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Reward-related eating, self-regulation, and weight change in pregnancy and postpartum: the Pregnancy Eating Attributes Study (PEAS)

Tonja R. Nansel, Ph.D.,
Social and Behavioral Sciences Branch, Division of Intramural Population Health Research, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, 6710B Rockledge Dr., MSC 7004, Bethesda, MD 20892

Leah M. Lipsky, Ph.D.,
Social and Behavioral Sciences Branch, Division of Intramural Population Health Research, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, 6710B Rockledge Dr., MSC 7004, Bethesda, MD 20892

Kyle Burger, Ph.D.,
Gillings School of Global Public Health, University of North Carolina Chapel Hill, 2204 McGavran-Greenberg Hall, CB# 7461, Chapel Hill NC 27599-7461

Myles Faith, Ph.D.,
Department of Counseling, School, and Educational Psychology, Graduate School of Education, 420 Baldy Hall, University at Buffalo – SUNY, Buffalo, NY 14250-1000

Wanda Nicholson, M.D., M.P.H.,
Obstetrics and Gynecology, University of North Carolina School of Medicine, 3027 Old Clinic Building, CB 7570, Chapel Hill, NC 27599

Alison Stuebe, M.D.,
Division of Maternal-Fetal Medicine, University of North Carolina School of Medicine, 3010 Old Clinic Building, CB 7516, Chapel Hill, NC 27599

Aiyi Liu, Ph.D.,
Biostatistics and Bioinformatics Branch, Division of Intramural Population Health Research, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, 6710B Rockledge Dr., MSC 7004, Bethesda, MD 20892

Anna Maria Siega-Riz, Ph.D.

corresponding author: 301-435-6937, tonja.nansel@nih.gov.

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Departments of Nutrition and Biostatistics and Epidemiology, School of Public Health and Health Sciences, University of Massachusetts, 109 Arnold House, 715 Pleasant St., Amherst, MA 01003-9303

Abstract

Background/Objectives.—Reward-related eating is hypothesized to underlie risk for weight gain in obesogenic environments, but its role is unknown during pregnancy and postpartum when weight change is normative, but excess weight gain and weight retention are common. This study examined associations of self-reported reward-related eating, self-regulation, and the home food environment with excessive gestational weight gain (GWG) and postpartum weight change.

Subjects/Methods.—Participants in the Pregnancy Eating Attributes Study observational cohort were enrolled at ≤12 weeks pregnancy and followed through one-year postpartum (458 recruited; 367 retained through delivery). Participants completed four measures of reward-related eating – Modified Yale Food Addiction Scale, Power of Food Scale, Multiple Choice Procedure, and a Reinforcing Value of Food Questionnaire; two measures of self-regulation – Barratt Impulsiveness Scale and Delay of Gratification Inventory; and a Home Food Inventory. Measured weight and skinfolds were obtained. Multinomial logistic and multiple linear regression analyses estimated associations of reward-related eating, self-regulation, and home food environment with excessive GWG, gestational fat gain, postpartum weight change, and percent of GWG retained.

Results.—Excessive GWG was associated with food reinforcement intensity, but not with any other measure of reward-related eating, self-regulation, or home food environment. Greater gestational fat gain was associated only with higher Multiple Choice Procedure. Postpartum weight change and percent of GWG retained were associated with greater Delay of Gratification and obesogenic home food environment, but not with any measure of reward-related eating or with impulsivity.

Conclusions.—Findings do not support the hypothesis that self-reported reward-related eating is associated with weight outcomes in pregnancy and postpartum but indicate a relation of Delay of Gratification with postpartum weight retention. Further research using both surveys and objective measures of reward-related eating is needed to advance our understanding of the relation of reward-related eating with weight changes during this critical period of a woman's life.

Introduction

Excessive gestational weight gain (GWG) and postpartum weight retention are important modifiable risk factors for numerous adverse maternal and child health outcomes (1). In the U.S., estimates from 2010–2011 indicate nearly half of women overall and up to two-thirds of women with overweight or obesity have excessive GWG (2), reflecting a biennial 0.8% increase in prevalence since 2000 (3). Similarly, postpartum weight retention is common, with one study finding that 35% of women retained up to 10 pounds and 27% retained greater than 10 pounds at 12-months postpartum (4). Excessive GWG and postpartum weight retention are associated with long-term BMI (5), and thereby represent an important modifiable risk factor for obesity. Efforts to reduce excessive GWG and postpartum weight retention have had limited success. While modest reductions in the frequency of excessive GWG have been observed in normal weight women participating in diet and physical activity interventions (6), these have been less effective in mothers with pre-pregnancy overweight or obesity, who are at greatest risk of excessive GWG and its health sequelae (1). Similarly, behavioral interventions have produced only modest reductions in postpartum weight retention, with diminished effects by one year postpartum and lesser effects in women with pre-pregnancy overweight and obesity (7). Therefore, identifying determinants of excessive weight gain during pregnancy and weight retention during postpartum is critical for developing more effective interventions. To address this need, one of the primary goals of the Pregnancy Eating Attributes Study (PEAS) was to investigate neurobehavioral predictors of excessive pregnancy-related weight gain and postpartum weight retention.

