The accelerator, the brake, and the terrain: associations of reward-related eating, self-control, and the home food environment with diet quality assessed by 24-hour recalls during pregnancy and postpartum in the Pregnancy Eating Attributes Study (PEAS) cohort

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Abstract

Background. Neurobehavioral factors, including reward-related eating and self-control, in conjunction with the food environment, may influence dietary behaviors. However, these constructs have not been examined in pregnancy and postpartum, a time of changing appetite and eating behaviors, and when dietary intake has implications for maternal and child health. This study examined associations of reward-related eating, self-control, and the home food environment with pregnancy and postpartum diet quality.

Methods. Participants in the Pregnancy Eating Attributes Study observational cohort were enrolled at ≤12 weeks gestation and followed through one-year postpartum. Pregnancy and postpartum Healthy Eating Index-2015 (HEI) was calculated by pooling 24-hour diet recalls during each trimester and during 2, 6, and 12 months postpartum. Participants completed four measures of reward-related eating – Modified Yale Food Addiction Scale (mYFAS), Power of Food Scale (PFS), Multiple Choice Procedure (MCP), and Food Reinforcement Questionnaire (FRQ); two measures of self-control – Barratt Impulsiveness Scale and Delay of Gratification Inventory; and a Home Food Inventory (HFI), yielding obesogenic (OBES) and fruit/vegetables (FV) scores. Linear regression analyses estimated associations of reward-related eating, self-control, and home food environment with diet quality during pregnancy and postpartum, adjusting for sociodemographic characteristics.

Results. Pregnancy, HEI was inversely associated with PFS, mYFAS, MCP, and 2 of the 5 FRQ indices, but most associations of postpartum HEI with reward-related eating measures were not statistically significant. Associations of HEI with general self-control measures were not statistically significant. Pregnancy and postpartum HEI were associated inversely with HFI-OBES and positively with HFI-FV.

Conclusions. Associations of diet quality with greater reward-related eating during pregnancy but not postpartum suggests the need to better understand differences in the determinants of eating behaviors and approaches to circumvent or moderate reward-related eating to facilitate more optimal diet quality across this critical period.

Background

Maternal diet quality during pregnancy is related to decreased risk of excess gestational weight gain (1), gestational diabetes (2), and offspring adiposity (3). However, across racial/ethnic groups and income levels, adherence to dietary recommendations during pregnancy is low, and little is known about influences on diet quality during this period (4–6). Therefore, identifying modifiable determinants of diet quality in pregnancy is essential for improving numerous maternal and child health outcomes (7, 8).

Poor diet quality, in particular, excessive intake of discretionary foods, may result from eating behavior motivated by the rewarding characteristics of food rather than homeostatic need, termed reward-related eating (9–12). The influence of discretionary foods on brain reward circuitry (13) may additionally contribute to their preferential selection (10, 14), potentially displacing intake of more healthful foods.

Previous research in non-pregnant samples using brief screeners or food frequency questionnaires has shown that reward-related eating is associated with unhealthy snack food choices in an experimental paradigm (15), and with increased intake of sugar-sweetened beverages (16), snacks (17) and discretionary foods (18–20) in observational studies. However, the relationship of reward-related eating with overall diet quality has not been examined in pregnant women, in whom preference for palatable foods may be heightened due to increased cravings (21, 22).

Reward-related eating is hypothesized to interact with inhibitory control of eating impulses (23–25) and with the availability of discretionary foods in the environment (26). Laboratory-based studies in non-pregnant samples indicate that greater self-control is associated with overall lower food intake (27, 28) and attenuates relationships of reward-related eating with food intake (29–31). Additionally, a food environment abundant with highly palatable discretionary foods not only facilitates accessibility, but also increases cues prompting their intake (32). While studies indicate that greater home food availability of discretionary foods is associated with worse diet quality in pregnant (33) and non-pregnant samples (34–38), previous studies have not investigated whether the availability of discretionary foods in the home moderates the association of reward-related eating with diet quality.

The primary aim of this study was to investigate the relationship of reward-related eating with diet quality during pregnancy and postpartum, and to examine whether self-control and the home food environment moderates this relationship. We hypothesized that greater reward-related eating is associated with poorer diet quality, particularly greater intake of discretionary foods, and that lower self-control or a more obesogenic home food environment would strengthen the relationship. Additionally, the study explores differences in measures of reward-related eating, self-control, and home food environment between pregnancy and postpartum.

