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ANTECEDENTS OF CHILDHOOD OBESITY RISK FACTORS, A SELF DETERMINATION THEORY PERSPECTIVE

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ANTECEDENTS OF CHILDHOOD OBESITY RISK FACTORS,

A SELF DETERMINATION THEORY PERSPECTIVE

BY

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ABSTRACT

Overweight and obesity effect one in three children in the US, with significant disparities for Non-Hispanic Black and Hispanic/ Latinx children. Factors such as rapid weight gain, non-responsive feeding practices, and poor diet quality in infancy and early childhood can contribute to the development of obesity. An in depth understanding of what predicts these factors is necessary to inform and improve obesity prevention and treatment efforts. This is especially important to understand in the communities disproportionately impacted by childhood obesity. Therefore, the objective of this dissertation was to explore the contextual factors that influence rapid weight gain, non-responsive feeding practices, and diet quality in infants and young children at increased risk for developing obesity. We developed a conceptual model using self-determination theory and hypothesized that caregivers' psychological well-being influences the socio-emotional context of feeding and can impact the child's obesity risk.

The first study was a longitudinal secondary data analysis of Nurture, a completed birth cohort of predominately Black mothers and their infants (n=666) that explored the impact of maternal perceived stress on change in weight-for-length (WFL) z-scores and risk of rapid weight gain in infancy. Mixed model analysis of repeated measures assessed associations between perceived stress and change in WFL z-score from 3 months to 6 ,9, and 12 months. Log-binomial models assessed the association between perceived stress and rapid weight gain from 3 months to 12 months. We found that rapid infant weight gain was prevalent in the sample, with nearly half of infants experiencing rapid weight gain between 3 and 12 months postpartum. Contrary to our hypothesis we did not find evidence that mothers perceived stress influenced weight gain trajectories or risk of rapid weight gain in the first year of life.

The second and third studies were cross-sectional secondary data analyses of baseline data collected as part of the Strong Families Start at Home Study; a pilot randomized control trial with predominately Hispanic/Latinx caregivers of preschool-aged children (n=67). The second study used multivariable linear regressions to assess the association between caregivers' basic psychological need satisfaction and frustration with responsive (autonomy supportive and structured) and non-responsive (controlling and chaotic) feeding. We found that psychological need frustration was positively associated with controlling and chaotic feeding. Contrary to our hypothesis, need satisfaction was not significantly associated with autonomy supportive or structured feeding.

The third study explored how children's eating behaviors influence their eating patterns and diet quality. We evaluated associations between eating behaviors and total diet quality score using multivariable linear regression. We assessed the impact of eating behaviors on the odds of high intake of components of diet quality including milk, whole grains, refined grains, protein, fruits, vegetables, fruit juice, sugar-sweetened beverages, other added sugars, and salty snacks using logistic regression. We found that meal size was negatively associated with food fussiness and satiety responsiveness, while positively associated with food responsiveness. The size of caloric beverages outside meals and snacks was positively associated with food fussiness. Exploratory analyses showed that eating behaviors were significantly associated with refined grain, fruit, and sugar-sweetened beverage scores.

Together, these studies provide evidence that interventions aiming to improve caregivers' feeding should support caregiver's psychological needs while considering differences in children's eating behaviors that may influence what nutritional targets need to be prioritized. This information can be used as targets for intervention to promote the development of healthy eating for children. We also highlight areas where research is needed, particularly with regards to rapid weight gain in infancy, and the role of maternal stress, and eating behaviors in diet quality and childhood obesity risk.

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PREFACE

This dissertation was written to comply with the University of Rhode Island Graduate School Manuscript Dissertation Format. This Dissertation contains three manuscripts:

Manuscript 1: Maternal Stress and Excessive Weight Gain in Infancy. This manuscript has been written in a form suitable for publication in BMC Pediatrics.

Manuscript 2: Associations Between Child Eating Behavior with Eating Patterns and Diet Quality in Preschool-Aged Children. This manuscript has been written in a form suitable for publication in Appetite.

Manuscript 3: Associations Between Caregivers' Basic Psychological Need Satisfaction and Frustration with the Socio-emotional Context of Feeding. This manuscript has been written in a form suitable for publication in the Journal of Nutrition Education and Behavior.

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Manuscript **1**

Maternal Stress and Excessive Weight Gain in Infancy

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ABSTRACT

Rapid weight gain in infancy increases the risk of developing obesity early in life and contributes significantly to racial and ethnic disparities in childhood obesity. While maternal perceived stress is associated with childhood obesity, little is known about the impact it has on infant weight gain. Therefore, this study explores the impact of maternal perceived stress on change in weight-for-length (WFL) z-scores and risk of rapid weight gain in infancy. We conducted a secondary data analysis of the longitudinal Nurture birth cohort, (n=666). Tertiles were used to compare mothers with high and low perceived stress. Mixed model analysis of repeated measures assessed associations between baseline perceived stress and change in infant WFL z-scores over time. Log-binomial models assessed the association between baseline perceived stress and rapid weight gain, defined as a change in WFL z-score >0.67 standard deviations from 3 to 12 months. Most mothers were non-Hispanic/Latinx Black. About one-half of mothers had overweight or obesity prior to pregnancy, were unemployed, and low income. Most infants were born full term, were normal weight and were breastfed for 14.7±18.2 weeks. Just under one half of infants experienced rapid weight gain between 3 and 12 months. Birthweight for gestational age (RR= 1.18, 95% CI= 1.08-1.29, p-value =.004), gestational age at birth (RR= 1.07, 95% CI= 1.01-1.14, p-value= .031), and weeks breastfed (0.99, 95% CI 0.99-1.00, p-value .044) were associated with risk of rapid weight gain in unadjusted analyses. WFL z-scores increased significantly over time, with no effect of perceived stress on change in WFL z-score or risk of rapid weight gain. Rapid weight gain in infancy was prevalent in this sample of predominately Black infants in the Southeastern US. We did not find evidence to support the hypothesis that maternal perceived stress influenced risk of rapid weight gain. More work is needed to identify and assess risk factors for rapid weight gain in infancy and to understand the role maternal stress plays in obesity risk, so that prevention efforts can be targeted.

Background

Childhood obesity continues to be a significant public health issue in the US with clear disparities in prevalence and severity across race, ethnicity, and socio-economic status that begin early in life (1,2). Addressing obesity early in life is critical as it tracks into adulthood and is associated with significant comorbidities including cardiometabolic disease (3,4). One factor that shown to contribute to the overall risk of developing childhood obesity, as well as to differences among racial and ethnic groups, is rapid weight gain in infancy.

Rapid weight gain, commonly defined as a change in weight-for age (WFA) or weight-for-length (WFL) z-scores of >0.67 standard deviations, is demonstrated by a cross in percentile bands on the World Health Organization growth chart and has been associated with increased odds of obesity in childhood, adolescence, and young adulthood worldwide (5–7). This association between rapid weight gain and later obesity risk remains, independent of birth weight, except for preterm (<34-week gestational age) infants (8). Importantly, data from the Early Childhood Longitudinal Study (ECLS) – Birth Cohort showed that weight gain in infancy was the largest contributing factor to differences in childhood obesity between racial and ethnic groups (9). The rate of weight gain in infancy accounted for 40-70% of the disparities in childhood obesity at kindergarten entry between White and Black children. Understanding contributors to rapid weight in infancy may be important for addressing disparities in childhood obesity.

Studies have identified both maternal and infant factors that impact rapid weight gain in infancy including non-modifiable (gender, race, ethnicity, and parity) as well as some modifiable factors (gestational weight gain, gestational age, low birth weight, formula feeding, feeding on a schedule, maternal cigarette smoking) (10–13). Although several risk factors have been identified, they account for a small percentage of rapid weight gain variance (7-11%), suggesting that other factors, such as maternal stress, may be playing an important role (10).

Maternal stress early in her child's life has been shown to increase obesity risk from toddlerhood to adolescence (14). In a study of the Lifestyle and Environmental Factors and their Influence on Newborn Allergy risk (LINA) prospective birth cohort, maternal perceived stress in the first year postpartum was significantly associated with longitudinal body mass index (BMI) in girls from birth to 5 years of age (15). There are several proposed mechanisms by which perceived stress in mothers impacts child BMI including modeling of unhealthy behaviors, having lower involvement with children, and being less responsive to children's needs (16–19). High levels of perceived stress (perceiving ones' life as stressful, unpredictable, uncontrollable, and overloaded) may negatively impact maternal child relations by decreasing how well a mother attunes to cues from her child (20). and the child's secure attachment (18). For example, one study found that a poor maternal-child relationship in early childhood (15-36 months) was associated with 2.45 times higher odds of adolescent obesity (18). Furthermore, the relationship between maternal perceived stress and child obesity risk is moderated by child gender, race, and ethnicity as well as household income status with findings suggesting a stronger association for females, non-Hispanic Black children, and in low-income households (15,16). Maternal perceived stress has also been associated with higher energy intake and increased consumption of breads and cereals among 0- to 6-month-old infants (21) – although findings on the relation between maternal stress and diet throughout childhood are less consistent (22).

Even though maternal perceived stress in the first year of life has been associated with childhood obesity risk and infant feeding, few studies have explored the impact of maternal perceived stress on infant weight gain trajectories and rapid weight gain to determine if stress impacts child obesity risk earlier than previously thought (13). This question is particularly important to explore in populations exposed to chronic stressors such as racism or financial insecurity. Therefore, the goal of this study is to explore the association between perceived stress, change in WFL z-score over time, and rapid weight gain (increase in WFL z-score >0.67) in infancy in a predominately low-income Black cohort. We hypothesized that higher maternal perceived stress will be associated with increases in WFL z-score over time and more rapid infant weight gain between 3 and 12 months.