One emerging hypothesis for excess dietary intake posits that the brain reward response to food overrides energy homeostatic processes, leading to excess intake (8). Repeated exposure to highly palatable, energy-dense foods typically high in added sugar and fat, elicits a strong, dopaminergic response i.e., positive reinforcement (9) that promotes habitual intake (10) predisposing to future weight gain (11). Body weight and weight change have been associated with the relative strength of the food reward response as measured by human functional neuroimaging (e.g., 12, 13) and as measured by a food reinforcement behavioral task (14). Larger studies using self-report measures of reward-related eating have found cross-sectional associations with BMI (e.g., 15, 16); however, prospective data on the extent to which self-report measures of reward-related eating are associated with weight change are sparse and have yielded mixed findings (17, 18). Furthermore, the association of reward-related eating with pregnancy-related weight change is unknown.

The reward system interacts with other neurobehavioral processes to impact behavior. The ability to self-regulate can modify the association of reward-related eating with body weight by incorporating long-term consequences into decision-making leading to use of impulse control (19). Some evidence in the general population suggests that impulsivity, a propensity for hasty responses without regard for consequences, is positively associated with energy intake and BMI (20, 21). Further, reward-related eating was more strongly associated with intake in individuals with high versus low impulsivity (22, 23) and in those with greater dietary disinhibition and lower dietary restraint (24). In one prospective study, the association of food reinforcement with weight gain was stronger for those with greater dietary disinhibition (14).

Additionally, given the role of reward pathways in attending and responding to behaviorally relevant stimuli in the environment (25), differences in the presence of reinforcing food stimuli in an individual's immediate environment likely modify the relationship of reward response with eating behavior. Environmental food cues (e.g., sight or smell) impact neural activity and can lead to physiological appetitive responses (19). While some studies suggest the presence of obesogenic foods in the home environment is cross-sectionally associated with greater energy intake (26) and higher BMI (27), no studies have investigated whether self-regulation and the home food environment moderate the association of reward-related eating with pregnancy-related weight change.

The purpose of this study was to investigate associations of multiple dimensions of self-reported reward-related eating with early pregnancy BMI and pregnancy-related changes in weight and adiposity. The second objective was to examine whether self-regulation or the home food environment moderate these associations. We hypothesized that higher reward-related eating would be associated with higher BMI and weight/adiposity change, and that this relationship would be stronger in the presence of lower self-regulation or a more obesogenic home food environment. Multiple measures reflecting dimensions of reward-related eating were included because there is currently no gold standard self-report measure of reward-related eating, and the degree to which existing measures of conceptually similar constructs are inter-related is not known. Therefore, an additional objective was to examine associations amongst measures of hedonic hunger, addictive-like eating, and food reinforcement value. We hypothesized moderate positive correlations among these measures of reward-related eating.

Subjects and Methods

Design and participants

The Pregnancy Eating Attributes Study (PEAS) was a prospective observational study of women from early pregnancy (≤12 weeks gestation) through one-year postpartum (28) designed to examine the roles of reward-related eating, self-control, and home food availability on dietary intake and weight change during pregnancy and postpartum. Participants were recruited from two university-based obstetrics clinics in Chapel Hill, North Carolina from November 2014 through October 2016; data collection was completed in June 2018. Inclusion criteria were: confirmed pregnant ≤12 weeks gestation at enrollment; uncomplicated singleton pregnancy anticipated; age ≥18 and <45 at screening; willingness to undergo study procedures and provide informed consent for her participation and assent for the baby's participation; BMI ≥18.5 kg/m2; ability to complete self-report assessments in English; access to internet with email; planning to deliver at the University of North Carolina Women's Hospital; and planning to remain in the geographical vicinity of the clinical site for 1 year following delivery. Exclusion criteria included: pre-existing diabetes; multiple pregnancy; participant-reported eating disorder; any medical condition contraindicating participation in the study such as chronic illnesses or use of medication that could affect diet or weight (e.g., chronic steroid use); psychosocial condition contraindicating participation in the study. Power analyses to determine sample size have been reported previously (28).

