Maternal Stress Predicts Postpartum Weight Retention

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Abstract Postpartum weight retention (PPWR) is a significant contributor to the development of overweight and obesity in women of childbearing age. Stress may be a key mechanism making it more difficult for mothers to lose weight in the year following delivery. The aim of this study was to assess whether specific aspects of parenting stress and life stress influence postpartum weight retention in new mothers. Women in late pregnancy or up to 2 months postpartum ($n = 123$) were enrolled in the study and followed through the first year postpartum. Linear regression models evaluated the associations of parenting stress (isolation, attachment and depressive symptoms) as well as overall life stress at 2, 6, and 12 months postpartum with PPWR at 6 and 12 months. During the first year

postpartum, higher depression and life stress were significantly associated with greater PPWR. As the effect of depression diminished, the effect of life stress became significant. Contrary to hypothesized relationships, fewer problems with attachment and less social isolation were significantly associated with greater PPWR. Higher gestational weight gain and African American race were also significantly associated with greater PPWR at both 6 and 12 months. Different types of stress predict weight retention in first time mothers during the first year postpartum. Understanding the relationships between parenting stress, concurrent life stress and PPWR can enhance the development of future interventions that specifically target self-identified stressors, leading to improved weight related outcomes.

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Introduction and Background

Overweight and obesity, which affect 68 % of US adults [1] are associated with an increased risk of morbidity and mortality for numerous health conditions, including hypertension, type 2 diabetes, coronary heart disease, stroke, and some types of cancer. Evidence suggests that postpartum weight retention (PPWR) is a significant contributor to the development of overweight and obesity in women of childbearing age [2–4]. Data from the National Health and Nutrition Examination Survey indicate that women who have had one live birth increase their risk of becoming overweight by 60 % and obese by 110 % [3].

Postpartum weight retention is defined as the difference in weight measured in the postpartum period (up to 1 year after delivery) and preconception weight. Average PPWR

ranges from 0.5 to 3 kg [5]. However, there is wide variability in weight retention among women. In the Stockholm Pregnancy and Weight Development Study, 12 month PPWR ranged from −12 to 26 kg. In comparison to their pre-pregnancy weight, over 50 % of women gained up to 5 kg, 13 % had a weight increase of 5–10 kg, and 1.5 % gained at least 10 kg [6]. The Infant Feeding Practices Study II, a longitudinal study of approximately 4,000 mother-infant pairs in the US found that 24 % of women retained more than 4.5 kg, with 12 % retaining more than 9 kg at 11–13.9 months postpartum [7].

Commonly cited predictors of PPWR include high pre-pregnancy body mass index (BMI) [8–11], excessive gestational weight gain (GWG) [12], minority race [13–15], and lower education level [13, 16, 17]. However, the transition to motherhood includes various behavioral, psychological, and social changes that also influence weight retention. Studies have found PPWR to be associated with television watching, lack of physical activity, trans fat intake [18], depression [19–21], lack of social support [21–23], psychological distress [23], having an infant hospitalized [17], and lack of sleep [17, 24].

There is limited research examining the impact of stress on PPWR. However, research has shown that higher perceived stress is associated with infant and maternal feeding behaviors [25–28], as well as lower levels of maternal physical activity [29, 30]. Stress is known to activate the hypothalamic pituitary adrenal (HPA) axis, which in turn increases the release of glucocorticoids in the blood. Glucocorticoids stimulate food intake, particularly of palatable foods (i.e. comfort foods), increasing the risk of overeating [26–28]. Therefore, elevated stress may contribute to the development of overweight/obesity by stimulating appetite. There are other, non-behavioral mechanisms that explain the relationship between HPA axis activity and weight status [31]. However, an overview of all potential physiologic mechanisms is outside the scope of this paper.