Methods

Study Design and Sample Characteristics

This study is a secondary data analysis of the longitudinal Nurture birth cohort (23). Nurture (n=666) is designed to evaluate the impact of caregivers on infant adiposity and weight trajectories through the first year of life. Mothers were 20-36 weeks' gestation at the time of recruitment, pregnant with a singleton with no known congenital abnormalities, >18 years of age, able to speak and read English, intending to keep the baby and reside in the area (Southeastern, USA) at least 12 months post-partum. After birth researchers excluded dyads if babies were born prior to 28 weeks of age, with congenital abnormalities that could affect growth and development, were hospitalized ≥ 3 weeks after birth or were not feeding by mouth at the time of hospital discharge. Trained research staff collected data on maternal demographics, and infant anthropometric measurements during home visits when infants were 3, 6, 9, and 12 months. Data collection took place from 2013 to 2017. The study was approved by the Institutional Review Board of Duke University Medical Center and full study details have been previously published (23)

Exposure Variable: Mothers completed the Perceived Stress Scale (PSS) (24), which is a 10-item scale that measures "the degree to which individuals appraise situations in their lives as stressful" on a five-point Likert scale ranging from never (0) to very often (4). A systematic review found the PSS to have good internal consistency (α=>0.7 in 12 studies), and high test-re-test reliability (>0.7 in 4 studies) (25). The measure has demonstrated criterion validity with other measures of stress and depression, and predictive validity with groups known to have higher levels of perceived stress (25–28). Four of the ten items were reverse scored, and all items' scores were summed to create a total score with possible scores ranging from 0-40, with a higher score indicating higher perceived stress. Mothers completed the PSS at baseline (3 months postpartum) and at each follow up visit (6, 9, and 12 months postpartum) and had strong internal validity in this sample with Cronbach alpha of 0.89. We assessed PSS continuously and using tertiles to compare risk of rapid weight gain in those with high (Q3) compared to low (Q1) stress as has been done in previous studies (29).

Outcome Variable: Trained research staff obtained measured weight and length in participants' homes using standardized methods. We then calculated z-scores using World Health Organization age and sex-specific references (30). Rapid weight gain, a binary outcome defined as an infant with an increase in weight-for-length z-score >0.67 SD from baseline (3 months postpartum) to study completion (12 months postpartum) (31).

Covariates: We selected covariates measured during the Nurture demographic survey with established relation with the exposure and outcome (10,32). Covariates included mother's age, race, pre-pregnancy BMI, prenatal diet quality, marital status, education, income, household composition and the infant's birth weight, gestational age at birth, gender, race, ethnicity, and total weeks the infant was breastfed. Mothers completed the Block FFQ, which assesses diet over the last 30 days (33). We assessed prenatal diet quality using the Alternate Healthy Eating Index 2010 (AHEI-2010), excluding the alcohol category, scored 0-100 with higher scores indicating better diet quality (34).

Statistical Analysis

We conducted analyses using SAS version 9.04 for Linux (SAS Institute Inc. Cary, NC). We assessed data for missingness. All the time-varying variables had missing data, as is common in longitudinal research studies (Supplementary Table 1) (35). We flagged missing data and assessed differences between observations with and without missing exposure (PSS score) using independent t-tests for normally distributed continuous variables, Wilcoxon rank sum test for non-normally distributed continuous variables, and Chi-Square tests for categorical variables (Supplementary Table 2). Women who had missing data were significantly younger and more likely to be Black, less likely to be Hispanic/Latinx, married or living with a partner, and have a high school education or greater. Infants with missing data were more likely to be Black, less likely to be Hispanic/Latinx, and were breastfed for fewer weeks. We determined, based on the limited number of significant associations with missingness, that the data were missing at random. Therefore, we used multiple imputation using the time-varying exposure and outcome variable, covariates and auxiliary variables associated with missingness (35–38). We used a fully conditional specification algorithm for imputation, with logistic regression used for binary variables (rapid weight gain, education, had overweight/obesity pre pregnancy, low- income, unemployed, marital status, and household composition) and predictive mean matching used for non-normally distributed variables (PSS score, household composition, and AHEI-2010 score). Given the high proportion of missing data, we created 50 imputations (35). All subsequent analyses were conducted using the imputed datasets and the estimates and confidence intervals presented reflect the pooled results (38).

First, stability of PSS over timed was assessed using Pearson's correlation between timepoint pairs and intraclass correlation coefficients calculated using a random intercept linear mixed model. PSS scores were moderately correlated across all timepoints (r 0.5-0.6, p<0.001). The ICC was 0.6 indicating good stability across time (p <.001). We therefore chose to assess baseline PSS tertiles (3-months postpartum) in all regressions to establish temporality between exposure and outcome, given the stability of the PSS measure over time. We calculated means and standard errors for continuous variables and percentages for categorical variables for the sample and each PSS tertiles. We assessed for trends in baseline demographic characteristics across PSS tertiles using linear regression for continuous variables and Cochran-Mantel-Haenszel Test for categorical variables (29).

Given the high prevalence of rapid weight gain, odds ratios may not be a good approximation of the risk ratio. Therefore, log-binomial models were developed to assess the association between risk factors (PSS and covariates) and rapid weight gain. We calculated mean change in WFL z-score at each timepoint by baseline PSS tertiles. We then fit a mixed model analysis of repeated-measure using a compound symmetry covariance structure, to assess the association of PSS tertiles and change in WFL z-score accounting for between and within subject variation.

To assess the association between tertiles and rapid weight gain (change in WFL z-score >0.67) we developed Log-binomial models. We added covariates individually to the model assessing influence of perceived stress tertiles on risk for rapid weight gain and kept variables in the adjusted model if the estimate changed by 10% or greater. Given previous literature suggesting that gender, race, and income status may be potential moderators between maternal perceived stress and childhood obesity risk, we tested for interaction effects between these variables and PSS.

Results

Demographic and anthropometric characteristics of the study population along with the imputed values are provided in Table 1. At baseline women were on average 27.3 +/-5.7 years, primarily non-Hispanic/Latinx (93.5%), Black (71.5%), with poor diet quality (AHEI-2010 42.2 ±11.2). About one-half of women had overweight or obesity prior to pregnancy (61.4%), were married or living with a partner (57.5%), unemployed (50.9%), and low income (<$20,000/year) (57.6%). On average infants were full term, born normal weight for gestational age (z-score -0.3+/- 0.9) and were breastfed on average for 14.7 +/-18.2 weeks.

On average, at 3-months postpartum, PSS score was 12.8±0.33, with a range of 0-30. When divided into tertiles the low stress group had a mean 5.3±02 and range of 0-9, the moderate stress group had a mean of 12.3±0.1 and a range of 10-15, and the high stress group had a mean of 20.7±0.4 and range 16-39. There were no significant differences for demographic or anthropometric characteristics across PSS tertiles (Table 1). Just under one half of infants (47%) experienced rapid weight gain between baseline (3 months) and follow up (12 months). Certain covariates were associated with rapid weight gain, including, birthweight-for-gestational-age z-score and gestational age at birth (Supplemental Table 3). A 1 standard deviation increase in birth weight-for-age z-score was associated with 1.18 times greater risk of rapid weight gain (RR= 1.18, 95%CI= 1.08-1.29, p-value <.001). A 1 week increase in gestational age at birth was associated with a 1.07 times greater risk of rapid weight gain (RR= 1.07, 95% CI= 1.01-1.14, p-value= .031). Total weeks breastfeeding was also associated with risk of rapid weight gain between 3 and 12 months (RR= 0.99, 95%CI= 0.99-1.00, p-value=.044), whereby breastfeeding for 1 year was associated with a 27 percent lower risk of rapid weight gain (RR= 0.73, 95%CI= 0.54-1.00, p-value= .049).

*Table 1 Characteristics of the Nurture Cohort by Baseline Perceived Stress Score (PSS)Tertiles**

Variables N (%) or mean ±SE	Full (n=666)	Low Stress (n=227)	Moderate Stress (n=214)	High Stress (n=224)	P-for-trend
Maternal					
Age	27.3±0.2	27.4±0.5	27.4±0.5	27.0± 0.4	.55
Race (Black)	476(71.5)	170(74.8)	142(66.6)	163(72.7)	.17
Ethnicity (Hispanic/Latinx)	43(6.5)	14(6.0)	11(5.3)	18(8.2)	.40
Overweight or Obese Pre-pregnancy	393 (59)	141(62.3)	124 57.9)	128(56.8)	.43
Prenatal diet quality (AHEI)	42.2±0.5	42.2±0.9	42.3±0.9	42.2±0.9	.96
Married or living with partner	380(56.7)	133(58.4)	124(58.1)	123(54.7)	.51
Highschool degree or greater	531(79.7)	185(81.5)	175(81.7)	171(76.1)	.31
Unemployed (looking for work)	125(18.8)	37(16.4)	47(22.0)	41(18.4)	.27
Low Income(<20,000/year)	399(59.9)	133(58.5)	123(57.2)	143(63.9)	.33
Number of people living in the home	3.5±0.1	3.6±0.1	3.4±0.1	3.5±0.1	.61
Perceived Stress Score**	12±0.3	5.3±0.2	12.3±0.1	20.7±0.4	<.01
Infant					
Gestational age at birth	38.6±0.2	38.7±0.1	38.7±0.1	38.4±0.1	.16
Birth weight for gestational age z-score	-0.3±0.1	-0.3±0.1	-0.3±0.1	-0.3±0.1	.64
Small for gestational age (<10th%ile)	65(9.8)	25(10.8)	19(9.1)	21(9.5)	.65
Large for gestational age (>90th%ile)	65(9.8)	22(9.9)	22(10.2)	21(9.3)	.73
Sex Male	341(51.2)	114(49.9)	112(52.1)	116(51.7)	.64
Weeks Breastfed	14.8±1.5	14.8±1.3	15.7±1.4	13.6±1.3	.56
Breastfed 6 months or greater	150(22.5)	53(23.5)	54(25.3)	42(18.9)	.28
Breastfed 12 months	90(13.5)	32(13.9)	31(14.5)	27(12.2)	.65
Rapid weight gain at 12 months	314(47.1)	107(46.9)	99(46.4)	108(48.0)	.57

Trends in baseline demographic characteristics across PSS tertiles using linear regression for continuous variables and Cochran-Mantel-Haenszel Test for categorical variables.
*Results pooled over 50 imputations
**PSS scored from 0-40 with higher score indicating higher stress

Weight-for-length z-score increased significantly over time with no significant effect of baseline PSS tertiles. (Figure 1, Table 2). PSS and PSS tertiles were not significantly associated with increased risk of rapid weight gain in the unadjusted or adjusted models (Table 3). No significant interaction effects were present for gender, race, or income.