Methods

Design and participants

The Pregnancy Eating Outcomes Study (PEAS) was a prospective observational study of women enrolled at ≤ 12 weeks gestation from two university-based obstetrics clinics in Chapel Hill, North Carolina from November 2014 through October 2016 and followed through one-year postpartum (39). The primary study aims were to examine the roles of reward-related eating, self-control, and home food availability on dietary intake and weight change during pregnancy and postpartum, including potential moderating roles of self-control and home food availability on the association of reward-related eating with diet and weight outcomes. Power analyses to determine sample size have been reported previously (39). 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; able to complete self-report assessments in English; access to Internet with email; plan to deliver at the UNC Women's Hospital; and plan 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; psychosocial condition contraindicating participation in the study.

Procedures

Research staff identified potential participants through the electronic clinical appointments and medical records database. At the time of the visit, eligibility was verified and signed informed consent obtained from those electing to participate. 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 measures were completed online within each study visit window. Study procedures were approved by the University of North Carolina Institutional Review Board.

Measures

Dietary Intake. Participants were asked to complete a dietary recall within each study visit window using the Automated Self-Administered 24-Hour Recall (ASA24), a web-based tool for obtaining self-administered 24-hour dietary recalls developed by the National Cancer Institute and validated against the interviewer-administered automated multiple pass method (40, 41). The ASA24 prompts participants to indicate all foods consumed, including details of food preparation, brands, portion size, and additions. From this data, the program assigns food codes from the U.S. Department of Agriculture Food and Nutrient Database for Dietary Surveys and provide estimates of macronutrient, micronutrient, food categories and USDA Food Patterns Equivalents Database food groups. Participants received written instructions on use of the program, and research staff provided assistance if participants reported difficulty using the interface. Research staff at the University of North Carolina Nutrition and Obesity Research Core identified and corrected implausible entries (e.g., food items with implausible energy, fat or weight) and missing food or nutrient values and quantities. Dietary records indicating daily energy intakes of < 600 kcal (36 of 1883 records, 1.9%) were excluded from analyses. Dietary records with daily energy intakes of > 4500 kcal were reviewed and determined to reflect plausible intake. Dietary intake data were used to calculate the Healthy Eating Index-2015 (HEI), an *a priori* indicator of diet quality that reflects conformance to the 2015 US Dietary Guidelines for Americans (42). The HEI total score ranges from 0–100 and is calculated by summing 13 component scores, including 9 “adequacy components” (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein, seafood and plant proteins, fatty acids) and 4 “moderation components” (refined grains, sodium and added sugars and saturated fats), which are calculated on a per-1000 kcal or percent of kcal basis. Subscale scores reflecting adherence to adequacy (max score = 60) and moderation (max score = 40) components were also calculated. Diet recalls from pregnancy and those from postpartum were combined to calculate HEI across pregnancy (n = 365) and across postpartum (n = 266).

Hedonic Hunger. The Power of Food Scale (PFS) is a 15-item questionnaire that measures hedonic hunger, the appetitive response to highly-palatable food cues in the environment (43). Items querying response to the availability, presence, or taste of desirable food are rated on a 5-point Likert scale. The measure demonstrates strong internal consistency (Cronbach's alpha = 0.91) and test-retest reliability ($r = 0.77$, $p < 0.001$), and has been validated with respect to overeating (29), outcomes of weight-loss interventions (44), and brain activity in response to viewing images of food versus control (45). The PFS was completed each trimester during pregnancy and at 6 months postpartum (n = 227); mean scores across pregnancy were calculated (n = 377).

Addictive-like Eating. The modified Yale Food Addiction Scale (mYFAS), a 9-item abbreviated version (46) of the Yale Food Addiction Scale assesses the presence of eating disorder symptoms consistent with diagnostic criteria for food addiction. The measure has demonstrated psychometric properties similar to the original instrument, and greater scores were associated with higher BMI across two cohorts of women (46). The mYFAS was completed at baseline (n = 344) and 6-months postpartum (n = 217). Due to the highly skewed distribution, responses of 2 or more (12.5% of responses) were collapsed (only 2.3% of respondents scored 3 and 1.8 scored 4 or higher).

Food Reinforcement Measures. The Food Reinforcement Questionnaire (FRQ) (47) and Multiple Choice Procedure (MCP) (48) assessed the relative reinforcing value of food. The FRQ asks participants to report the number of portions of a specified food that they would purchase for same-day intake at varying cost levels. The measure generates five indices: breakpoint (first price at which consumption was zero), intensity of demand (consumption at the lowest price), elasticity of demand (sensitivity of consumption to increase in cost; individual elasticities calculated using the modified exponential demand equation) (49), O_{max} (maximum expenditure), and P_{max} (price at which expenditure was maximized). The measure has demonstrated validity against a laboratory task assessing food reinforcement value (47). The MCP asks participants to make a series of discrete choices between receiving an increasing amount of a monetary reward versus an alternative reinforcer. The datum of interest is the specific price at which participants begin to select the money over the reinforcer (breakpoint). The MCP has previously been validated in the assessment of reinforcement value of alcohol and cigarettes (e.g., 50), and was adapted by the investigators to assess the relative reinforcing value of food. Subjects were presented with the name and images of 18 palatable foods and asked to provide hedonic ratings. The two highest-rated foods were then used for the FRQ and MCP, which were assessed at the first two pregnancy visits and six months postpartum (n = 209 for FRQ and 211 for MCP). For each measure, mean scores across the two pregnancy visits were calculated (n = 348 for FRQ and 350 for MCP). Due to highly skewed distributions, scores were grouped into quartiles for analysis.