One form of stress receiving increased interest regarding its relationship to overweight/obesity in women is stress associated with parenting. This issue is particularly salient given the significant increase in incidence of overweight/obesity after first live birth [3]. While becoming a first time parent is typically a positive experience, it is also life altering and has been found to be associated with higher perceived stress [32], reduced marital satisfaction [33, 34], and higher rates of depression [35, 36]. Further, new first time mothers report higher rates of stress during the first year postpartum than during subsequent pregnancies and births [32]. As first time mothers are developing parenting skills, they are susceptible to aspects of parenting stress such as poor/insecure attachment to the child and lack of social support for parenting decisions [37, 38]. Thus high

levels of parenting stress could be a mechanism that makes it more difficult for new mothers to lose weight in the year following delivery. In addition to parenting stress, overall life stress has been shown to adversely impact weight status in women [39], and could also play a role in PPWR. As women incorporate care of their child into their lifestyle, they must still cope with other life issues such as work and redefining relationships with important others [40, 41].

To our knowledge, no previous prospective studies have examined the relationships between parenting and life stress among new mothers and PPWR. In particular, depression [42], poor/insecure attachment [43] and isolation [44] have been shown to be associated with difficulty losing weight for women. Therefore, it could be expected that these stresses during the first year postpartum might also be associated with PPWR. In addition, given the known increase in overall life stress upon the birth of a first child [32] it was hypothesized that overall stress would be related to PPWR. The aim of this study was to assess whether specific aspects of parenting stress (depression, attachment, isolation) and life stress are associated with PPWR in new mothers. We hypothesized that elevated levels of parenting and life stress at 2 and 6 months would predict greater PPWR at 6 and 12 months, and that 6 and 12 month stressors will be concurrently associated with greater PPWR at 6 and 12 months. We examine both predictions and concurrent associations to provide a more complete picture of the relationship between stress and PPWR during the first year postpartum.

Methods

Study Participants

The Georgia Regents University and Health System Institutional Review Board approved study protocols. Participants were recruited in Georgia and South Carolina to take part in a larger study examining how first time mothers create the eating and activity environment for their babies during the first year of life. Women were screened for eligibility during their third trimester up to 2 months postpartum. Consent was obtained prior to the baseline evaluation, which coincided with the baby's 2-month well child checkup (± 2 weeks). Inclusion criteria were: 18–39 years old; first biologic baby; non-smoking; not diagnosed with type 1, type 2, or gestational diabetes; no untreated mental health issues and chronic conditions that could impact the subject's food intake, metabolism or ability to exercise; and not taking Beta blockers for hypertension. Women on Beta blockers

were excluded because this class of drug can cause fatigue, which may indirectly influence PPWR through reduced physical activity. Medical history relevant to inclusion and exclusion criteria was assessed via self-report.

Data Collection

Age, race, marital status, years of education completed, pre-pregnancy weight, and GWG at the time of delivery were self-reported at baseline. Additional data collection occurred in conjunction with the baby's 2, 6, and 12 month well child medical visit (± 2 weeks). Mothers completed the Parenting Stress Index (PSI) [32] and had their weight measured using an electronic scale (model UC-300, A&D Co. Ltd.) at each visit.

The 120-item PSI was designed to evaluate the magnitude of stress in the parent–child system by focusing on three major domains: child characteristics, parent characteristics, and life stress. Child-related subscales include Distractibility/Hyperactivity, Adaptability, Reinforces Parent, Demandingness, Mood, and Acceptability. Parent subscales include Competence, Isolation, Attachment, Health, Role Restriction, Depression, and Spouse/Support. Respondents are directed to rate their agreement from strongly agree to strongly disagree. The validity and reliability of the parental subscales have been well established, with over 500 studies reporting use of these subscales, including research with parents of infants and young children [32, 45]. The alpha reliability coefficients as reported in the PSI manual for the parental subscales used in this study are 0.84 for depression, 0.75 for attachment, and 0.82 for isolation [32].

The 9-item depression scale assesses the woman's affective status. The 7-item attachment scale item asks the mother to rate her "bond" with her baby ("Most times I feel that my child likes me and wants to be close to me"). The 7-item isolation scale queries the woman's sense of social support/isolation. ("I feel alone and without friends"). The 19-item life stress domain measures the number of life stressors caused by factors outside the parent–child relationship. Life stress statements include events such as divorce, loss of income, and death of a friend or family member.