Procedures

Participants were identified through the electronic clinical appointments and medical records database and recruited by research staff, who obtained signed informed consent from all participants. Study visits were conducted prenatally at baseline (<12 weeks gestation), 13–18 weeks, 16–22 weeks, and 28–32 weeks gestation, and postpartum at 4–6 weeks, 6 months, and 12 months. Self-report surveys were completed online within each study visit window. Study procedures were approved by the University of North Carolina at Chapel Hill Institutional Review Board.

Measures

Anthropometrics.—Height was measured at baseline using a wall-mounted stadiometer and recorded to the nearest 0.1 cm. Weight was measured at each trimester study visit using a standing scale and recorded to the nearest 0.1 kg. Skinfolds thickness was measured with skinfold calipers at each study visit using established protocols and recorded to the nearest 0.1 mm (29). Each measure was obtained twice; if the two measurements varied by more than 1 cm (height), 0.2 kg (weight) or 2 mm (skin folds), a third measure was taken. The mean of the two closest measurements was calculated. Research staff were trained and certified prior to data collection. Baseline BMI was calculated from baseline measured height and weight as kg/m^2. Additionally, all prenatal weights from medical visits were obtained from the electronic medical record. Gestational weight gain (GWG) was calculated as the difference between the study enrollment weight and the last prenatal medical visit weight (mean ± SD = 0.35 ± 0.75 week prior to delivery). GWG adequacy was classified as inadequate, adequate, or excessive corresponding to the 2009 IOM guidelines indicating optimal range of total first trimester weight gain and range of weekly weight gain in the second and third trimesters according to BMI classification (30). For women having term births (≥37 weeks gestation), these values were used to determine the range of adequate weight gain for each participant's gestational age, and participants were classified as below, within, or above this range. GWG is treated as categorical given that the appropriate range of weight gain differs by BMI classification (30) and the association of GWG with outcomes is not linear – the health effect of a unit change in GWG may be positive, neutral, or negative depending on whether GWG is within an inadequate, adequate, or excessive range. Gestational fat gain (GFG; in kg) at the third trimester study visit was estimated using the following formula: fat gain=0.77 (weight change, kg) + 0.07 (change in thigh skinfold thickness, mm) – 6.13 (31). Postpartum weight change (weight at each postpartum visit minus visit 1 weight) and percent of GWG retained were calculated at each postpartum visit.

Hedonic Hunger.—The Power of Food Scale (PFS) was administered each trimester during pregnancy and at 6 months postpartum. PFS is a 15-item questionnaire that measures appetite for, rather than consumption of, palatable foods, in three contexts – food available, food present, and food tasted. The mean of these constructs is thought to assess hedonic hunger, the psychological impact of highly-palatable food cues in the environment (17, 32). Items are rated on a 5-point Likert scale with a higher number indicating greater susceptibility. The measure demonstrates strong internal consistency (Cronbach's alpha = 0.91) and test-retest reliability ($r = 0.77$, $p < 0.001$). The measure has been validated with respect to overeating (23), outcomes of weight-loss interventions (33), and brain activity in response to viewing images of food versus control (34). Correlations among assessments at the three trimesters ranged from 0.68 to 0.81 ($p<.01$); mean scores across pregnancy were calculated.

Addictive-like Eating.—The modified Yale Food Addiction Scale (mYFAS), a 9-item abbreviated version of the Yale Food Addiction Scale (15) was administered at baseline and 6-months postpartum. The measure assesses the presence of eating disorder symptoms consistent with diagnostic criteria for food addiction. The measure demonstrated similar psychometric properties to the original instrument, and greater scores on the measure were associated with greater BMI across two cohorts of women (15). Due to the highly skewed distribution, responses of 2 or more (12.5% of baseline responses) were collapsed (only 2.3% of respondents scored 3 and 1.8 scored 4 or higher).