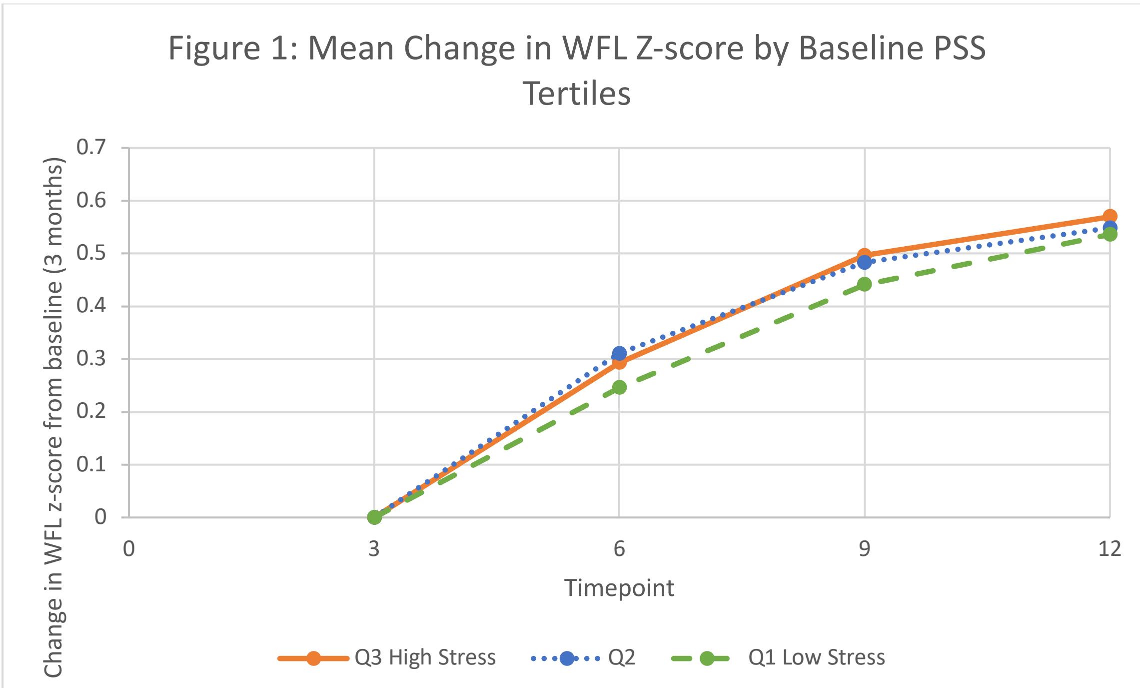

Table 2 Association of Baseline PSS Tertiles and Change in WFL z-score from Baseline

Variable	β Estimate	95%CI	P value
Timepoint			
6 months	Ref		
9 months	0.20	0.08-0.31	.001
12 months	0.29	0.18-0.44	<.001
PSS Tertiles			
Q1 (Low)	Ref		
Q2	0.06	-0.13-0.26	.531
Q3 (High)	0.07	-0.151-0.29	.527
PSS * Time			
Q2 *9 months	-0.02	-0.18-0.13	.772
Q2 * 12 months	-0.05	-0.20-0.10	.498
Q3 *9 months	0.01	-0.15-0.17	.923
Q3 *12 months	-0.01	-0.18-0.15	.868

Values were calculated with multivariable adjusted, repeated subjects, mixed-effects model, adjusted for birth weight, and gestational age at birth

Table 3 Association of Baseline PSS Tertiles and Risk of Rapid Weight Gain Between 3-12 months*

Maternal PSS	PSS Range	Risk Ratio Exp (β)	95%CI	P value
Continuous	0-39	1.00	0.99-1.02	.776
Tertiles				
Low	0-9	Ref	Ref	Ref
Moderate	10-15	1.01	0.80-1.26	.945
High	16-39	1.06	0.81-1.38	.657

Values were calculated with multivariable adjusted log-binomial model adjusted for birthweight and gestational age at birth.*Rapid weight gain defined as a change in WFL z-score >0.67 representing upward crossing of percentile bands on WHO growth chart

Discussion

The goal of this study was to assess the impact of perceived stress on infant weight gain trajectories and rapid weight gain among this predominately Black, low-income sample. We found that PSS scores were low and stable over time. Rapid weight gain in infancy was prevalent in this population with nearly half of infants experiencing rapid weight gain from 3 to 12 months postpartum. Contrary to our hypothesis, we did not find any association with mother's perceived stress and change in WFL z-score over time or infant rapid weight gain. More research is needed to identify and assess predictors for rapid weight gain in infancy.

The primary results of this study suggest that there is insufficient evidence to claim that perceived stress in mothers influence infants' weight gain trajectories or risk of rapid weight gain in the first year of life. These results are consistent with recent studies of the Maternal Adiposity, Metabolism, and Stress (MAMAS) Study, a non-randomized control trial(13,39) In this study of racially and ethnically diverse mothers and their infants, researchers found that neither prenatal or postpartum perceived stress nor depressive symptoms were associated with rapid weight gain in infancy(13) This study did find however, that the number of stressful life events a woman experienced in pregnancy was associated with 40% greater odds of rapid weight gain from birth to 6 months. In addition, they also found that mothers with higher perceived stress rated their infants as more reactive and less able to regulate but perceived stress was not associated with the infants' physiologic response to stress. In contrast, mothers who experienced more stressful life events in pregnancy had infants with greater physiological stress response (40) Authors did report an interaction with high perceived stress increasing the effect of stressful life events. Similarly, another study conducted among predominantly Black women found that perceived stress increased the risk of preterm birth, only for women with high social disorder (41) Together these studies suggest that perceived stress may be important, in the context of other measures of stress (such as number of stressful life events) to predict infant outcomes.

Perceived stress was slightly lower in this sample with limited variability compared to other studies with similar populations (mean 12.8 compared to other studies with means ~16 out of 40) (29,42–44). The lower score seen in our population could be explained by several reasons. First, it could reflect true lower levels of perceived stress. Second, given that PSS is self-reported, participants could be under-reporting how stressed they truly feel due to social-desirability bias. For example, one study conducted among 355 Black women in the South found similar low PSS scores which were attributed to the cultural norms described in the Superwoman Schema, that Black women experience an obligation to manifest an image of strength and minimize reports of stress (43,45,46). More research is needed to elucidate stress perception in this population and to determine if other measures of stress show alternative associations.

The prevalence of rapid weight gain in infancy seen in this sample (47%) is similar to what other studies conducted with racially and ethnically diverse infants have found. For example, among infants in the Boston Birth Cohort, rapid weight gain in infancy at 1 year of age was 38.5% for full term infants (39-42 weeks gestational age) and 60.1% for early term infants (37-39 weeks gestational age) (8). Similarly, Felder et al. observed that the prevalence of rapid weight gain from birth to 6 months was 28% in a racially and ethnically diverse sample (13). The prevalence observed in this study is markedly higher than the prevalence reported in predominately White, higher income samples (13-19%) (10,12). This highlights the importance of understanding the etiology of rapid weight gain in infancy, particularly in low-income and Black communities.

Although not the primary aim of this study, it is worth noting that the only variables significantly associated with rapid weight gain were birthweight-for-gestational-age z-score, gestational age at birth, and breastfeeding. Our results suggest that the risk for rapid weight gain in infancy is likely influenced by factors prior to birth (pre-conception/gestational risk factors associated with increased birth weight) and breastfeeding (11). This contrasts with studies which have found that low birth weight was predictive of rapid weight gain (10,12). It is possible that these results are conflicting because these studies looked at rate of weight gain from birth which may capture catch-up growth for low-birth-weight infants, although rapid weight gain from birth to 4-months has been shown to track through the first year of life for 95% of infants (8). Consistent with previous literature, length of time breastfeeding was associated with decreased risk of rapid weight gain, with breastfeeding for the recommended 12 months being associated with lower risk of rapid weight gain(10,47). Other predictors of rapid infant weight gain reported in the literature include infant sex, first born status, Black/other race, Medicaid status, maternal cigarette use, formula use, and feeding on a schedule (10,12,47). This study did not find an association between sex, race, or income/employment status and rapid weight gain. More research is needed to better understand what predicts and causes rapid infant weight gain so that prevention efforts can be targeted.

Limitations of this study are important to note. One limitation is the high proportion of missing data, particularly on the exposure variable. Although we attempted to account for this missing data using multiple imputation with variables associated with perceived stress and missingness it is possible that an unobserved variable influenced stress perception and therefore not accounted for in the imputation model. Another limitation is that the sample was limited to two prenatal clinics in one state in the southeastern US. Therefore, results may not generalize to other populations. However, this study has many strengths including longitudinal data collection allowing us to establish temporality between the exposure and outcome. Secondly, there were objective anthropometric data collected by trained staff at all timepoints.

Conclusion

While rapid weight gain in infancy was prevalent in this sample of predominately Black infants in the Southeastern US, perceived stress in mothers did not influence rapid infant weight gain. This study also adds to the growing literature on rapid weight gain in infancy by highlighting the influence of birthweight and breastfeeding on risk. This provides further support for pre-conception and prenatal interventions which may promote normal birthweight and increase rates and duration of breastfeeding.

Although our hypothesis was not supported, it is still worth examining if maternal perceived stress influences infant weight gain in the context of other measures of stress. While exposure to stress is not easily modifiable, interventions exist to decrease maternal stress perception and may play an important role in childhood obesity prevention. Future studies, with longer follow up periods, should explore when and how maternal stress influences the development of childhood obesity so that intervention efforts can be targeted.

Abbreviations

WFL, weight-for-length; WFA, weight-for-age; BMI, body mass index; PSS, Perceived Stress Scale; AHEI, alternative healthy eating index; FFQ, food frequency questionnaire

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Supplementary Table 1: Missing Data for Main Exposure, Outcome and Covariate Variables

Variable		N (%) Missing		
	3 months	6 months	9 months	12 months
Maternal				
Marital status	135 (20.3)	175 (26.3)	211 (31.7)	203 (30.5)
Unemployed	135 (20.3)	175 (26.3)	211 (31.7)	202 (30.3)
Low income	154 (23.1)	184 (27.6)	216 (32.4)	204 (30.6)
Household number	139 (20.9)	184 (27.6)	223 (33.5)	206 (30.9)
PSS score	272 (40.8)	295 (44.3)	292 (43.8)	312 (46.9)
Infant				
Rapid weight gain from baseline	N/A	231 (34.7)	263 (39.5)	256 (38.4)
Weight for length z-score	153 (23.0)	198 (29.73)	232 (34.8)	217 (32.6)

Supplementary Table 2: Associations Between Variables and Missingness for the Identification of Auxiliary Variables to be Used for Multiple Imputation

Variable	Not Flagged for Missing	Flagged for Missing	P Value
Maternal			
Age	28.1±5.8	26.2±5.4	<0.0001*
Race (Black)	64.9%	79.85%	<0.0001*
Ethnicity (Hispanic)	7.5%	5.2%	0.0137*
Overweight/obese	63.4%	59.1%	0.0280*
Prenatal diet quality (AHEI)	42.1+/-10.2	42.7 +/-11.6	0.5390
Married/living with partner	62.0%	51.0%	<0.0001*
Highschool or higher	55.3%	48.1%	0.0002*
Unemployed	46.0%	42.5%	0.1955
Low income (<$20,000/year)	52.9%	56.3%	0.2108
Household number	3.6±2.1	3.4±1.6	0.2196
Infant			
Gestational age at birth	38.7±1.5	38.4±1.7	0.0620
Weight for length z-score	0.4±1.1	0.5±1	0.2070
Birthweight for gestational age z-score	-0.3±1	-0.3±0.9	0.6834
Race (Black)	61.8%	77.3%	<0.0001*
Ethnicity (Hispanic)	11.5%	6.7%	<0.0001*
Infant sex (male)	50.2%	52.5%	0.2281
Total weeks breastfed	17.9±19.8	10.5±14.8	<0.0001*

Independent t-tests were used to compare normally distributed continuous variables, Wilcoxon rank sum test for non-normally distributed continuous variables, and Chi Square tests for categorical variables.