Items from the PSI were summed to obtain raw scores from which percentile rankings were derived from normalized scales [32]. The raw scores range from 9 to 45 for the depression subscale, 7–35 for attachment, 6–30 for isolation, and 0–115 for life stress. Normal range scores are within the 15th to 80th percentiles. Higher percentile rankings indicate a higher level of stress related to the content area of the scale. Higher depression scores indicate greater depressive symptoms. Higher attachment scores

indicate greater problems with attachment to the child, and is discussed as "poor/insecure attachment" in this study. Higher isolation scores indicate the parent feels socially isolated from peers, relatives, and other emotional support systems. Higher life stress scores indicate greater frequency of stressful life events. The Cronbach's alpha for the depression, poor/insecure attachment, isolation and life stress subscales in this population were 0.83, 0.59, 0.70, and 0.62, respectively, indicating acceptable to good internal consistency. The range of corrected item total correlations for these subscales in this population are as follows: depression = 0.40–0.62; attachment = 0.10–0.51; isolation = 0.18–0.60; and life stress = 0.03–0.44.

Statistical Analyses

SPSS Version 20 was used for all analyses. We examined the associations of race, education, marital status, pre-pregnancy BMI and GWG category with PPWR at 6 and 12 months using one-way ANOVA tests. The associations between PSI percentiles, age, GWG and PPWR at 6 and 12 months were also examined using Pearson correlations to assess unadjusted relationships. Continuous variables were examined for skewness and kurtosis; all variables were normally distributed. Demographic variables were compared across races using independent t-tests or Chi square tests as appropriate. All statistical tests were performed at a .05 level of significance.

Linear regression with hierarchical entry of variables was used to model the outcomes of PPWR at 6 and 12 months, controlling for demographic variables known to be predictive of PPWR. Mother's age, race, and education were entered into the first block [13, 16, 17]. In the second block we examined factors associated with weight, including pre-pregnancy BMI and GWG. Pre-pregnancy BMI was tested as a continuous and categorical variable. Results were similar; therefore only models using pre-pregnancy BMI as a categorical variable are presented. GWG was entered as a continuous variable. In the third and final block, PSI scales hypothesized to have a direct relationship with the outcome of interest were added, including: depression, poor/insecure attachment, isolation, and life stress. Linear regression models were used to examine the associations between PSI subscales at 2, 6 and 12 months and PPWR at 6 and 12 months.

For each multivariate model, we computed the variance inflation factors as a multicollinearity diagnostic statistic to test the impact of multicollinearity among the PSI covariates included in the model. The variance inflation factors computed displayed weak dependencies and therefore no modifications were made to the PSI variables included in the multivariate models.

Table 1 Sociodemographics and anthropometrics of study participants

Characteristic	Baseline n = 123 % (n)	6 month PPWR (kg) n = 102		12 month PPWR (kg) n = 85	
		Mean (SD)	p-value ^a	Mean (SD)	p-value ^a
Race			0.541		0.009
White	41.5 (51)	5.2 (7.9)		3.7 (8.5)	
Black	58.5 (72)	6.2 (7.1)		8.5 (8.0)	
Education			0.684		0.286
<HS	8.9 (11)	6.3 (7.9)		9.8 (11.6)	
HS or GED	29.3 (36)	5.6 (7.4)		8.3 (6.9)	
Some college	30.9 (38)	7.0 (9.1)		6.8 (10.4)	
College graduate	22.0 (27)	3.8 (4.2)		4.2 (5.4)	
Graduate or professional	8.9 (11)	6.1 (7.3)		3.3 (7.8)	
Marital status			0.051		0.006*
Single	61.0 (75)	6.8 (8.0)		8.6 (9.4)	
Married	38.2 (47)	3.9 (6.0)		3.6 (6.3)	
Missing	0.8 (1)				
Pre-pregnancy BMI category			0.730		0.880
Underweight	2.4 (3)	2.3 (3.2)		2.3 (0.0)	
Normal weight	46.3 (57)	6.3 (0.9)		6.0 (7.9)	
Overweight	22.8 (28)	6.3 (7.2)		6.2 (8.1)	
Obese	28.5 (35)	6.7 (9.4)		7.5 (10.1)	
GWG category			<0.001*		0.003*
Inadequate	13.0 (16)	0.8 (5.6)		7.6 (11.0)	
Adequate	26.8 (33)	1.1 (3.7)		1.3 (4.2)	
Excessive	56.1 (69)	9.0 (7.2)		8.4 (8.6)	
	Mean (SD) Range	r	p-value ^b	r	p-value ^b
Age (years)	24.3 (4.5) 18.0–38.5	−.038	0.703	−0.284	0.008*
GWG (kg)	15.6 (6.8) 2.3–36.4	0.504	<0.001*	0.235	0.032*