Food Reinforcement Measures.—Two questionnaire measures were used to assess the reinforcing value of food at the first two pregnancy visits and six months postpartum. A Reinforcing Value of Food Questionnaire (RVFQ) (35) asks participants to report the number of portions of a specified food that they would purchase at varying cost levels. The measure generates five indices, each indicating varying, but related aspects of reinforcing value of food: breakpoint (first price at which number of portions selected was zero), intensity of demand (number of portions selected at the lowest price), elasticity of demand (sensitivity of decrease in consumption to increase in cost; individual elasticities calculated using the modified exponential demand equation) (36), O_{max} (maximum expenditure, product of portions selected and price), and P_{max} (price at which expenditure was maximized). The measure has demonstrated validity against a laboratory task assessing food reinforcement value and was associated with BMI (35). The Multiple Choice Procedure (MCP) asks participants to make a series of discrete choices between receiving a monetary reward or an alternative reinforcer (37). The datum of interest is the specific price at which participants begin to select the money over the reinforcer (breakpoint), with a higher breakpoint thus indicating greater reinforcing value of food. The measure has previously been validated in the assessment of reinforcement value of alcohol and cigarettes (e.g., 38). The MCP was adapted by the investigators to assess the relative reinforcing value of specified foods. Subjects were first asked to provide hedonic ratings of 18 highly palatable foods. The name of each food was accompanied by a corresponding image. The two highest-rated foods were then used for the RVFQ and MCP. For each measure, mean scores across visits 1 and 2 were calculated. Due to highly skewed distributions, scores were log-transformed.

Self-regulation.—Two measures of self-regulation were assessed at baseline and 6 months postpartum. The 15-item short form of the Barratt Impulsiveness Scale (BIS-15) measures impulsivity across three dimensions – non-planning, motor impulsivity, and attentional impulsivity. The measure demonstrated similar psychometric properties and associations with neurobehavioral traits as the original instrument (39). The Delaying Gratification Inventory (DGI) is a 35-item questionnaire that measures the tendency to forego immediate satisfaction in favor of long-term rewards (40). Five domains implicated in delay behavior are evaluated, including food, physical pleasure, social interaction, money and achievement. The subscale scores demonstrated good internal consistency (Cronbach's alpha = 0.69 – 0.89) and strong test-retest reliability (r = 0.74 – 0.90).

Home Food Environment.—The Home Food Inventory was administered at baseline and 6 months postpartum. This measure is a food checklist that asks participants to indicate the presence of specific foods in their home (26). It includes a comprehensive list of foods in 15 categories. Consistent with the measure's scoring protocol, a fruit and vegetable home food environment score (HFI-FV) and an obesogenic home food environment score (HFI-OBES) were calculated as the total number of foods in the home in each classification. The fruit and vegetable score comprises 26 common fruits and 20 common vegetables. Foods classified as obesogenic include regular-fat versions of cheese, milk, yogurt, other dairy, frozen desserts, prepared desserts, savory snacks, added fats, regular-sugar beverages, processed meat, high-fat microwavable foods, candy, and access to unhealthy foods in refrigerator and kitchen.

Demographic and medical characteristics.—Demographic information including education attainment, family income, marital status, household composition, and race/ethnicity was self-reported at baseline. Income-to-poverty ratio was calculated from family income and household size (41); higher values indicate greater income relative to the poverty threshold. Breastfeeding status at each postpartum visit was also reported and categorized as any breastfeeding versus none. Participant age, parity, and gestational age at delivery were obtained from the electronic medical record.

Analysis

Pearson correlation coefficients examined bivariate associations. Separate multiple linear regression analyses estimated associations of reward-related eating, self-regulation, and home food environment with baseline BMI, GFG, postpartum weight change, and percent of GWG retained. Separate multinomial logistic regression analyses estimated associations of reward-related eating, self-regulation, and home food environment with GWG adequacy (adequate GWG used as reference category) for participants delivering at 37 weeks gestational age or greater. Analyses examining pregnancy weight variables as outcomes adjusted for age, education, income, gestational age, and parity; analyses examining postpartum weight variables as outcomes additionally adjusted for number of weeks since delivery and breastfeeding status. Multiplicative interaction terms were used to determine whether self-regulation, home food environment, or baseline BMI moderated associations of reward-related eating with weight outcomes. Variables were standardized to a mean of zero and standard deviation of one prior to analyses to provide standardized estimates. SPSS version 21 was used for all analyses.

Given literature suggesting potential bidirectional relations between reward related eating and weight change (42), we conducted post-hoc analyses examining associations of GWG and GFG with change in reward-related eating from pregnancy to postpartum. A change score was calculated for each variable as the postpartum value minus pregnancy value. Analysis of covariance and multiple linear regression examined associations of GWG adequacy and GFG, respectively, with change in each measure of reward-related eating, adjusting for the same covariates as above.