Supplemental Table 3: Baseline Demographic Characteristics of the Nurture Cohort of Infants with and Without Rapid Weight Gain* from 3 to 12 months and Unadjusted Risk Ratios.

Variables N (%) or mean ±SE	Not Rapid (n=227)	Rapid (n=214)	RR Exp(β)	95% CI
Maternal				
Age	27.5±0.3	27.0±0.4	1.0	1.0-1.0
Race (Black)	256(72.6)	220(70.2)	0.9	0.8-1.1
Ethnicity (Hispanic/Latinx)	19(5.3)	24(7.9)	1.2	0.9-1.7
Overweight or Obese Pre-pregnancy	199(56.4)	194(62.0)	1.1	0.9-1.4
Prenatal diet quality (AHEI)	42.0±0.7	42.5±0.7	1.0	1.0-1.0
Married or living with partner	203(57.6)	177(56.4)	1.0	0.8-1.2
Highschool degree or greater	277(78.6)	254(80.9)	1.1	0.8-1.4
Unemployed (looking for work)	68(19.4)	57(18.3)	1.0	0.7-1.2
Low Income(<20,000/year)	215(61)	184(58.6)	0.9	0.8-1.2
Number of people living in the home	3.6±0.1	3.5±0.1	1.0	0.9-1.0
Infant				
Gestational age at birth	38.4±0.1	38.8±0.1	1.1	1.0-1.1
Birth weight for GA z-score	-0.5±0.1	-0.1±0.1	1.2	1.1-1.3
Small for GA (<10^{th}%ile)	43(12.3)	22(7.0)	0.7	0.5-1.0
Large for GA (>90^{th}%ile)	29(8.3)	36(11.5)	1.2	0.9-1.6
Sex Male	189(53.7)	152(48.4)	0.9	0.7-1.1
Weeks Breastfed	16.2±1.1	13.0±1.0	1.0	1.0-1.0
Breastfed 6 months or greater	86(24.5)	64(20.3)	0.9	0.5-1.0
Breastfed 12 months	58(16.4)	32(10.3)	0.7	0.5-1.0

Values were calculated with log-binomial models
*Rapid weight gain defined as a change in WFL z-score >0.67 representing upward crossing of percentile bands on WHO growth chart

Title: Control and Chaos: Caregiver's Basic Psychological Need Frustration is Associated with the Socieomotional Context of Feeding.

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Abstract

Objective: The socioemotional context of feeding influences the development of children's eating behavior. Yet, little is known about what modifiable factors influence feeding. This cross-sectional study utilizes a self-determination theory perspective to identify psychosocial factors associated with the socioemotional context of feeding.

Methods: Caregivers of 2–5-year-old children(n=66) completed the Parent Socioemotional Context of Feeding Questionnaire, the Basic Psychological Need Satisfaction and Frustration Scale and demographic surveys. Multivariable linear regressions assessed the association between need satisfaction and frustration and autonomy-supportive, structured, controlling, and chaotic feeding.

Results: Participants were predominately Hispanic/Latinx, women, born outside of the US. Psychological need frustration was positively associated with controlling (β=0.97, SE=0.26, p< .001) and chaotic (β=0.78, SE=0.25, p=.004) feeding.

Conclusions and Implications: The results support the hypothesis that psychological need frustration is associated with controlling and chaotic feeding. Interventions aiming to decrease controlling or chaotic feeding should consider how caregivers' needs may be frustrated.

Keywords: feeding environment, parenting, self-determination theory

Abbreviations: Self-Determination Theory, SDT; Parent Socio-emotional Context of Feeding, PSCFQ; Childhood Eating Behavior Questionnaire, CEBQ

Introduction

Poor diet quality in childhood disproportionately affects ethnic and racial minority groups, putting them at increased risk for childhood obesity and diet-related diseases including cardiovascular disease and certain cancers.[1–4] Addressing diet quality early in childhood is important for preventing the development of disease because food preferences and eating patterns are established early in life and track into adulthood.[5–7] As children grow, caregivers' interactions at mealtimes play an important role in the development of children's eating behaviors.[8] Chaotic and controlling feeding are associated with the development of eating behaviors that can contribute to poor diet quality and obesity.[9–11] Conversely, providing structure while supporting children's autonomy is associated with fewer obesogenic eating behaviors.[12–14] However, gaps in understanding remain on what modifiable parental factors predict the use of parenting practices and the emotional climate created around feeding.

While parenting interventions in infancy have been associated with increased autonomy support and structure in feeding, leading to improved outcomes, they have not been as effective for pre-school-aged children.[15–17] This highlights the need for a theoretical framework to provide insight into why caregivers create different environments around feeding and what interventions need to target when attempting to change feeding behaviors in preschool-aged children. Self-determination theory (SDT) is one such framework that has been suggested to help conceptualize the role of caregivers' influences on child obesity behaviors and may also provide an understanding of the antecedents to practices that support children's needs.[18–21]

SDT is a meta-theory of human motivation that suggests that behavioral regulation depends on the degree to which people can satisfy three basic psychological needs.[22] These needs, defined as essential for psychological growth, integrity, and well-being are competence (feeling capable of achieving the desired outcome), autonomy (feeling of being the origin of one's behavior), and relatedness (feeling understood and cared for by others).[23] SDT literature suggests that it is the caregivers' role is to guide children through needs-supportive environments and socialization.[24]

Three distinct parenting dimensions have been identified as needs-supportive (autonomy support, structure, and involvement), which are also known to support the development of healthy eating behaviors.[14,25] It has been suggested that caregivers' needs satisfaction or frustration is an important antecedent to their use of needs-supportive practices.[26,27] Psychological needs frustration occurs when an individual's needs are actively threatened (not just the lack of need satisfaction) and can result in suboptimal parenting practices such as fostering a controlling or chaotic environment.[28] While this research has been conducted in the general parenting literature, understanding the relationship between needs satisfaction and frustration and the feeding environments caregivers create will be important in designing interventions to best support caregivers in feeding their children in ways that promote healthy eating behaviors.

Therefore, this study examines whether self-determination theory (SDT) constructs—caregiver's basic psychological needs satisfaction and frustration-- predict feeding environments that support their child's needs. We hypothesized that high basic psychological need satisfaction would predict feeding environments that are responsive to children's needs (autonomy support and structure) and that high basic psychological need frustration would predict non-responsive environments (control and chaos).

Methods

This study is a cross-sectional analysis of the baseline data collected as part of the *Strong Families Start at Home study (SFSH study) (n=66).* (Fox et al., 2020) The SFSH study is a pilot randomized control trial aimed at improving diet quality of 2-5-year-old children through home-based intervention. Bilingual research staff recruited participants using flyers and in-person recruitment at early childcare sites and WIC offices in Providence, RI, and surrounding areas. Eligibility criteria included: Parent or guardian of child 2-5 years old, fluent in English or Spanish, over 18 years of age, guardian lived with the child most of the time, the child was not underweight, the child did not have a diagnosed eating or feeding disorder, dietary restrictions, or a medical condition that impacted how the child was fed, guardian owned a phone capable of video recording and was willing to video record an evening meal. Enrolled participants received $50 for completing baseline measures. Trained research assistants administered survey measures using RedCap (Research Electronic Data Capture, Vanderbilt University), an electronic data capture tool hosted at the University of Rhode Island. The study the University of Rhode Island's Institutional Review Board approved this study.

Caregivers Basic Psychological Needs Satisfaction and Frustration

Caregivers completed the Basic Psychological Need Satisfaction and Frustration Scale.[29] The BPNSF has demonstrated construct and predictive validity with need satisfaction associated with increased life satisfaction and vitality and need frustration associated with decreased life satisfaction and increased depression.[30] It uses a 5-point Likert scale ranging from 1 (completely untrue) and 5 (completely true), with scores averaged for each subscale. We chose to use a two-factor structure (need satisfaction and need frustration) to develop a more parsimonious model. [28] Psychological need satisfaction assesses the extent to which an individual feels that their needs for autonomy, competence, and relatedness are satisfied. For example, the BPNSF asked caregivers to rate how true they felt the following statements were; "I feel that my decisions reflect what I really want" (autonomy satisfaction), "I feel capable at what I do" (competence satisfaction), and “I feel close and connected with other people who are important to me” (relatedness satisfaction). Psychological need frustration measures the extent to which an individual feels that their needs for autonomy, competence, and relatedness are threatened. For example, the BPNSF asked caregivers to rate how true they felt the following statements were; “I feel pressured to do many things” (autonomy frustration), “I feel like a failure because of the mistakes I make” (competence frustration), and “I feel the relationships I have are just superficial” (relatedness frustration). The BPNSFS had good internal consistency in this sample (α=0.8).

Socioemotional Context of Feeding

Caregivers completed the Parent Socioemotional Context of Feeding Questionnaire (PSCFQ) [20]. This 24-item measure has been validated with mothers of 4-8-year-old children and measures the extent to which a feeding environment is autonomy-supportive, structured, controlling, or chaotic and has demonstrated good internal consistency and construct validity. The PSCFQ defines an autonomy-supportive feeding environment as “behaviors and emotions (of the caregiver) that give a message of valuing children’s autonomy and choice and encouraging agency and individual expression”. Conversely, the PSCFQ defines a controlling environment as one that demands obedience. A structured environment provides clear limits enforced predictably and consistently while a chaotic environment is characterized by inconsistent, erratic, arbitrary parenting behaviors or emotions. The PSCFQ had acceptable-good internal consistency (α=0.7-0.8) in this sample.