Self-control. Two measures of self-control were administered. 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 has demonstrated similar psychometric properties and associations with neurobehavioral traits as the original instrument (51). The Delaying Gratification Inventory (DGI) is a 35-item questionnaire measuring the tendency to forego immediate satisfaction in favor of long-term rewards across five domains – food, physical pleasure, social interaction, money and achievement (52). The subscale scores have shown good internal consistency (Cronbach's alpha = 0.69–

0.89) and strong test-retest reliability (r = 0.74–0.90). Both measures were completed at baseline (n = 314 for BIS and 330 for DGI) and 6 months postpartum (n = 215 for BIS and 219 for DGI). For this study, associations with the total score and the food subscale (DGI-food) were examined.

Home Food Environment. The Home Food Inventory includes a comprehensive range of foods in 15 categories and queries the presence of each food in the home (53). Participants completed the inventory at baseline (n = 303) and 6 months postpartum (n = 266). 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 counts of the number of foods in the home in each classification. The fruit and vegetable score includes 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 household composition, marital status, education, and race/ethnicity were reported by participants at baseline. Income-to-poverty ratio was calculated from family income and household size (54); higher values indicate greater income relative to the poverty threshold. Participant age and parity were obtained from the electronic medical record.

Analysis

Paired t-tests and Wilcoxon signed-rank tests (for highly skewed variables) examined differences in measures of reward-related eating, self-control, and home food environment between pregnancy and postpartum; Pearson and Spearman correlations examined associations of these variables between pregnancy and postpartum. Multiple linear regression analyses estimated associations of measures of reward-related eating, self-control, and home food environment with diet quality during pregnancy and postpartum, adjusting for age, education, income, household size, marital status, and parity. Variables were standardized to obtain the regression coefficient and its corresponding standard error. Multiplicative interaction terms were used to determine whether self-control or home food environment moderated associations reward-related eating with diet quality. Simple slopes analyses were used to interpret significant interaction terms. SPSS version 21 was used for all analyses. Analyses employed complete-case analysis; p values < 0.05 were interpreted as statistically significant.

Results

Of 458 women enrolled, 91 (20%) withdrew prior to delivery and 41 (9%) withdrew during postpartum (Fig. 1). Diet records were provided by 365 participants during pregnancy and 267 during postpartum. The sample was predominantly married, college-educated, and white; approximately half were of normal weight status (Table 1). FRQ-breakpoint and FRQ-P_{max} were significantly lower, while BIS-15 and HFI-FV were significantly higher, during postpartum versus pregnancy (Table 2). No other measures differed significantly between pregnancy and postpartum.

Table 1
Sample characteristics of participants with diet recall data (n = 365) in the Pregnancy Eating Attributes Study (PEAS)

Demographic characteristic	Mean ± SD or N (%)
Age at baseline	30.9 ± 4.6
Household size	3.0 ± 1.2
Poverty to income ratio	3.9 ± 1.9
Marital status	
Married/living with partner	315 (92.1)
Divorced/widowed/separated/single	27 (7.9)
Education	
High school graduate or less	27 (7.9)
Some college or associate's degree	63 (18.4)
Bachelor's degree	106 (31.0)
Master's/advanced degree	146 (42.7)
Race	
White	262 (75.3)
Black	49 (14.1)
Asian	17 (4.9)
Other or multi-race	20 (5.7)
Ethnicity	
Hispanic or Latino	26 (7.5%)
Not Hispanic or Latino	319 (92.5)
Parity	
Nulliparous	181 (49.6)
Parous	184 (50.4)
BMI group at baseline	
Normal weight	186 (51.0)

Demographic data missing for 26 participants for income; 23 participants for household size, marital status and education; 20 participants for ethnicity; and 17 participants for race

Demographic characteristic	Mean ± SD or N (%)
Overweight	97 (26.6)
Obese	82 (22.5)
Healthy Eating Index total score	
Pregnancy	57.82 (12.49)
Postpartum	58.24 (13.53)
Demographic data missing for 26 participants for income; 23 participants for household size, marital status and education; 20 participants for ethnicity; and 17 participants for race	