Results

As shown in Table 1, approximately half of the sample were of normal weight status; mean age was 30.5 years at baseline. The sample was predominantly married and had a college degree; just over half were non-Hispanic white. Of the 458 women enrolled, 91 (20%) withdrew prior to delivery and 41 (9%) withdrew during postpartum. Reasons for withdrawal included 54 no longer willing to participate; 29 experienced miscarriage, stillbirth, or death of baby; 24 moved away or changed medical provider; 19 were noncompliant with study visits; and 6 developed conditions resulting in ineligibility. There were no differences in sociodemographic characteristics between those who withdrew and those who were retained. Data on baseline weight were obtained for all participants, gestational weight gain was obtained for all those retained through delivery, of which, 347 delivered at ≥37 weeks gestation, and third trimester skinfolds were obtained for 355 participants. Weight was obtained for 293 participants at 12 months postpartum.

Except for inverse associations of mYFAS with income and education, measures of reward-related eating were not associated with participant age, income-poverty ratio or education; however, income-poverty ratio and education were associated positively with DGI and inversely with BIS-15, HFI-OBES, and HFI-FV (Table 2). Correlations among measures of reward-related eating ranged from r=0.06 to r=0.39 (Table 3). The strongest positive correlations were of the PFS with mYFAS (r=0.27) and of the PFS with RVFQ intensity (r=0.39). Correlations of reward-related eating constructs with BIS-15 ranged from r=0.3 to r=0.35; and with DGI ranged from r=0.11 to r=−0.40.

Higher baseline BMI was associated with a higher mYFAS, RVFQ intensity, and RVFQ elasticity (Table 4). Excessive GWG was not associated with any measure of reward-related eating, either measure of self-regulation, or home food environment. Greater gestational fat gain was associated with higher MCP, but no other variable of interest.

At 12 months postpartum, neither postpartum weight change nor percent of GWG retained were significantly associated with any measure of reward-related eating (Table 5). Postpartum weight change and percent of GWG retained were negatively associated with DGI but were not associated with BIS-15. Postpartum weight change and percent of GWG retained were negatively associated with HFI-OBES, but not with HFI-FV.

Analyses examining potential interactions of BIS-15, DGI, and HFI-OBES with reward-related eating on weight outcomes yielded few significant interaction terms and no consistent pattern of findings suggestive of the hypothesized interactions (data not shown). Similarly, there were no consistent interactions of baseline weight status with reward-related eating on weight outcomes (data not shown). Additionally, in post-hoc analyses, neither GWG adequacy nor GFG was associated with any measure of reward-related eating (data not shown).

Discussion

Few associations of weight change with measures of self-reported reward-related eating were observed in this sample of women followed from early pregnancy through one-year postpartum. While nearly half of the sample exhibited excessive GWG, this weight gain was not associated with most measures of reward-related eating, nor was it associated with either measure of self-regulation or the home food environment. GFG was associated only with the MCP. Postpartum weight outcomes were not associated with measures of reward-related eating or BIS-15. However, lower postpartum weight retention was associated with higher DGI. Unexpectedly, a higher HFI-OBES was also associated with lower postpartum weight retention.

The association of the mYFAS with baseline BMI is consistent with previous literature showing that higher food addiction scores are associated with higher BMI across diverse samples (15, 43–45). However, only two studies have examined associations with weight change, both in weight loss patients. Food addiction classification was associated with lower weight loss following bariatric surgery (46) but was not associated with weight loss among participants of a weight loss program (47). Our sample contained too few participants meeting the recommended threshold for a food addiction categorization, limiting the ability to assess the association of food addiction classification with outcomes. The null association of PFS with weight change is consistent with previous studies in non-clinical samples (48, 49), though a positive association was reported in a study of persons undergoing bariatric surgery (50). While some studies in the general population have found positive associations of PFS with BMI (17, 51, 52), others have shown null associations (23, 52), consistent with the current study. To our knowledge, no previous research has examined the association of the RVFQ or MCP with weight change. One study reported associations of BMI with RVFQ O_{max} and elasticity (but not other indices) (35), while BMI was related only to intensity in the current study. Null associations of most of the self-report measures of reward-related eating with excess weight may reflect limitations related to reporting bias associated with self-report or may indicate minimal relevance of reward-related eating to excess GWG and postpartum weight change. Due to physiological aspects of pregnancy that support weight gain, associations of neurobehavioral constructs with weight change may differ from that of non-pregnancy populations.