Covariates

Caregivers reported their age, gender, race, ethnicity, country of birth, highest education level achieved, income status, and employment. Trained research staff obtained height and weight using standardized methods and calculated body mass index (BMI).[31]

Caregivers completed a two-item validated screener to assess for any level of food insecurity.[32] We report caregivers' race as White or non-White and ethnicity as Hispanic/Latinx or non-Hispanic/Latinx. We categorized individuals as having overweight/obesity based on a BMI greater than or equal to 25.[31] We report the caregivers' highest level of education achieved as some post-secondary education and we defined low-income as a family income less than $25,000 per year, corresponding to the federal poverty threshold for a four-person household.[33]

Statistical Analysis

We calculated descriptive statistics with mean (SD) for continuous variables and percentages for categorical variables. Exposure variables were skewed, and regression residuals were non-normally distributed therefore we conducted analyses using log-transformed basic psychological need satisfaction and frustration scores. We then used Spearman's rank correlations to assess the relationship between PSCFQ and BPNSF subscales with demographic variables. We fit separate models using multivariable regressions to assess the association between parental need satisfaction and need frustration with PSFQ subscales (autonomy, structure, control, and chaos). We identified a priori covariates that have been associated with food parenting in the literature (caregivers' age, gender, race, ethnicity, education level, and weight status, household income and food insecurity as well as child's age and gender)[34–37] and included them in the adjusted model. We assessed collinearity and model fit and removed low-income and college education from the model due to their correlation with food insecurity (r=0.3, r=-0.3, respectively). We then re-assessed model fit by evaluating R^2, adjusted $R^{2,}$ and Root Mean Squared Error (RSME) to determine the proportion of variance explained by the model.

Results

Participants were predominately Hispanic/Latinx (86.6%), women (92.5%), born outside of the US (60%) with a mean age of 34.2±7.6. Approximately half of the participants had some college education (49%), were low-income (55%), and were food insecure (46%). Children were 43.1 months (3.6 years) old and 52% male. The mean basic psychological need satisfaction score was 4.5±0.5 with a range of 2.2-5.0 out of a possible 5. The mean frustration score was 2.0±0.8 with a range of 1-4.3 out of a possible 5. Mean subscale scores for the PSCFQ were autonomy 2.4±1.0, structure, 3.2± 0.7, control 0.9±0.8, and chaos 1.2±0.8 out of a possible 4 with a higher score indicating greater endorsement of the environment.

In unadjusted models, basic psychological need frustration was associated with both controlling and chaotic feeding environments (β=0.80, SE = 0.24, p = .001 and β=0.81, SE = 0.24, p = .001, respectively). Psychological need frustration explained 15% of the variance in control (R^2 = .15, F (1, 64) = 11.42, p = .001) and 15% of the variance in chaos (R^2 = .15, F (1, 64) = 11.31, p = .001). Upon adjusting for covariates, basic psychological need frustration continued to be significantly associated with a controlling environment (β=0.97, SE = 0.26, p< .001) and the model explained 23% of the variance in control (R^2 = .23, F (8, 57) = 2.15, p = .046). Similarly, upon adjusting for covariates, basic psychological need frustration continued to be significantly associated with a chaotic feeding environment (β=0.78, SE = 0.25, p = .004) and the model explained 28% of the variance in chaos (R^2 = .23, F (8,57) = 2.81, p = .011).

Table: Cross-sectional Association Between Basic Psychological Need Satisfaction and Frustration with Parent Socio-emotional Context of Feeding Questionnaire Subscales (n=66)

Component	Autonomy		Structure		Control		Chaos	
	B(SE)	P value	B (SE)	P value	B (SE)	P value	B (SE)	P value
Unadjusted								
Satisfaction [a]	1.30(0.85)	.130	1.01(0.64)	.119	-0.67(0.72)	.361	-0.26(0.73)	.304
Frustration [a]	-0.25(0.30)	.420	-0.20(0.23)	.382	0.80(0.24)	.001*	0.81(0.24)	.001*
Adjusted								
Satisfaction [a]	1.21(0.88)	.174	1.04 (0.64)	.108	-0.84(0.76)	.273	-0.59(0.72)	.418
Frustration [a]	-0.36(0.33)	.287	-0.26(0.24)	.293	0.97(0.26)	<.001*	0.78(0.25)	.004*

1. Values calculated using multivariable linear regressions adjusting for caregivers' age, gender, race, ethnicity, and food insecurity as well as child's age and gender.
** Significant at p < .05*
[a] Log-transformed variable

Discussion

This study is the first, to our knowledge, to examine the association between caregivers' basic psychological need satisfaction and need frustration and the socioemotional context in which they feed their children. The results support the hypothesis that psychological need frustration is associated with controlling and chaotic feeding environments. Contrary to our hypothesis however, psychological need satisfaction was not associated with autonomy-supportive or structured feeding environments. This relationship warrants further exploration with larger samples, as factors including immigration, language barriers, and exposure to racism can frustrate caregivers need for autonomy, competence, and relatedness potentially contributing to disparities in childhood obesity risk across racial and ethnic groups.[38,39]

Need frustration is a critical theme in the SDT literature, where research suggests that need frustration may lead individuals to compensate by exerting power over others or disengagement from the context entirely.[23] The finding that psychological need frustration was associated with more controlling and chaotic feeding environments is consistent with the general parenting literature in that caregivers' need frustration predicts controlling parenting.[27,40] Our findings, within a SDT framework, provide insight into why caregivers may use controlling or chaotic feeding practices. This has important implications given the link between controlling and chaotic feeding environments and lower intake of fruits, vegetables, and whole grains and increased risk of developing overweight/obesity.[41–47] SDT literature offers potential strategies to increase resilience to psychological need frustration such as increasing parental autonomy, mindfulness, and awareness. [28] Future interventions may consider targeting caregivers' psychological need frustration to decrease controlling or chaotic feeding practices and understanding if it results in improved outcomes.

While there appeared to be a trend where those with high levels of satisfaction scored higher on supportive practices, this association was not significant. These results differ from Costa et al.'s findings which did show a significant association between needs satisfaction and autonomy supportive general parenting.[27] While estimates trended in the hypothesized direction for all PSCFQ subscales, needs satisfaction was highly skewed with limited variability and the sample size was small. Another possible explanation is the difference between general autonomy support in caregiving and autonomy support in the feeding context. While we know that needs satisfaction can lead to better life satisfaction and vitality, those benefits may not translate to healthier eating and feeding environments.[30] While need satisfaction may result in generally more supportive caregiving, the context of feeding presents unique challenges particularly for caregivers of pre-school-aged children. For example, energy-dense nutrient-poor foods are abundant and even highly advertised to pre-school-aged children, which may make it difficult for caregivers to maintain structure.[48] Picky eating, a normal developmental phase characterized by food refusal, typically peaks at age 2 and declines at age 5. This can be challenging for caregivers and may make them less likely to respect children's autonomy while eating.[49] Future research should explore if the ways parents support (or do not support) children's needs differ across contexts such as feeding, sleep, education. Fortunately, generally need supportive parenting strengthens the association between supportive feeding and children's dietary intake.[50] Therefore, we could expect that educating caregivers, who are generally supportive of their children's needs, in the benefits of structure and promoting children's autonomy in feeding as well as strategies they can implement could lead to improved dietary intake. More research is needed to explore the role of caregivers' psychological needs satisfaction and general well-being in how they feed their children and respond to interventions aimed at improving feeding.

There are limitations to this study that are important to note. A first limitation is that interviewer-administered surveys may have introduced social desirability bias. Interviewer-administered surveys are a strength as they increase the response rate, allow for clarification of questions and wording, and do not require participant literacy. However, participants may have wanted to present more positively when speaking with study staff (reporting more desirable feeding environments or higher levels of need satisfaction). Also, caregivers completed BPNSF on their overall satisfaction and frustration of their psychological needs and were not specific to the context of feeding their children. Future research should explore if caregivers' needs satisfaction and frustration differ across contexts, including feeding. Lastly, the study sample is small comprised predominately of low-income, Hispanic /Latinx women born outside of the US and findings may not generalize to a larger more diverse population. However, this study has numerous strengths including a hypothesis supported by SDT, considering not only feeding literature, but also literature on parenting and development. It also provides important information on antecedents to feeding for a population whose children are at increased risk for childhood obesity.

Implications for Research and Practice

Overall, this study provides important insight into the role of caregivers' psychological need satisfaction and frustration plays in how they feed their children. Our results suggest that interventions aiming to decrease controlling or chaotic feeding need to consider ways in which caregivers' needs may be frustrated. More research is needed to provide insight into how psychological need frustration may contribute to disparities in childhood obesity across racial and ethnic groups so that effective and equitable interventions can be developed.

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Title Title: Associations Between Child Eating Behavior with Eating Patterns and Diet Quality in Preschool-Aged Children

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Keywords: Childhood Eating Behavior, Eating Patterns, Diet Quality

Abbreviations: BMI, Body Mass Index; CEBQ, Childhood Eating Behavior Questionnaire; DQIS, Diet Quality Index Score; AAP, American Academy of Pediatrics; DGA, Dietary Guidelines for Americans; SSB, sugar-sweetened beverage

Abstract

Childhood eating behaviors are associated with weight status and laboratory assessments of dietary intake. However, little is known about how eating behaviors relate to the eating patterns and diet quality of diverse children in their typical environments. This study examined the effect of eating behaviors on children's eating patterns and diet quality. We studied 61 predominately low-income Hispanic/Latinx preschool-aged children with complete baseline data from the Strong Families Start at Home Study. Caregivers completed the Childhood Eating Behavior Questionnaire and two 24-hour dietary recalls. We calculated meal size, eating frequency and diet quality (modified Diet Quality Index Score, DQIS). We evaluated associations between eating behaviors with eating patterns and total diet quality using multivariable linear models. We calculated Spearman rank correlation coefficients to explore the relationship between eating behaviors and DQIS components. We evaluated the impact of eating behaviors on the odds of consuming greater than median intake for each DQIS component. Main meal size was negatively associated with food fussiness and satiety responsiveness, while positively associated with food responsiveness. The size of caloric beverages outside meals and snacks was positively associated with food fussiness. Exploratory analyses showed that eating behaviors were significantly associated with intake of refined grain, fruit, and sugar-sweetened beverage scores. Future research is needed to examine how eating behaviors influence intake and if dietary modifications influence behavior and weight status.