Table 2

Paired comparisons of reward-related eating, self-control, and home food environment during pregnancy and postpartum

	Pregnancy[a]	Postpartum[a]	Significance of change[b]	Correlation[c]
Power of food scale	2.22 ± 0.61	2.25 ± 0.77	0.04 ± 0.47, t = 1.15, p = 0.25	0.79
Yale food addiction scale	0.00, 0.00–1.00	0.00, 0.00–1.00	Z=-0.13, p = 0.89	0.60
Food reinforcement questionnaire				
Breakpoint	3.00, 2.00–5.00	3.00, 1.50-4.00	Z=-2.97, p = 0.003	0.39
Intensity	3.00, 2.00-4.50	4.00, 2.00-5.50	Z=-1.90, p = 0.06	0.42
O_{max}	2.50, 1.26–4.50	2.00, 1.00–4.00	Z=-1.80, p = 0.07	0.40
P_{max}	2.00, 0.75–4.50	2.00, 0.50-3.00	Z=-2.72, p = 0.007	0.36
Elasticity	0.03, 0.02–0.05	0.03, 0.01–0.05	Z=-1.80, p = 0.07	0.34
Multiple choice procedure	2.25, 0.78–4.98	2.56, 1.16–5.62	Z=-0.55, p = 0.58	0.48
Barratt impulsiveness scale, short form	25.30 ± 5.59	27.20 ± 5.05	1.89 ± 3.48, t = 7.67, p < 0.001	0.79
Delaying gratification inventory	139.56 ± 10.18	139.13 ± 12.05	-0.42 ± 7.91, t=-0.77, p = 0.44	0.76
Delaying gratification inventory, food subscale	24.19 ± 3.71	24.42 ± 3.90	0.23 ± 3.37, t = 0.98, p = 0.33	0.61
Home food inventory, obesogenic score	22.16 ± 8.22	22.26 ± 8.49	0.09 ± 6.98, t = 0.20, p = 0.84	0.61

[a]Values are median and interquartile range for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; mean ± SD for all other variables.

[b]Comparisons using Wilcoxon signed ranks test for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; paired-samples t-tests for all other variables, with mean ± SD of change presented.

[c]Spearman correlation used for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; Pearson correlations used for all other variables; p < .001 all correlations.

	Pregnancy[a]	Postpartum[a]	Significance of change[b]	Correlation[c]
Home food inventory, fruit and vegetable score	18.77 ± 5.46	20.17 ± 6.32	1.40 ± 5.97, t = 3.58, p < 0.001	0.65

[a]Values are median and interquartile range for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; mean ± SD for all other variables.

[b]Comparisons using Wilcoxon signed ranks test for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; paired-samples t-tests for all other variables, with mean ± SD of change presented.

[c]Spearman correlation used for Yale food addiction scale, food reinforcement questionnaire, and multiple choice procedure; Pearson correlations used for all other variables; p < .001 all correlations.

Pregnancy HEI-total was inversely associated with reward-related eating as measured by the PFS, mYFAS, MCP, FRQ-intensity, and FRQ-O_{max}, but not FRQ-breakpoint, FRQ-P_{max}, or FRQ-elasticity (Table 3). These associations were more consistently observed with the HEI adequacy components than the HEI moderation components. Higher self-control (lower BIS-15 and higher DGI) was associated with greater HEI-adequacy but was unassociated with HEI-total or HEI-moderation, whereas DGI-food was positively associated with all diet quality indicators. HEI-total, HEI-adequacy and HEI-moderation were associated inversely with HFI-OBES and positively with HFI-FV.

Table 3

Associations of reward-related eating, self-control, and home food environment with pregnancy diet quality