GWG gestational weight gain, PPWR postpartum weight retention

^a p-values for categorical variables were based on one-way ANOVAs

^b p-values for continuous variables were based on Pearson's correlations

* $p < .05$

Results

Of the 269 mothers screened, 198 were eligible (74 % of screened). Reasons for ineligibility included multi-parity and health exclusions. A total of 128 participants were enrolled (65 % of eligible), 80 % (n = 104) completed 6-month evaluations, and 70 % (n = 90) completed 12-month outcome assessments. Data from mothers who did not report a pre-pregnancy weight or were pregnant at 12 months were not included (n = 5), resulting in a final sample of 123 participants at baseline, 102 at 6 months, and 85 at 12 months.

Sample Characteristics

Characteristics of study participants are shown in Table 1. Participants averaged 24.3 years, 62 % had some college education, and 38 % were married. All mothers were first

time parents with no other children under their full time care. Black participants were more likely to be younger, single, have less education, and have a higher PPWR at 12 months ($p < .01$) than White participants. Approximately 50 % of participants were overweight or obese before pregnancy, 71 % at 12 months postpartum. Half of participants gained weight during pregnancy in excess of recommendations. Mean PPWR at 6 and 12 months was 5.8 kg (s.d. 7.4; range −12.1–32.9) and 6.4 kg (s.d. 8.5; range −9.7–35.9), respectively, indicating continued weight gain postpartum. There were no significant differences in age, race, education, pre-pregnancy BMI and GWG between those who completed the study and those lost to follow up.

Parenting Stress Index percentiles at 2, 6, and 12 months are presented in Table 2. Mean PSI percentiles decreased across time in all subscales. The percentage of women with high scores (PSI percentiles ≥ 85) across all subscales also decreased over time. For example, 39 % of participants

Table 2 PSI percentiles among study participants

PSI subscales	2 month PSI percentiles		6 month PSI percentiles		12 month PSI percentiles	
	Mean (SD) Range	% ≥85th percentile	Mean (SD) Range	% ≥85th percentile	Mean (SD) Range	% ≥85th percentile
Depression	41.7 (32.2) 1.0–97.7	13.8	37.6 (31.7) 1.0–98.3	10.6	36.5 (29.5) 1.0–95.0	3.6
Attachment	46.3 (29.0) 1.0–99.0	12.3	38.1 (30.9) 1.0–99.0	7.3	37.6 (29.5) 1.0–99.0	4.1
Isolation	53.1 (29.2) 1.0–99.0	17.2	49.6 (33.0) 1.0–99.0	15.5	45.9 (29.8) 5.0–99.0	5.7
Life stress	71.5 (21.9) 35.0–99.0	39.1	62.3 (25.3) 5.0–99.0	25.2	54.5 (32.9) 3.5–99.0	18.7