1. Introduction

Early childhood (2-5 years old) is a critical period for the development of eating behaviors and food preferences that track into adulthood (Anzman-Frasca et al., 2018; Caton et al., 2014; Fry Vennerød et al., 2018; Herle et al., 2020). Eating behaviors are phenotypes of how a child eats and relate to differences in appetite regulation that influence how individuals respond to a given food environment, making some children more likely to develop obesity than others (Carnell & Wardle, 2007; Llewellyn et al., 2012, Birch & Fisher, 1998; Kininmonth et al., 2021). While eating behaviors have shown consistent associations with child adiposity and obesity risk, less is known about the specific ways they impact dietary intake (Kininmonth et al., 2021; Wood et al., 2018). Understanding how eating behaviors contribute to eating patterns and diet quality is important as diet quality predicts the development of chronic diseases such as obesity, cardiovascular disease, and certain cancers (Clarke & Joshu, 2017; Shan et al., 2020; Vargas et al., 2016; Wolongevicz et al., 2010).

Food approach eating behaviors (e.g., food responsiveness, enjoyment of food) describe an elevated appetite and/or interest in food and have demonstrated consistent associations with adiposity in cross-sectional and longitudinal studies. (Kininmonth et al., 2021). Conversely, food avoidant eating behaviors (e.g., satiety responsiveness and food fussiness) represent a decreased appetite and/or interest in food and are negatively associated with child BMI, although the association with food fussiness is not as consistent in adjusted analyses and prospective studies (French et al., 2012; Llewellyn et al., 2012; Webber et al., 2010). Eating behaviors' impact on weight status is attributed to differences in hunger, fullness, and response to food cues which could influence eating patterns such as meal size, eating frequency, and/or the types of foods children consume (Carnell & Wardle, 2007; French et al., 2012).

A child's response to appetite cues can influence meal size, or how much energy is consumed on an average eating occasion. For example, a child with low satiety responsiveness may continue to eat despite physiologic signs of fullness, such as gastric distention or changes in hormone levels, without compensating by decreasing intake at the next eating occasion. (Carnell & Wardle, 2007). Meal size is an important driver in the development of obesity (Syrad et al., 2016), and is positively associated with food approach subscales (enjoyment of food, food responsiveness) and negatively with two food avoidant subscales (satiety responsiveness and slowness in eating) in laboratory-based studies (Carnell & Wardle, 2007).

In addition to meal size, eating behaviors could contribute to excessive caloric intake by influencing how often a child eats. A child who responds strongly to environmental food cues may eat more frequently, particularly in environments where highly palatable foods are readily available. Studies have found that eating frequency is negatively associated with food fussiness and positively associated with food responsiveness and enjoyment of food, although the relationship between eating frequency and childhood obesity is not clear (Garcidueñas-Fimbres et al., 2021; Taylor et al., 2017, Syrad et al., 2016).

Difference in the hedonic response to food (how pleasurable a child finds food) may influence the type of foods a child consumes, however research is limited (French et al., 2012; Kininmonth et al., 2021). Most studies have focused on food fussiness, the frequent rejection of familiar and new foods, which is inversely associated with intake of fruits, vegetables, total protein, and total diet quality, (Brown et al., 2018) as well as increased consumption of non-core snack foods (Mallan et al., 2016). Less is known about the impact of other eating behaviors and the quality of the foods consumed. Given the correlation between food fussiness and other food avoidant eating behaviors and consistent associations with decreased overall energy intake, we may expect similar associations with diet quality (French et al., 2012). However, studies have found that food avoidant behaviors were differently associated with eating non-core/ ‘treat’ foods (Jani et al., 2020). Few studies have explored the relationship between food approach behaviors and diet quality, although data from British and Australian preschool children suggests differential associations with food preferences (Fildes et al., 2015).

Much of the work assessing eating behaviors has been conducted with primarily white, higher income populations and in laboratory settings (Jalkanen et al., 2017; Jani et al., 2020; Syrad, Johnson, et al., 2016). While convergent validity with BMI has been established in diverse populations, little is known about how eating behaviors relate to racially and ethnically diverse children’s eating patterns and diet quality the environments they typically eat (Domoff et al., 2015; Perez et al., 2018.; Vandyousefi et al., 22012). Understanding the way in which child eating behaviors impact dietary intake in diverse populations is important so that interventions seeking to improve diet quality and prevent or treat obesity can provide specific guidance to caregivers, acknowledging that children behave in different ways.

Therefore, the overall goal of this study is to explore how child eating behavior relates to dietary outcomes in a predominately low-income Hispanic/Latinx population. We hypothesize that 1) food avoidant subscales will be associated with decreased meal size while food approach subscales will be associated with increased meal size. 2) Food avoidant subscales will be associated with decreased eating frequency while food approach subscales will be associated with increased eating frequency.3) Food avoidant subscales will be negatively associated with diet quality. Given the limited research on food approach eating behaviors and the types of food consumed, we will also conduct an exploratory analysis looking at eating behavior subscales and components of diet quality.

2. Methods

2.1 Procedure and Sample

This study is a cross-sectional analysis of the baseline data collected as part of the Strong Families Start at Home (SFSH) study, a detailed description of the study design and protocol has been previously published (K. Fox et al., 2020). The SFSH study is a NIH R34 pilot randomized control trial aimed at improving diet quality of 2-5-year-old children through home-based intervention. Participants were recruited using fliers and in person recruiters at early childcare sites and WIC offices in Providence, RI, and surrounding areas. Eligibility criteria included; Parent or guardian of child 2-5 years old, fluent in English or Spanish, over 18 years old, guardian lives with the child most of the time, child is not underweight, as assessed by asking parents if the child's primary care provider or WIC provider has told them that their child is underweight in the past 6 months, child does not have a diagnosed eating or feeding disorder, dietary restrictions, or a medical condition that impacts how the child is fed, the family eats a minimum of 3 evening meals together per week, guardian owns a phone capable of video recording and is willing to video record an evening meal. Enrolled participants received $50 for completing baseline measures. All survey measures were administered in the participants preferred language by trained research assistants using RedCap (Research Electronic Data Capture, Vanderbilt University), an electronic data capture tool hosted at the University of Rhode Island.

2.2 Measures

2.2.1 Child Eating Behavior

The Children Eating Behavior Questionnaire (CEBQ) is widely used to measure parents' report of children's eating behaviors and has been validated with lab-based assessments of eating behavior (Carnell & Wardle, 2007; Wardle et al., 2001). This 35-item measure has good internal consistency (α=0.74-0.91), test-retest reliability (0.52-0.87) and has been validated against objective measures of eating behaviors in children (Carnell & Wardle, 2007). Participants rate items on a 5-point Likert scale ranging from 1 (never) to 5 (always) with a higher score indicating higher endorsement of the behavior. To limit the number of variables analyzed we chose to evaluate the food avoidant (food fussiness, slowness in eating, and satiety responsiveness) and food approach (food responsiveness and enjoyment of food) subscales assessed by Webber et al. and Power et al. based on their consistent relationship with child weight status and energy intake (Power et al., 2019; Webber et al., 2010).

2.2.2 Child Diet.

Trained research staff administered 24-hour dietary recalls using the multiple pass approach (RK et al., 1996). The first 24-hour recall was conducted in the home during the study's baseline assessment. The second dietary recall was conducted over the phone, within one week of the first with the goal of obtaining 1 weekday and 1 weekend day of intake. Study staff used the Nutrition Data System for Research (NDSR, University of Minnesota, Minneapolis) standardized interviewing process ensuring consistency among interviewers in the type or amount of information collected. Interviewers prompted caregivers to report meal type, time, who fed the child, and everything their child has consumed in the past 24 hours. They then probed for information around brand names, preparation methods, and potentially omitted foods. Caregivers estimated portion sizes using food amount booklets published by NDSR. (Ziegler, Clusen, et al., 2006) Quality assurance measures were implemented during the interview and after the interview process. We imported the data from NDSR into SAS version 9.04 for Linux (SAS Institute Inc. Cary, NC) to calculated meal size, eating frequency, and intake of milk, grains (whole grains, refined grains), proteins (meat, poultry, eggs, yogurt, and cheese), vegetables, whole fruit, 100% juice, sugar sweetened beverages, other added sugars, and salty snacks. If more than one diet recall was available we present the mean of each variable to approximate usual intake.

2.2.3 Meal Size and Eating Frequency.

During the 24-hour diet recall respondents reported what they would call each eating occasion (Breakfast, Brunch, Lunch, Snack, Dinner/Supper, Other, School Lunch, Beverage only (just a drink). No participants reported brunch or other meals therefore we grouped eating occasions into main meal (breakfast, lunch, dinner, school lunch), snack, and caloric beverage outside of meal and snack time. We calculated **Meal size** as the total amount of energy consumed per eating occasion, as well as the average kcal consumed per eating occasion as in previous studies (Leech et al., 2015; Syrad, Johnson, et al., 2016). We calculated **Eating frequency** as the number of eating occasions where food or caloric beverage were consumed at a unique time including beverages consumed at the same time as the food. We calculated frequencies for each eating occasion as well as total number of eating occasions in the day.

2.2.4 Diet Quality.

We assessed diet quality using the modified Diet Quality for Index and Toddlers Score (DQIS). The DQIS was developed validated in infants and toddlers in Puerto Rico, (Ríos et al., 2016) and modified to reflect the nutrient needs of children 6 months- 4 years old based on the USDA Dietary Guidelines for Americans (Hamner & Moore, 2020). The modified DQIS includes 9 components: drinking milk, grains (whole grains, refined grains), proteins (meat, poultry, eggs, yogurt, and cheese), vegetables, whole fruit, 100% juice, sugar sweetened beverages, other added sugars, and salty snacks. Scoring and portion sizes for whole and refined grains, protein, fruit, and vegetables, and added sugars were developed based on the 2020-2025 DGAs for a sedentary 2-3- and 4–5-year-old with estimated kcals needs of 1000 kcals/day and 1200-1400 kcals/day respectively (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2020). Scoring and portion sizes for milk and 100% fruit juice drinking were based on AAP recommendations (Holt et al., 2011). Milk included liquid milk and formula. Protein included ounces of protein from meat, poultry, seafood, organ meats, cured meat, eggs, soy, nuts and seeds, yogurt, and cheese. Sugar sweetened beverages, and salty snacks guidelines were based on the original DQIS criteria and were consistent with AAP recommendations (Holt et al., 2011). For each component, children achieved the maximum score of 5 for meeting the guideline, 2.5 for consuming the component but not meeting the guideline, and 0 if the component was not consumed or was consumed in excess. The modified DQIS is scored from 0-45 with a maximum score indicating greater adherence to the guidelines.

