the first prenatal visit was used to calculate the total GWG and proportion of women meeting GWG goals. Given that the mean and median gestational age at the first visit was 8 weeks, our measures of total GWG are likely accurate representations of the actual total GWG. Furthermore, we accounted for different gestational ages at delivery by standardizing the GWG variable.

Because stress appears to be associated with GWG, stress reduction interventions during pregnancy may be a novel way to promote appropriate GWG, and to positively affect maternal and neonatal outcomes. Interventions shown to reduce rates of excessive GWG have the potential to influence the obesity epidemic across generations. More importantly, if psychological factors do affect GWG, then targeting these modifiable factors with directed interventions may prove to have a greater impact on GWG than the current interventions that primarily focus on health behaviors such as diet and exercise. Accordingly, further intervention studies are needed to determine the most appropriate and effective approach to achieving GWG goals.

Funding This study was supported by: HHSN275201200007—HHSN27500005. National Children's Study: Vanguard Study—Task Order 5: Stress and Cortisol Measurement for the National Children's Study (AB) and K23HD076010 from the Eunice Kennedy Shriver National Institute of Child Health & Human Development of the National Institutes of Health (MAK).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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