PSI percentiles ≥85 are considered high

Table 3 Correlations between PSI Percentiles and PPWR at 6 and 12 months

	6 month PPWR r (p-value)	12 month PPWR r (p-value)
<i>2 month PSI percentiles</i>		
Depression	0.023 (0.818)	−0.014 (0.898)
Attachment	−0.259 (0.009)*	−0.172 (0.115)
Isolation	0.070 (0.483)	0.173 (0.114)
Life Stress	−0.230 (0.021)*	−0.137 (0.214)
<i>6 month PSI percentiles</i>		
Depression	−0.064 (0.523)	−0.052 (0.644)
Attachment	−0.319 (0.001)*	−0.292 (0.008)*
Isolation	−0.114 (0.256)	−0.153 (0.172)
Life Stress	0.124 (0.215)	0.190 (0.089)
<i>12 month PSI percentiles</i>		
Depression		0.086 (0.435)
Attachment		−0.077 (0.481)
Isolation		0.082 (0.457)
Life stress		0.022 (0.842)

* $p < .05$

scored high on the life stress subscale at 2 months postpartum, 25.2 % at 6 months and 18.7 % at 12 months. Less than 20 % of participant had a high score at any given time point in all other subscales.

Bivariate Associations with 6- and 12-month PPWR

Gestational weight gain was the only hypothesized confounder significantly correlated with greater PPWR at 6 months ($r = .504$, $p < .001$). At 12 months, higher GWG and younger age were correlated with greater PPWR ($r = .235$, $p = .032$; $r = -.284$, $p = .008$, respectively). As seen in Table 3, greater PPWR at 6 months was inversely correlated with high life stress at 2 months and poor/insecure attachment at 2 and 6 months. Greater PPWR at 12 months was correlated with poor/insecure attachment at 6 months.

Results of 6-month PPWR Regression Models

As seen in Table 4, significant predictors of greater PPWR at 6 months were Black race ($p = .050$), higher pre-pregnancy BMI ($p = .002$), higher GWG ($p < .001$), higher depression at 6 months ($p = .037$) and fewer problems with attachment to the baby at 6 months ($p = .001$). The total model explained 47 % of the variance in 6-month PPWR ($p < .001$). Fewer problems with attachment at 2 months predicted greater PPWR at 6 months ($p = .002$).

Results of 12-month PPWR Regression Models

As seen in Table 5, significant predictors of greater PPWR at 12 months were Black race ($p = .048$), higher GWG ($p = .012$), higher life stress at 6 months ($p = .048$), and fewer problems with attachment at 6 months ($p = .012$). Less isolation at 6 months trended toward significance ($p = .096$). The total model explained 33 % of the variance in 12-month PPWR ($p < .001$). Less isolation at 2 months predicted greater PPWR at 12 months ($p = .037$). PSI subscales from 12 months were not associated with 12 month PPWR.

Parenting competence and child temperament are often examined as factors contributing to parenting stress [46–48]. Therefore, although not originally hypothesized to be associated with PPWR, we conducted post hoc analyses associating the overall child stress scale and parenting competence subscale with PPWR. Controlling for the same risk factors used in primary analyses, neither was a significant predictor in any regression generated.

Conclusions and Discussion

Supporting our hypothesis, higher depression and life stress were significantly associated with greater PPWR. As the association between depression and PPWR diminished from 6 to 12 months, the association between life stress

Table 4 Associations of Stress at 2 and 6 months and PPWR at 6 months

Dependent variable	Model F (p value)	Variable t (p)	Stand. Beta	R ²
<i>Model 1 (PSI, 2 m)</i> <i>n</i> = 96	7.065 (.000)			.425
Age		0.627 (.532)	.077	
Race		−1.627 (.107)	−.148	
Education		−0.831 (.408)	−.103	
Pre-pregnancy BMI cat.		3.173 (.002)*	.271	
Gestational weight gain		6.023 (.000)*	.535	
2-months depression percentile		0.087 (.931)	.008	
2-months attachment percentile		−3.235 (.002)*	−.280	
2-months isolation percentile		0.125 (.901)	.120	
2-months life stress percentile		−1.398 (.166)	−.120	
<i>Model 2 (PSI, 6 m)</i> <i>n</i> = 96	8.307 (.000)			.465
Age		0.711 (.479)	.083	
Race		−1.964 (.050)*	−.177	
Education		−0.603 (.548)	−.072	
Pre-pregnancy BMI cat.		3.125 (.002)*	.261	
Gestational weight gain		6.617 (.000)*	.560	
6-months depression percentile		2.122 (.037)*	.257	
6-months attachment percentile		−3.556 (.001)*	−.390	
6-months isolation percentile		−1.478 (.143)	−.161	
6-months life stress percentile		1.365 (.176)	.114	