2.2.5 Covariates

Caregivers reported their own age, race, ethnicity, country of birth, education level, income, and participation in food assistance programs. Caregivers completed the short form Household Food Security Scale (Blumberg et al., 1999). Trained research staff measured children's height and weight using standardized methods and calculated BMI z-score based on WHO growth chart using publicly available SAS code (Development, 2008; Lohman et al., 1988). Six participants completed their baseline assessment over the phone due the COVID-19 pandemic, therefore do not have anthropometric data. We categorized caregiver's highest level of education as achieved some post-secondary education and low-income as a family income less than $25,000 based on the federal poverty threshold for a typical four-person household (U.S. Census Bureau, 2019).

3. Statistical Analysis

We conducted a complete-case analysis with all participants who had at least one reliable dietary recall. We calculated mean (SD) for continuous variables and percentages for categorical variables. We calculated Cronbach's alpha for each CEBQ subscales to assess internal reliability. General linear models were fit to evaluate the association between child eating behavior and eating patterns and diet quality, adjusting for child's age and gender to account for differing energy needs. Model fit was assessed by examining the evaluating R^2, adjusted $R^{2,}$ and Root Mean Squared Error (RSME) to determine the proportion of variance explained by the model. Multivariable models were developed using covariates known to influence eating patterns and eating behavior (BMI z-score, race, and ethnicity, the household's income and use of food assistance programs, and the caregiver's education level) and kept in the fully adjusted model if they changed the effect by greater than 10%.(Hamner & Moore, 2020; Thomson et al., 2019). We used the Benjamani Hochberg correction to control for the false discovery rate resulting from multiple testing (Benjamini & Hochberg, 1995). We calculated Spearman Rank correlation coefficients to assess the relationship between eating behaviors and DQIS component intake given the non-normal distribution of the variables. Multiple logistic regressions were fit to determine the impact of CEBQ subscales on the odds of consuming greater than the median intake for each DQIS component. Firth's penalized maximum likelihood estimator was used to reduce the bias away from zero resulting from the study's small sample size (Rainey & McCaskey, 2021).

4. Results

4.1 Sample

Sixty-six participants provided one 24-hour dietary recalls and 61 participants provided a second diet recall. Of those recalls 22 were excluded from the analysis due to being unreliable (caregiver unsure of what the child ate when not in their care for 1 or more meal). This provided a final analytic sample of 61 participants with at least one reliable dietary recall and 43 participants with two reliable dietary recalls.

Demographics of the study sample are presented in Table 1. Participants were predominately female (92%) with a mean age of 33.6±7.5. Most participants identified as Hispanic/Latinx (87%), were born outside the US (61%), reported diverse racial identities (39% White), and participated in at least one food assistance program (86%). About half of participants had some post-secondary education (49%), a household income <$25,000 (53), and some level of food insecurity (45%). Children were 55% male, on average 42.5±10.9 months (3.5 years) with a mean BMI-z score of 0.7±1.1.

4.2 CEBQ

Mean scores, standard deviations, and ranges for CEBQ subscales are presented in Table 1 with scores out of a possible 1-5 with higher scores indicating greater endorsement of the behavior. The scale had acceptable to good internal reliability in this sample with Cronbach α ranging from 0.64-0.84.

4.3 Eating Patterns

Meal size and frequency are shown in Table 1. On average main meals had 275.4 ±99.0 kcals, snacks contained 134.3 ±72.6 kcals and caloric beverages outside of meal/snacks contained 105.4 ± 52.4kcals. Overall eating occasions contained an average of 204.5±80.2 kcals. On average caregivers reported their child having 2.8 main meals per day, 2.5 snacks per day, and 0.9 caloric beverages, outside of meal/snacks. Children had 5.9±1.4 eating occasions per day.

4.4 Diet Quality

The overall DQIS of the sample ranged from 11.3-36.3 with a median 23.8 and a mean of 23.3± 5.4 out of a maximum of 45. Descriptive characteristics of DQIS components can be found in Table 2. Scores were highest for 100% fruit juice, sugar sweetened beverages, and salty snacks indicating more adherence to guidelines for these components. Scores were lowest for milk, protein, and vegetables indicating more children under consuming or overconsuming. Of those with the minimum score for dairy, most children were under consuming (20 of 23 with the minimum score). Of those with the minimum score for protein most children were over consuming (23 of 25 with the minimum score).

Table 3 Characteristics of the Strong Families Start at Home Study

Caregiver	N(%) or mean	Range
Gender (Female)	57 (92)	
Age	34.2 ± 7.6	21-65
Race (White)	24 (39)	
Ethnicity (Hispanic)	53 (87)	
Born in the US	24 (39)	
College education (at least some college)	30 (49)	
Low Income (<25,000/year)	33 (54)	
Food Insecure (any level)[1]	27 (44)	
Receives Food Assistance (WIC, SNAP, Food Bank, free/reduced school meals)	51 (86)	
Child		
Age in months	42.9 ± 10.6	24.4-69.6
BMI for age z-score	0.7 ± 1.1	-2.4-3.4
Gender Male	28 (46)	
Child Eating Behavior Subscales		
Food Fussiness (FF)	2.8 ± 0.9	1-4.8
Satiety Responsiveness (SR)	2.9 ±0.8	1.75-5
Food Responsiveness (FR)	2.6 ± 1.1	1-5
Enjoyment of Food (EF)	3.8 ± 1.0	1.75-5
Eating Patterns[2,3]		
Meal size		
Main meal (kcal/meal)	275.4 ± 99.0	108.2-
Snack (kcals/ snack) (n=60)	134.3 ± 72.6	25.4-359.1
Beverage size (kcal/beverage (n=35)	105.4 ± 52.4	23.5-249.5
Average size (kcal/meal, snack, or beverage)	204.5 ± 80.2	98.7-505.1
Eating Frequency		
Main meals	2.8 ± 0.4	2-3.5
Snacks	2.5 ± 1.2	1-5
Beverages[4]	0.9 ± 0.9	0-3
Total	5.9 ± 1.4	3-10
Diet Quality[2,5]		
DQIS Score (0-45)	23.3 ± 5.4	11.3-36.3

[1] We defined food insecure as having any level of food insecurity based on responses to the Household Food Security Scale. [2]We calculated dietary variables using the average of the dietary recalls provided. [3]Eating occasions were participant defined as main meal (breakfast, lunch, dinner), snack, and "Just a beverage". [4]Beverages include caloric beverages consumed outside of a meal or snack.[5]We assessed diet quality using the modified Diet Quality Index Score (Ríos et al., 2016, Hamner & Moore, 2020) and reflects adherences to the USDA Dietary Guidelines for Americans.

Table 4 Dietary Quality Index Score (DQIS) Scoring Criteria, Mean Scores, and Children Meeting Guideline in the Strong Families Start at Home Study (SFSH, n=61)

Component	DQIS Scoring Criteria			SFSH Sample Score	
	2-3 years	4-5 years	Score	Score Mean± SD	Met Guideline n(%)
Milk (oz/day)	16.0–20.0 8.0–15.9 or 20.1–24.0 <8.0 or >24.0	20.0–24.0 8.0–19.9 or 24.1–28.0 <8.0 or >28.0	5 2.5 0	1.9±1.7	9 (14.8)
Whole grains (oz/day)	1.5-3.0 0.1-1.4 0 or >3	2.0-5.0 0.1-1.9 0 or >5	2.5 1.25 0	1.2±0.7	9 (14.8)
Refined grains (oz/day)	0-1.5 1.6-3.0 >3.0	0-2.5 2.5-5 >5	2.5 1.25 0	1.2±1.0	16 (26.2)
Proteins (oz/day)	1.5-2.5 0.1-1.5 0 or >2.5	3.0-4.0 0.0-3.0 0 or >4	5 2.5 0	2.0±2.0	14 (23.0)
Vegetables (oz/day)	>= 8.0 0-8 0	>=12 0-12 0	5 2.5 0	2.3±0.8	1 (1.6)
Fruits (oz/day)	>= 8.0 0-8 0	>=12 0-12 0	5 2.5 0	2.4±1.4	8 (13.1)
100% Juices (oz/day)	<4.0 4.0-6.0 >6.0	<6.0 6.0-8.0 >8	5 2.5 0	3.6±1.9	37 (60.7)
Sugar Sweetened Beverages SSB (oz/day)	0 0.1-4.0 >4	0 0.1-4.0 >4	5 2.5 0	3.1±2.1	30 (49.2)
Other added sugars (g/day)	<3.125 3.125-6.25 >6.25	<3.75 3.75-7.5 >7.5	5 2.5 0	2.6±1.9	19 (31.2)
Salty snacks (oz/day)	0 0.1-1.0 >1.0	0 0.1-1.0 >1.0	5 2.5 0	0.5±0.8	24 (38.7)

1)Scoring and portion sizes for whole and refined grains, protein, fruit, and vegetables, and added sugars were developed based on the 2020-2025 DGAs for a sedentary 2-3- and 4–5-year-old with estimated calorie needs of 1000 kcals/day and 1200-1400 kcals/day. Scoring for milk and 100% fruit juice were based on AAP guidelines. Sugar sweetened beverages, and salty snack guidelines were based on the original DQIS criteria and were consistent with AAP recommendations.

4.5 Associations Between Eating Behavior Subscales with Eating Patterns

4.5.1 Meal Size (Table 3)

Food fussiness was associated with decreased meal size (kcals per main meal) whereby a 1 point increase on the food fussiness scale was associated with a decrease of 35.9 kcals per meal($F(4,56)=5.91$, R-Square0.2967, Root MSE 85.96). Food fussiness was associated with consuming 30.4 more kcals per beverage, when consuming caloric beverages outside of meal and snack times ($F(4,30)=4.56$ R-Square 0.3781, Root MSE 44.00).Satiety responsiveness (SR) was associated with consuming 48.8 fewer kcals per main meal ($F(4,56)=7.7$, $p<.001$, R-Square0.35, Root MSE 82.3). Food responsiveness was associated with consuming 16.91 kcals more per average eating occasion $F(4,56)=5.62$, R-Square0.2863, Root MSE 70.12) and 20.79 kcals more per main meal. $F(4,56)=4.77$, R-Square0.2540, Root MSE 88.53).