While there is some evidence linking alternative measures of delay of gratification to obesity in the general population (53–55), the relevance of this construct during pregnancy is not well-understood. Women have previously reported relaxing efforts to control eating during pregnancy (56, 57) in response to psychosocial needs/norms, hunger, or cravings. Our finding that DGI is associated with weight outcomes during postpartum, but not pregnancy, may reflect that tendency. The association of postpartum weight change with DGI, but not reward-related eating, may suggest that the extensive availability of highly palatable, energy-dense foods promotes excess consumption even at relatively low levels of susceptibility to reward-related eating, thereby necessitating ongoing use of self-regulation to curb intake. Interventions designed to promote food-related future-oriented thinking (termed episodic future thinking training) have shown efficacy for increasing health-promoting eating behaviors; however, their utility for weight loss is not well-known (58).

The association of lower postpartum weight retention with a more obesogenic home food environment was unexpected. Previous research in non-pregnant samples has found a positive association of fruit and vegetable intake with home availability of fruits/vegetables (59–61) and a positive association of energy intake with home availability of high-fat foods (62). However, few studies have examined associations of the home food environment with weight change. In one investigation of untreated spouses of study participants, decreased home availability of high-fat foods was associated with reduced energy intake and weight loss in spouses (63). However, in another investigation of a behavioral weight control program, home food environment changes from pre- to post-intervention were not associated with changes in weight (64). Further research is needed to clarify the role of home food availability in weight change.

Notably, measures of reward-related eating were only modestly correlated with each other. The strongest correlation observed (PFS with RVFQ intensity) was similar to that of PFS with both measures of self-regulation, which are not food-specific and therefore likely to have a weaker association with reward-related eating. A previous study similarly showed minimal to moderate associations of measures of food reward different from those used in this study (65); however, a larger correlation between PFS and Yale Food Addiction Scale (long version) than observed here has been reported previously (66). Findings suggest that measures of reward-related eating examined are not assessing a single construct and indicate a need to better delineate and understand the dimensions they are measuring. While the PFS has demonstrated associations with neural activity measured by magnetoencephalography (34) and functional magnetic resonance imaging (48, 67, 68), and the RVFQ is associated with performance on a behavioral choice task (35), the degree of correspondence between self-report, neural, and task-based measures warrants further investigation. Future research examining these measures in relationship to objective measures of neurological response such as assessment using functional magnetic resonance imaging or electroencephalography, or task-based measures of food reinforcement may be informative.

Findings from this study should be interpreted in consideration of the study’s strengths and limitations. The use of multiple measures of reward-related eating, as well as the assessment of both weight and body composition, provides a comprehensive examination of the research question. Additional strengths include the large sample size, the repeated assessments from early in pregnancy to one year postpartum, and the measurement of multiple potential confounders. However, we did not use a behavioral choice task assessment or brain imaging measures of food reinforcement in this sample. There is currently no gold standard self-report measure of reward-related eating and further research is needed to clarify the constructs that these self-report measures assess. Since women were not assessed prior to pregnancy, the potential influence of pregnancy and postpartum on self-reported reward-related eating cannot examined in this study. The mean PFS score in this sample of pregnant women (2.20±0.67) was similar to that reported previously (2.28±0.76) in a general sample of women (32), while the percent of food addiction classification using the mYFAS was lower than the 5–6% prevalence previously observed (15, 16). This sample demonstrated higher reward-related eating than that previously reported on most RVFQ indices, but lower RVFQ intensity (35). In total, our data provide no clear indication as to whether pregnant women report higher or lower reward-related eating then non-pregnant women. Finally, the sample was drawn from a single geographic area with limited racial/ethnic diversity and of generally high education level, thus limiting the generalizability of these findings.

In conclusion, findings provide limited support of an association of self-report measures of reward-related eating with gestational weight gain or postpartum weight change. However, the association of these measures with delay of gratification, and the association of delay of gratification with lower postpartum weight retention were promising. These findings call for the need for further research to understand how dimensions of reward-related eating and self-regulation may influence weight outcomes following pregnancy. Given the modest intercorrelation of dimensions of reward-related eating, research using both surveys and objective measures of reward-related eating is needed to advance understanding the relationship of reward-related eating with maternal weight outcomes.

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Table 1.