Final models only, PPWR postpartum weight retention, PSI Parenting Stress Index

* $p < .05$

and PPWR became significant. Contrary to hypothesized relationships, fewer problems with attachment and less social isolation were significantly associated with greater PPWR. Consistent with existing research, we found that higher GWG [14, 49, 50] and Black race [13–15] were associated with PPWR at both 6 and 12 months. Pre-pregnancy BMI was associated with weight retention at 6 months only.

There is limited research examining the relationships between stress variables and PPWR, with mixed results. Multiple studies have found an association between depression and PPWR [19–21, 23], but not all [22]. Herring and colleagues found that mothers diagnosed with new-

Table 5 Associations of Stress at 2, 6, and 12 months and PPWR at 12 months

Model variables	Model F (p)	Variable t (p)	Stand. Beta	R ²
<i>Model 1 (PSI, 2 m)</i> <i>n</i> = 82	3.061 (.004)			.277
Age		−0.931 (.340)	−.136	
Race		−2.245 (.028)*	−.245	
Education		−0.365 (.716)	−.051	
Pre-pregnancy BMI cat.		1.777 (.080)	.191	
Gestational weight gain		2.592 (.012)*	.285	
2-months depression percentile		−0.710 (.480)	−.082	
2-months attachment percentile		−1.465 (.147)	−.152	
2-months isolation percentile		2.124 (.037)*	−.245	
2-months life stress percentile		−0.876 (.384)	−.093	
<i>Model 2 (PSI, 6 m)</i> <i>n</i> = 79	3.759 (.001)			.329
Age		−0.234 (.816)	−.034	
Race		−2.013 (.048)*	−.219	
Education		−0.927 (.357)	−.135	
Pre-pregnancy BMI cat.		1.380 (.172)	.148	
Gestational weight gain		2.569 (.012)*	.277	
6-months depression percentile		1.613 (.111)	.235	
6-months attachment percentile		−2.573 (.012)*	−.343	
6-months isolation percentile		1.690 (.096)	−.218	
6-months life Stress percentile		2.015 (.048)*	.212	
<i>Model 3 (PSI, 12 m)</i> <i>n</i> = 83	2.365 (.021)			.226
Age		−1.022 (.310)	−.149	
Race		−2.124 (.037)*	−.244	
Education		−0.365 (.716)	−.056	
Pre-pregnancy BMI cat.		1.459 (.149)	.169	
Gestational weight gain		2.174 (.033)*	.258	
12-months depression percentile		1.378 (.172)	.206	
12-months attachment percentile		−1.465 (.147)	.015	
12-months isolation percentile		0.118 (.906)	−.216	

Table 5 continued

Model variables	Model F (<i>p</i>)	Variable t (<i>p</i>)	Stand. Beta	R ²
12-months life stress percentile		−0.224 (.823)	−.027	

Final model only, *PPWR* postpartum weight retention, *PSI* Parenting Stress Index

* $p < .05$

onset postpartum depression had twice the risk of retaining more than 5 kg at 12 months (OR 2.54), while Harris found no association between postpartum depression and weight gain 2.5 years after the birth of the child ($r = -0.05$, $p = .649$). Current study results find depressive symptoms to be a significant predictor of PPWR at 6 months, but not 12 months. These findings may be due to the low prevalence of depressive symptoms in the sample at 12 months.

Two previous studies were identified that examined factors related to life stress and PPWR. Walker examined life event stress using the Psychosocial Profile, which included items such as financial worries and stress related to family, friends, moves, losses, and work [21]. No association was found between life event stress and weight gain at 12 months postpartum. Conversely, Pederson reported that burdens in areas such as finances, housing, or work were associated with PPWR at both 6 and 12 months [23]. Similar to Pederson, in this study, higher level of life stress was related to PPWR at 12 months.