	HEI2015 Total Score[a]		**HEI Adequacy Score[a]**		**HEI Moderation Score[a]**	
	β	**p**	**β**	**p**	**β**	**p**
Power of food scale	-0.14 ± 0.05	0.006	-0.12 ± 0.05	0.02	-0.14 ± 0.06	0.01
Yale food addiction scale	-0.13 ± 0.06	0.02	-0.13 ± 0.05	0.01	-0.09 ± 0.06	0.16
Food reinforcement questionnaire						
Breakpoint	-0.08 ± 0.05	0.12	-0.08 ± 0.05	0.08	-0.05 ± 0.06	0.38
Intensity	-0.15 ± 0.05	0.003	-0.12 ± 0.05	0.01	-0.15 ± 0.05	0.005
O_{max}	-0.12 ± 0.05	0.03	-0.10 ± 0.05	0.03	-0.10 ± 0.06	0.08
P_{max}	-0.07 ± 0.05	0.16	-0.09 ± 0.05	0.06	-0.02 ± 0.06	0.70
Elasticity	0.02 ± 0.05	0.67	0.04 ± 0.05	0.40	-0.02 ± 0.06	0.76
Multiple choice procedure	-0.14 ± 0.05	0.007	-0.10 ± 0.05	0.046	-0.17 ± 0.06	0.003
Barratt impulsiveness scale, short form	-0.09 ± 0.05	0.08	-0.10 ± 0.05	0.04	-0.04 ± 0.06	0.41
Delaying gratification inventory	0.09 ± 0.05	0.09	0.10 ± 0.05	0.046	0.04 ± 0.06	0.46
Delaying gratification inventory, food subscale	0.22 ± 0.05	< 0.001	0.20 ± 0.05	< 0.001	0.19 ± 0.06	0.001
Home food inventory, obesogenic score	-0.19 ± 0.06	0.001	-0.19 ± 0.06	0.001	-0.13 ± 0.06	0.049
Home food inventory, fruit and vegetable score	0.25 ± 0.05	< 0.001	0.23 ± 0.05	< 0.001	0.21 ± 0.06	< 0.001

[a]Multiple linear regression analyses; standardized coefficients adjusted for age, education, income, household size, marital status, and parity

In postpartum, few associations of diet quality with reward-related eating or self-control were statistically significant (Table 4). FRQ-breakpoint was positively associated with HEI-total and HEI-adequacy, FRQ-P_{max} was positively associated with HEI-adequacy, and DGI was associated with HEI-moderation; no other associations were statistically significant. HEI-total and HEI-adequacy were associated inversely with HFI-OBES and positively with HFI-FV; HEI-moderation was associated only with HFI-OBES.

Table 4
Associations of reward-related eating, self-control, and home food environment with postpartum diet quality

	HEI2015 Total Score[a]		HEI Adequacy Score[a]		HEI Moderation Score[a]	
	β	p	β	p	β	p
Power of food scale	0.02 ± 0.07	0.77	0.03 ± 0.07	0.64	-0.004 ± 0.07	0.97
Yale food addiction scale	-0.02 ± 0.08	0.76	-0.02 ± 0.08	0.77	-0.02 ± 0.08	0.65
Food reinforcement questionnaire						
Breakpoint	0.14 ± 0.07	0.04	0.15 ± 0.07	0.02	0.09 ± 0.07	0.22
Intensity	0.03 ± 0.07	0.71	0.01 ± 0.07	0.85	0.04 ± 0.07	0.58
O_{max}	0.07 ± 0.07	0.31	0.07 ± 0.07	0.30	0.05 ± 0.07	0.48
P_{max}	0.13 ± 0.07	0.06	0.14 ± 0.07	0.03	0.07 ± 0.07	0.33
Elasticity	-0.03 ± 0.07	0.57	-0.04 ± 0.06	0.54	-0.02 ± 0.07	0.74
Multiple choice procedure	0.003 ± 0.07	0.97	-0.02 ± 0.07	0.75	0.05 ± 0.08	0.55
Barratt impulsiveness scale, short form	-0.13 ± 0.07	0.05	-0.11 ± 0.06	0.09	-0.13 ± 0.07	0.06
Delaying gratification inventory	0.13 ± 0.07	0.07	0.08 ± 0.07	0.28	0.19 ± 0.07	0.01
Delaying gratification inventory, food subscale	0.07 ± 0.07	0.29	0.04 ± 0.07	0.53	0.10 ± 0.07	0.14
Home food inventory, obesogenic score	-0.26 ± 0.09	0.002	-0.21 ± 0.09	0.01	-0.28 ± 0.09	0.002
Home food inventory, fruit and vegetable score	0.17 ± 0.07	0.01	0.20 ± 0.07	0.004	0.08 ± 0.07	0.29

[a]Multiple linear regression analyses; standardized coefficients adjusted for age, education, income, household size, marital status, and parity

Tests for interaction of each measure of reward-related eating with each self-control and home food environment on HEI-total yielded few significant interaction terms (Fig. 2). In pregnancy, HFI-FV significantly interacted with FRQ-elasticity ($B = 0.14 \pm 0.06$, $p = .01$) such that lower reward-related eating was associated with greater diet quality when fruit and vegetable availability was high. In postpartum, BIS-15 ($B = 0.21 \pm 0.07$, $p = .001$) and DGI ($B=-0.22 \pm 0.07$, $p = .002$) significantly interacted with MCP such that greater self-control was associated with higher diet quality when reward-related eating was low. Additionally, HFI-OBES significantly interacted with FRH-intensity ($B = 0.19 \pm 0.08$, $p = .02$) such that reward-related eating was positively associated with diet quality in a higher obesogenic food environment. No other significant interactions were observed.