Socio-demographic and clinical characteristics of participants (n=458) in the Pregnancy Eating Attributes Study (PEAS)

	Mean±SD or N (%)
Age	30.5 ± 4.7
Household size	3.0 ± 1.2
Poverty to income ratio	3.8 ± 2.0
Marital status	
Married/living with partner	333 (90.7)
Divorced/widowed/separated/single	34 (9.3)
Education	
High school graduate or less	34 (9.3)
Some college or associate's degree	70 (19.1)
Bachelor's degree	108 (29.4)
Master's/advanced degree	155 (42.2)
Race	
White	282 (71.4)
Black	67 (17.0)
Asian	21 (5.3)
Other or multi-race	25 (6.3)
Ethnicity	
Hispanic or Latino	33 (8.6)
Not Hispanic or Latino	349 (91.4)
Parity	
Nulliparous	250 (54.6)
Parous	208 (45.4)
BMI category at baseline	
Normal weight; BMI ≥18.5, <25	219 (47.8)
Overweight; BMI ≥25, <30	115 (25.1)
Obese; BMI ≥30	124 (27.1)
Gestational age at delivery	39.30 ± 2.09
GWG adequacy among deliveries ≥37 weeks gestation	
Inadequate	55 (15.9)
Adequate	137 (39.5)
Excessive	155 (44.7)
Gestational fat gain (kg)	0.48 ± 3.46
12-month postpartum weight difference (kg)	0.78 ± 5.37
Percent of GWG lost at 12 months postpartum	96.69 ± 51.75

IOM, Institute of Medicine; GWG, gestational weight gain

Demographic data missing for 94 participants for income; 91 participants for household size, marital status, and education; 63 participants for race; and 76 participants for ethnicity

Table 2.

Summary statistics for reward-related eating, self-control, and home food environment measures and Pearson correlations with sociodemographic characteristics

	Mean ± SD[a]	Age	Income to poverty ratio	Education
Power of food scale	2.20 ± 0.67	−0.09	0.06	0.004
Yale food addiction scale	0.50 0.95	−0.14 **	−0.23 **	−0.26 **
Reinforcing value of food questionnaire[b]				
Breakpoint ($)	7.75 ± 32.67	−0.03	0.09	0.07
Intensity (portions)	3.95 ± 4.29	−0.04	−0.005	−0.03
O_{max} ($)	4.89 ± 16.31	−0.03	0.05	0.03
P_{max} ($)	3.80 ± 16.08	−0.05	0.07	0.05
Elasticity	0.07 ± 0.22	−0.02	−0.05	−0.02
Multiple choice procedure ($)	3.67 ± 4.58	−0.04	0.10	0.08
Barratt impulsiveness scale, short form	25.96 ± 6.12	−0.10	−0.17 **	−0.19 **
Delaying gratification inventory	138.42 ± 11.93	0.11	0.14 *	0.24 *
Home food inventory, obesogenic score	22.21 ± 9.53	−0.09	−0.34 **	−0.36 **
Home food inventory, fruit and vegetable score	18.67 ± 6.04	0.13 *	−0.14 *	−0.09

[a]Summary statistics are from values prior to transformation

[b]Breakpoint = first price at which consumption was zero, intensity of demand = consumption at the lowest price, O_{max} = maximum expenditure, P_{max} = price at which expenditure was maximized, elasticity = sensitivity of consumption to increase in cost

*$p < 0.05$;

**$p < 0.01$

Table 3.

Pearson correlations of baseline measures of reward-related eating, self-control, and home food environment

	PFS	mYFAS	RVFQ-B	RVFQ-I	RVFQ-O	RVFQ-P	RVFQ-E	MCP	BIS	DGI	HFI-OBES
mYFAS	0.27**										
RVFQ-B	0.11	0.06									
RVFQ-I	0.39**	0.13	0.06								
RVFQ-O	0.16	0.11	0.86**	0.22**							
RVFQ-P	0.09	0.06	0.92**	−0.01	0.80**						
RVFQ-E	−0.11	−0.07	−0.67**	−0.18	−0.75**	−0.61**					
MCP	0.23**	−0.08	0.31**	0.21**	0.33**	0.29**	−0.29**				
BIS	0.35**	0.18	0.05	0.21*	0.07	0.03	−0.08	0.08			
DGI	−0.40**	−0.28**	−0.13	−0.26**	−0.14	−0.12	0.11	−0.12*	−0.68**		
HFI-OBES	0.07	0.15	0.06	0.15	0.07	0.04	−0.04	0.08	0.10	−0.20*	
HFI-FV	−0.06	0.02	−0.04	−0.12	−0.07	−0.04	0.07	−0.14	−0.12	0.06	0.23**

PFS – Power of Food Scale; mYFAS – modified Yale Food Addiction Scale; FRQ – Reinforcing Value of Food Questionnaire, B – Breakpoint, I – Intensity, O – O_{max}, P – P_{max}, E – Elasticity; MCP – Multiple Choice Procedure; BIS Barratt Impulsiveness Scale short form; DGI – Delay of Gratification Inventory; HFI-OBES – Home Food Inventory Obesogenic score; HFI-FV Home Food Inventory Fruit and Vegetable score

* $p < 0.05$;

** $p < 0.01$; Sidak-adjusted p-values

Table 4.