No studies were identified that examined mother-infant attachment and PPWR. However, the transition to parenthood is thought to be more difficult for parents who exhibit insecure attachment characteristics [51]. Avoidant attachment has been shown to lead to greater levels of stress after birth [37], possibly resulting in adverse health consequences for the mother. In this study women who had fewer problems with attachment experienced higher weight retention. One possible explanation for this is that women who were securely attached to their babies, being attuned to their needs, spent less time on healthful behaviors for themselves.

Multiple studies have found a significant association between social isolation and higher weight retention. For example, Walker reported that lower levels of instrumental and emotional social support were associated with higher weight gain 12 months postpartum [21]. Pederson and colleagues found that women who had less frequent contact with family members had higher weight retention at 18 months [23]. In this study, the opposite relationship was found. Less isolation at 2 months predicted greater PPWR at 12 months, and less isolation at 6 months trended toward significance in predicting 12 month PPWR. One possible explanation for this unexpected relationship is that our participants engaged in and received support for social

activities that involve sedentary behaviors such as sitting and talking.

There are several limitations of the current analysis. Pre-pregnancy weight and GWG were self-reported by mothers and may not have been accurate. However, self-reported weight in similar contexts has shown to be reliable estimates of weight [52, 53]. Self-report of GWG within the first year postpartum has also shown to be a reliable measure as compared to birth certificate data [54]. Approximately 30 % of women were lost to follow up. Given the various life circumstances of the women (poor, mobile, rural), retention was considered acceptable. Baseline characteristics of mothers who remained in the study versus those lost to follow up were not statistically different. However, it is possible that those lost to follow up differed on other characteristics not measured in this study. Differential attrition is therefore an alternate explanation for the shifting predictors of PPWR. It is also possible that the questionnaire chosen to evaluate stress may not have captured particular stresses relevant to this population such as lack of resources for healthy living, stress eating or poor overall quality of life. Finally, the relatively small sample size limits statistical power so that meaningful but modest associations may not have been detected.

We did not control for dietary intake in these analyses because the focus of the paper was on stress, not stress related eating (i.e. emotional eating). Future research should examine stress-related/emotional eating and level of physical activity in order to better understand potential mechanisms mediating the relationships between stress and PPWR. Breastfeeding was also not controlled for in the analyses due to the overall low rates of exclusive breastfeeding reported in this population.

Major strengths of this study included the diversity of the sample studied, prospective design, and collection of data at three time points (2, 6, and 12 months). Prospective data collection permitted examination of both associational and predictive relationships between stress and weight. As new first time mothers experience frequent changes in their life circumstances, retrospective collection of data could be expected to produce biased estimations of time specific perceived stress [55]. Few maternal PSI percentile scores reached clinically significant elevation suggesting that the sample was not skewed towards mothers who self-selected to participate because of high levels of stress.

Implications for Practice and/or Policy

Weight management interventions during pregnancy and the postpartum period have primarily emphasized diet and physical activity. These studies report poor retention rates and have mixed results [56]. Parenting stress and increasing life stress may partly explain why women experience

difficulty adhering to weight management interventions in the postpartum period. The results from this study suggest that different types of stress predict weight retention in first time mothers during the first year postpartum. Understanding the relationships between parenting stress and PPWR could enhance the development of future interventions that specifically target self-identified stressors, leading to improved adherence and better weight related outcomes.

For example, interventions could teach coping strategies to women who experience lack of support for parenting decisions or who become overwhelmed by stressful life events. Findings suggest that it may also be necessary to intervene in the mother's social milieu during the first year postpartum to develop a network of individuals who will help reduce life stress and encourage healthful living behaviors. Future research should seek to better understand relationships between women, their babies, their support systems and how that impacts health behaviors. And finally, a model of prevention might be considered: addressing anticipated stressors as well as GWG pre-partum in the context of medical care.

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