Discussion

In this sample of women followed from early pregnancy through one-year postpartum, diet quality during pregnancy was inversely associated with multiple measures of reward-related eating; however, these associations were not observed during postpartum. The few significant associations observed during postpartum were in the opposite direction to that hypothesized. Across both periods, diet quality was associated positively with fruit and vegetable availability in the home and inversely with an obesogenic home food environment. Diet quality was not associated with measures of general self-control during pregnancy or postpartum; however, diet quality was positively associated with food-related delay of gratification in pregnancy.

Findings of an inverse association of reward-related eating with diet quality during pregnancy is consistent with a small body of research showing relationships of reward-related eating with greater intake of discretionary foods. Higher PFS was associated with greater intake frequency of discretionary, but not healthful, foods in US emerging adults (18) and more frequent snacking in a small sample of Australian adults (17). Classification as “food addicted” using the YFAS was associated with greater intake of red/processed meat, low-fat snacks/desserts, and low-calorie beverages in the Nurses’ Health Study (20), greater percent energy intake from discretionary foods in Australian adults (19), and greater sweetened beverage intake in Dutch adolescents (16). In the current study, however, associations of reward-related eating with diet quality were more consistently observed for the adequacy components than for the moderation components, contrary to our hypothesis.

To our knowledge, no previous studies have examined reward-related eating during pregnancy and postpartum. The differences in relationships of measures of reward-related eating with diet quality between pregnancy and postpartum observed in this study were unexpected and may reflect differential influences between periods. Previous research indicates that women may relax efforts to control eating during pregnancy (55, 56), which may result in greater susceptibility to reward-related eating. Little is known about influences of eating behaviors during postpartum, when there are no physiological expectations for weight gain. It is plausible that postpartum women may regulate their eating more carefully in an effort to return to their pre-pregnancy weight (57).

The association of higher diet quality with greater delay of gratification for food, but not overall delay of gratification, during pregnancy is a novel finding. While limited research has shown associations of general delay discounting with dietary intake (30, 58), assessment of domain-specific delay of gratification may have greater utility. Further research to determine the potential relevance of this construct and its malleability to intervention would be informative.

Consistent with previous research in pregnant (33) and general samples (34–38), better diet quality was associated with a less obesogenic home food environment. This association likely reflects both self-selection and environmental shaping. That is, food purchases likely reflect one's eating intentions; additionally, the availability of foods in the home constrains or facilitates eating choices. In focus groups, women reported keeping foods they craved out of their homes to help them resist cravings (55). Given that approximately two-thirds of energy intake is consumed from foods in the home (59), efforts to promote a healthful food environment during pregnancy and postpartum are likely to improve diet quality.

Findings yielded little evidence that self-control or the home food environment moderated relationships of reward-related eating with dietary intake. The few interactions observed should be interpreted with caution given the multiple measures of reward-related eating and therefore large number of interaction terms tested. For most of the significant interactions observed, differential associations were observed at low levels of reward-related eating, suggesting that high reward-related eating may override the influence of self-control and the home food environment on diet quality. The interaction of FRH-intensity with HFI-OBES in the opposite direction to that hypothesized may reflect a spurious finding, given the absence of similar findings with any other measure of reward-related eating.

Findings from this study should be interpreted in consideration of the study's strengths and limitations. While there is no gold standard measure of reward-related eating, the use of multiple measures of the construct facilitates examination of the research question. However, measures did not include a behavioral choice task assessment or brain imaging measures of food reinforcement. Dietary intake was assessed using multiple 24-hour recalls across pregnancy and postpartum; however, only one recall was obtained at each time point, precluding the ability to examine differences between trimesters or different times in postpartum. The study's use of HEI as the outcome of interest facilitates a focus on overall dietary intake; however, it is notable that the same HEI score can be achieved through a variety of eating patterns. Additional strengths include the large sample size, repeated assessments from early in pregnancy to one year postpartum, and measurement of multiple potential confounders. An important limitation relates to the sample characteristics, as the study was conducted in a single geographic area with limited racial/ethnic and socioeconomic diversity. Thus, future research examining these questions in more diverse samples is needed.

Conclusion

In summary, greater reward-related eating and food-related delay of gratification were associated with lower diet quality in this sample of primary well-educated women during pregnancy but not postpartum, while the home food environment was associated with diet quality across both time periods. In addition, there was some evidence that higher reward-related eating may outweigh influences of self-control and the home food environment. Findings suggest the importance of research to further advance our understanding of the determinants of reward-related eating and the development of approaches to circumvent or moderate them. Additionally, there is a need to better understand differences in determinants of eating behaviors between pregnancy and postpartum to facilitate more optimal diet quality during this critical period.