Association of pregnancy reward-related eating, self-control, and home food environment with baseline BMI, GWG adequacy, and gestational fat gain

	Baseline BMI[a]		Excessive GWG[b]		Gestational fat gain[c]	
	β	p	OR	95% CI	β	p
Power of food scale	0.06 ± 0.05	0.21	1.21	0.93, 1.57	0.06 ± 0.06	0.29
Yale food addiction scale	0.28 ± 0.05	<0.001	0.86	0.66, 1.12	−0.06 ± 0.06	0.33
Reinforcing value of food questionnaire						
Breakpoint	−0.05 ± 0.05	0.34	0.95	0.72, 1.26	−0.04 ± 0.06	0.53
Intensity	0.16 ± 0.05	0.001	1.24	0.95, 1.61	0.007 ± 0.06	0.90
O_{max}	−0.04 ± 0.05	0.43	1.01	0.76, 1.35	−0.02 ± 0.06	0.78
P_{max}	−0.07 ± 0.05	0.15	0.95	0.73, 1.24	−0.01 ± 0.06	0.87
Elasticity	0.16 ± 0.05	0.001	0.85	0.63, 1.14	−0.05 ± 0.05	0.36
Multiple choice procedure	−0.01 ± 0.05	0.87	1.06	0.81, 1.39	0.13 ± 0.06	0.02
Barratt impulsiveness scale, short form	0.04 ± 0.05	0.41	1.13	0.85, 1.51	0.05 ± 0.06	0.41
Delaying gratification inventory	−0.08 ± 0.05	0.12	1.05	0.80, 1.39	−0.03 ± 0.06	0.65
Home food inventory, obesogenic score	0.09 ± 0.05	0.10	1.25	0.90, 1.74	−0.05 ± 0.06	0.45
Home food inventory, fruit and vegetable score	0.04 ± 0.05	0.45	0.95	0.71, 1.28	−0.05 ± 0.06	0.40

GWG, gestational weight gain

[a] Separate multiple linear regression analyses; standardized coefficients adjusted for age, education, income, and parity

[b] Separate multinomial logistic regression analyses; standardized coefficients adjusted for age, education, income, and parity; adequate GWG serves as the reference category

[c] Separate multiple linear regression analyses; standardized coefficients adjusted for age, education, income, gestational age, and parity

Table 5.

Association of postpartum food reward sensitivity, self-control, and home food environment with weight change at 12 months postpartum,

	Postpartum weight change[ab]		Percent of GWG retained[a]	
	β	p	β	p
Power of food scale	0.01 ± 0.09	0.92	0.03 ± 0.08	0.75
Yale food addiction scale	−0.05 ± 0.10	0.60	−0.07 ± 0.10	0.45
Reinforcing value of food questionnaire				
Breakpoint	−0.08 ± 0.10	0.40	−0.03 ± 0.09	0.76
Intensity	0.16 ± 0.09	0.07	0.11 ± 0.08	0.17
O_{max}	−0.04 ± 0.10	0.67	0.03 ± 0.09	0.75
P_{max}	−0.04 ± 0.10	0.67	0.02 ± 0.08	0.82
Elasticity	0.24 ± 0.12	0.05	0.18 ± 0.11	0.10
Multiple choice procedure	−0.06 ± 0.10	0.55	−0.07 ± 0.11	0.44
Barratt impulsiveness scale, short form	0.04 ± 0.09	0.66	−0.003 ± 0.09	0.97
Delaying gratification inventory	−0.24 ± 0.10	0.02	−0.19 ± 0.09	0.04
Home food inventory, obesogenic score	−0.28 ± 0.11	0.01	−0.31 ± 0.10	0.003
Home food inventory, fruit and vegetable score	−0.14 ± 0.09	0.12	−0.14 ± 0.09	0.11

GWG, gestational weight gain

[a]Separate multiple linear regression analyses; standardized coefficients adjusted for age, education, income, gestational age at delivery, number of weeks since delivery, breastfeeding status and parity

[b]Calculated as weight at 12 months postpartum – early pregnancy weight