Abbreviations

HEI, Healthy Eating Index-2015; mYFAS, Modified Yale Food Addiction Scale; PFS, Power of Food Scale; MCP, Multiple Choice Procedure; FRQ, Food Reinforcement Questionnaire; HFI, Home Food Inventory; HFI-OBES, obesogenic home food environment score; HFI-FV, fruit and vegetable home food environment score; BIS-15, Barratt Impulsiveness Scale; DGI, Delaying Gratification Inventory

Declarations

Ethics approval and consent to participate: Study procedures were approved by the University of North Carolina Institutional Review Board.

Consent for publication: Not applicable

Availability of data and materials: Data described in the manuscript, code book, and analytic code will be made available upon request pending approval of a data use agreement. Following publication of study objectives, de-identified data will be shared in the NICHD Data and Specimen Hub.

Competing interests: The authors have no competing interests to declare.

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Authors' contributions: TRN, LL, MF, AL, and AMSR designed the research. TRN analyzed data, wrote the paper, and had primary responsibility for final content. All authors provided substantive revisions to the manuscript.

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Figures

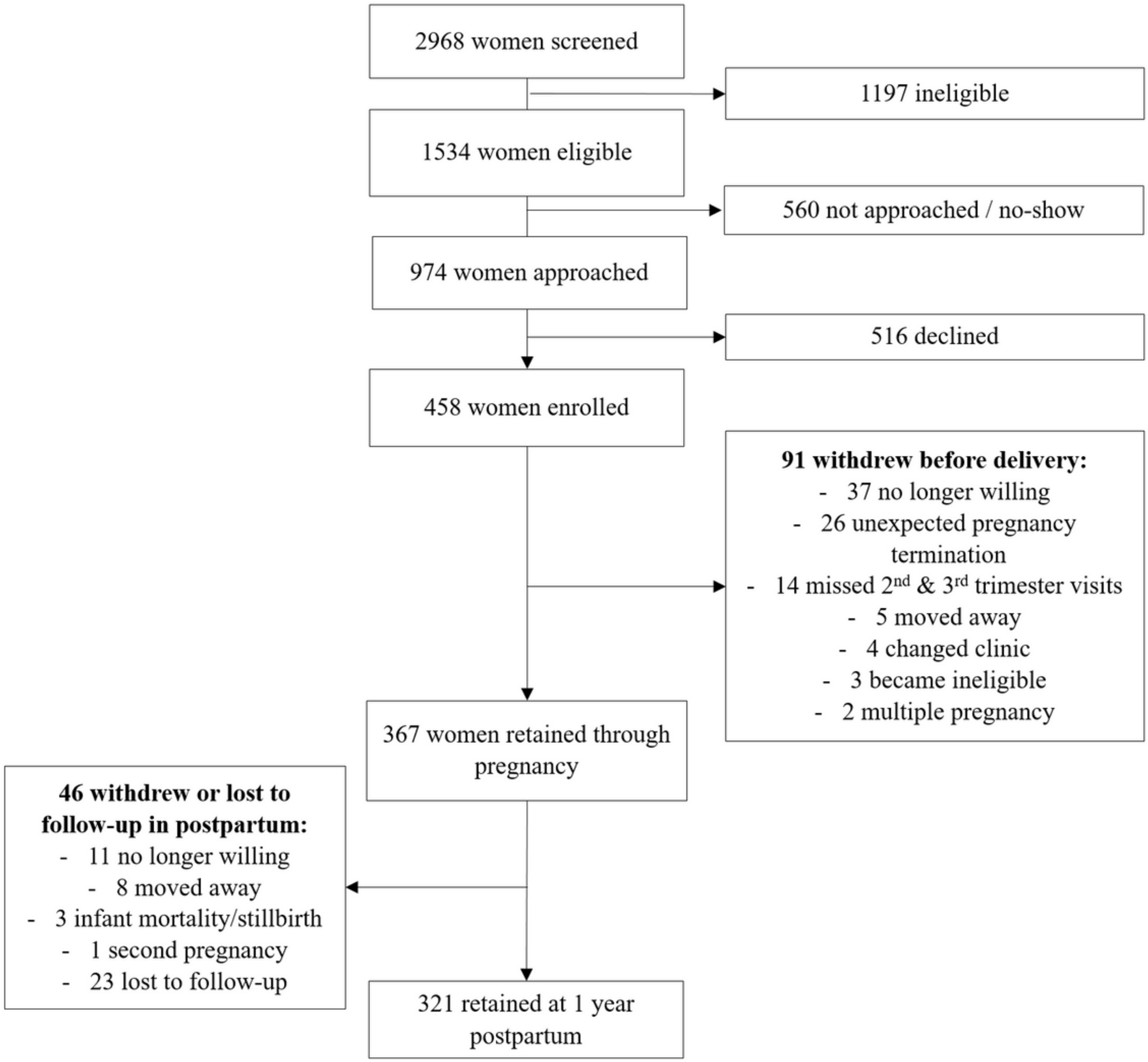

Figure 1

Flow of recruitment and participation in the Pregnancy Eating Attributes Study (PEAS).

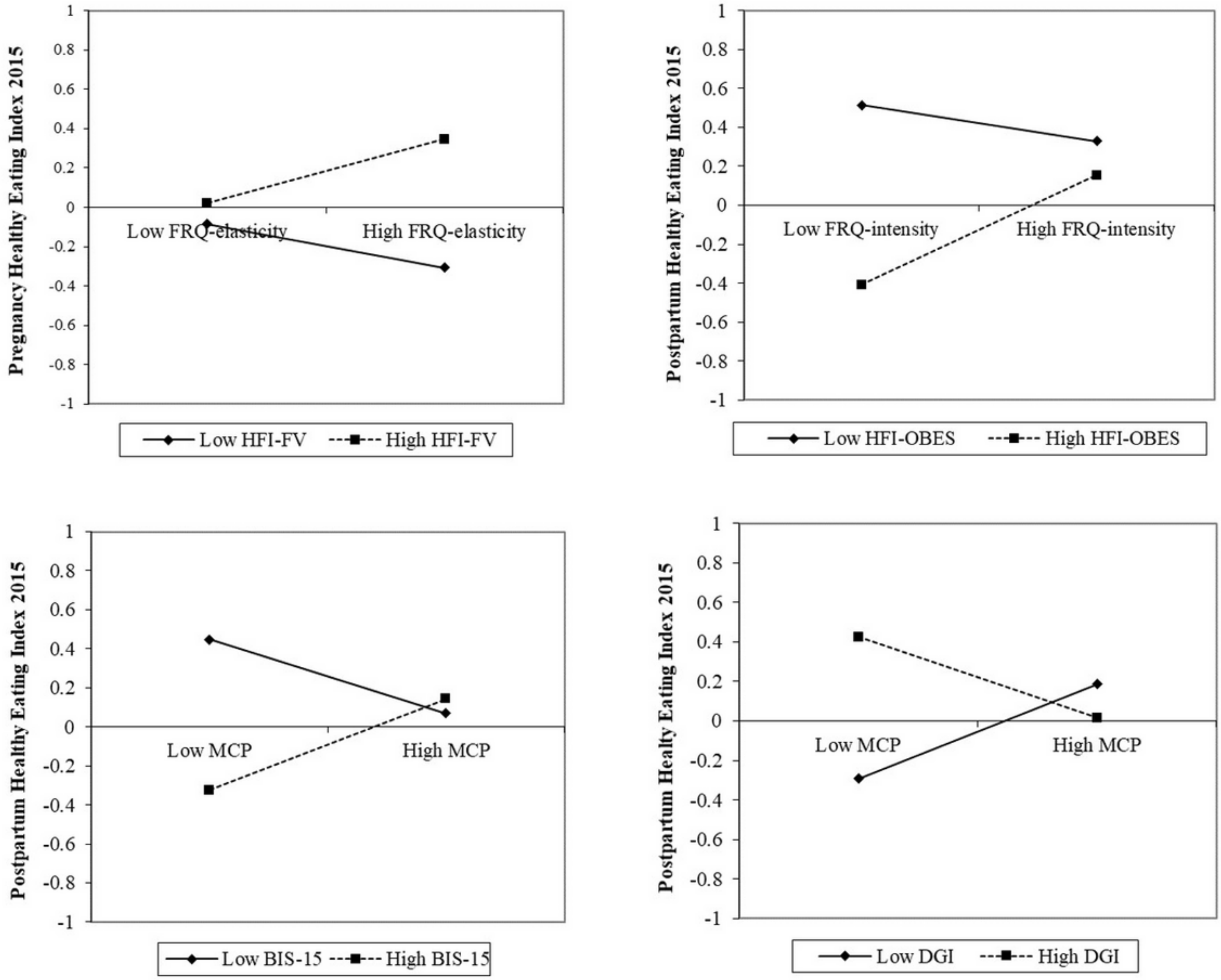

Figure 2

Interactions of home food environment and self-control with reward-related eating on diet quality. FRQ, Food Reinforcement Questionnaire; MCP, Multiple Choice Procedure; HFI-FV, fruit and vegetable home food environment score; HFI-OBES, obesogenic home food environment score; BIS-15, Barratt Impulsiveness Scale; DGI, Delaying Gratification Inventory