4.5.2 Eating frequency (Table 4)

No eating behaviors were significantly associated with frequency of meals, snacks, beverages, or overall eating occasions after adjusting for age, gender and correcting for the false discovery rate.

4.5.3 Diet Quality

Eating behaviors were not correlated with DQIS score therefore regression analyses are not presented.

Table 5 Associations Between CEBQ Subscales and Meal Size

	Average Size (kcal/ occasion)	Meal Size (kcal/meal)	Snack Size (kcal/snack)	Beverage size (kcal/beverage)
	B (SE) P value	B (SE) P value	B (SE) P value	B (SE) P value
FF Model 1	-16.35 (11.18)	-35.17 (13.29)	-8.93 (10.67)	29.93 (8.76)
	.237	.056	.500	.014*
FF Model 2	-17.11 (10.73)	-35.91 (12.97)	-9.92 (10.25)	30.42 (8.38)
	.169	.041*	.385	.008*
SR Model 1	-25.21 (11.74)	-47.06 (13.75)	-19.60 (11.22)	21.11 (11.27)
	.144	.014*	.197	.188
SR Model 2	-26.95 (11.21)	-48.81 (13.34)	-20.92 (10.73)	24.16 (10.89)
	.078	.008*	.113	.109
FR Model 1	12.25 (8.50)	16.14 (10.48)	5.20 (8.15)	-2.44 (7.86)
	.237	.237	.601	.809
FR Model 2	16.91 (8.20)	20.79 (10.34)	9.08 (7.92)	1.22 (8.06)
	.044*	.049*	.257	.880
EF Model 1	9.35 (10.24)	17.72 (12.53)	-2.01 (9.82)	-17.45 (8.51)
	.487	.237	.839	.156
EF Model 2	14.02 (9.92)	22.51 (12.37)	1.66 (9.57)	-15.09 (8.69)
	.163	.074	.863	.093

*Values calculated using multivariable linear regression. Model 1Adjusted for age and gender. Model 2 Adjusted for age, gender, and income. * Statistically significant at p-value <0.05 after Benjamani Hochberg correction.*

Table 6 Associations Between CEBQ Subscales and Eating Frequency

	Total	Main Meal	Snack	Beverage Outside Meals
	B (SE) P value	B (SE) P value	B (SE) P value	B (SE) P value
FF Model 1	0.03 (0.20) .940	-0.03 (0.06) .865	-0.13 (0.18) .755	0.14 (0.13) .658
FF Model 2	0.04 (0.20) .952	-0.03 (0.06) .890	-0.14 (0.18) .697	0.14 (0.13) .655
SR Model 1	-0.02 (0.21) .940	0.06 (0.06) .725	-0.42 (0.18) .133	0.39 (0.13) .072
SR Model 2	-0.03 (0.22) .952	0.06 (0.31) .655	-0.43 (0.18) .140	0.39 (0.13) .082
FR Model 1	-0.19 (0.15) .621	-0.03 (0.05) .755	0.02 (0.14) .940	-0.17 (0.10) .384
FR Model 2	-0.19 (0.15) .655	-0.04 (0.05) .655	0.05 (0.14) .952	-0.16 (0.10) .439
EF Model 1	-0.22 (0.18) .621	0.01(0.05) .940	-0.01 (0.16) .940	-0.27 (0.11) .133
EF Model 2	-0.21 (0.18) .655	0.00 (0.06) .952	0.01 (0.17) .952	-0.27 (0.12) .140

*Values calculated using multivariable linear regression. Model 1Adjusted for age and gender. Model 2 Adjusted for age, gender, and income. * Statistically significant at p-value <0.05 after Benjamani Hochberg correction*

4.6. Correlation between Eating Behavior Subscales and DQIS Component Intake

Food fussiness was negatively correlated with intake of refined grains (r = -0.3, p-value = .002) and salty snacks (r = -0.3, p-value = .017). Satiety responsiveness negatively correlated with refined grain intake (r = -0.4, p value <.001) and positively correlated with SSB intake (r = 0.3, p-value= .019). Food responsiveness was positively correlated with whole fruit intake (r=0.2, p-value = .013). Enjoyment of food was negatively correlated with milk intake (r=-0.3, p-value = .008) and positively correlated with refined grain intake (r=0.3, p-value= .030) and fruit juice intake (r=0.3, p-value= .02

Table 7 DQIS Component Intake and Correlation with CEBQ Subscales

		Average Intake		Correlation Between DQIS Component Intake with CEBQ Subscales	
	Median (Range)	FF r (p-value)	SR r (p-value)	FR r (p-value)	EF r (p-value)
Milk (oz)	10.0 (0-41.2)	0.1 (.305)	0.1 (.678)	-0.2(.158)	-0.3 (.008)*
Whole grains (oz)	0.4 (0-3.0)	-0.2 (.054)	0.0 (.980)	0.0 (.608)	-0.1 (.693)
Refined grains (oz)	2.8 (0.4-8.6)	-0.3 (.002)*	-0.4 (<.001)*	0.1 (.139)	0.3 (.030)*
Proteins (oz)	2.3 (0-7.4)	-0.3 (.266)	-0.2 (.209)	0.1 (.446)	0.2 (.201)
Vegetables (oz)	3.1 0-11.9)	-0.2 (.208)	-0.1 (.651)	0.0 (.851)	0.1 (.252)
Fruits (oz)	3.2 (0-19.7)	-0.1 (.686)	-0.2 (.072)	0.2 (.013) *	0.2 (.091)
100% Juices (oz)	3.6 0-17.7)	-0.2 (.150)	-0.2 (.148)	0.2 (.219)	0.3 (.024)*
Sugar Sweetened Beverages SSB (oz/day)	0.3 (0-11.4)	0.1 (.421)	0.3 (.019)*	0.0 (.751)	-0.1 (.493)
Other added sugars (g)	4.4 (0.1-11.5)	0.2 (.226)	-0.1 (.615)	0.1 (.580)	-0.1 (.585)
Salty snacks (oz)	0.2 (0-3.4)	-0.3 (.017)*	-0.1 (.509)	0.2 (.130)	0.2 (.129)

Intake of each component presented averaged over the available number of recalls. Milk includes fluid milk (cow's milk or imitation milk, plain or flavored) and formula. Protein includes meat, poultry, seafood, organ meat, cured meat, eggs, soy, and nuts and seeds (excludes legumes). Fruit includes whole fruit. 100% juice includes 100% fruit and vegetable juices. Other added sugar includes g added sugar not accounted for in SSB. Salty snacks include fried potatoes and salty snacks from grain products (chips pretzels etc. except low sodium crackers). Spearman rank correlation coefficients are presented. With * indicating significance at p< .05.

4.7 Adjusted Odds of High Consumption for DQIS components by CEBQ Subscale

Food fussiness was associated with 50% lower odds of high refined grain intake (OR=0.5, 95% CI= 0.2-0.9). Satiety responsiveness was associated with 70% lower odds of high refined grain intake (OR=0.3, 95%CI= 0.1-0.7) and 2 times higher odds of high SSB intake (OR=2.0, 95% CI=1.0-4.0). Food responsiveness was associated with 1.9 times higher odds of high fruit intake. Enjoyment of food was not significantly associated with high intake of any component.

Table 8 Odds of High Consumption of DQIS components (>median intake per day)

	High Milk Intake	High Whole Grain Intake	High Refined Grains Intake	High Proteins Intake	High Vegetable Intake	High Fruits Intake
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
FF	1.4 (0.8-2.5)	0.9 (0.5-1.6)	0.5 (0.2-0.9) *	0.6 (0.3-1.1)	0.7 (0.4-1.3)	0.8 (0.4-1.4)
SR	1.2 (0.6-2.2)	1.1 (0.6-2.2)	0.3 (0.1-0.7) *	0.7 (0.3-1.3)	1.1 (0.6-2.0)	0.6 (0.3-1.2)
FR	0.7 (0.4-1.0)	0.7 (0.4-1.1)	1.3 (0.9-2.2)	1.2 (0.8-2.0)	0.9 (0.5-1.4)	1.9 (1.1-3.4) *
EF	0.5 (0.2-0.8)	0.7 (0.4-1.1)	1.6 (0.9-2.8)	1.4 (0.8-2.4)	1.1 (0.7-2.0)	1.7 (1.0-3.2)

	High 100% Fruit Juice Intake	High SSB Intake	High Other Added Sugar Intake	High Salty Snack Intake
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
FF	0.8 (0.4-1.4)	1.0 (0.6-1.7)	1.2 (0.7-2.1)	1.2 (0.7-2.1)
SR	0.8 (0.4-1.4)	2.0 (1.0-4.1) *	0.6 (0.3-1.2)	0.6 (0.3-1.2)
FR	1.1 (0.7-1.8)	1.0 (0.6-1.5)	1.4 (0.9-2.3)	1.4 (0.9-2.3)
EF	1.5 (0.9-2.6)	0.9 (0.5-1.5)	1.2 (0.7-2.0)	1.2 (0.7-2.0)

*Values calculated using multivariable adjusted logistic regression. Adjusted for child age and gender *Significant at p<.05.*

5. Discussion

In this predominately low-income, Hispanic/Latinx sample of preschool aged children we found that CEBQ subscales were associated with meal size, intake of fruits, refined grains, and sugar sweetened beverages. Consistent with our hypothesis, food avoidant subscales (food fussiness and satiety responsiveness) were negatively associated with meal size while food responsiveness was associated with increased meal size and average eating occasion size. Contrary to our second and third hypotheses, we did not see a significant association between eating behaviors and eating frequency or overall diet quality. However, exploratory analyses revealed that eating behaviors were associated with differences in consumption of refined grains, fruits, and sugar sweetened beverages.

Food fussiness and satiety responsiveness were, as predicted, negatively associated with meal size, defined as energy (kcals) per main meals (Breakfast, Lunch, and Dinner). Food responsiveness was associated with increased meal size and size of average eating occasions, when adjusting for low-income status. These results provide evidence that CEBQ subscales are associated with meal size when children are eating in their natural environments. Enjoyment of food exhibited a trend towards larger meals size however, this relationship was not significant after correcting for the false discovery rate. Meal and snack sizes were consistent with previous research in 12–24-month-old children (Ziegler, Hanson, et al., 2006). Given Hispanic/Latinx children typically consume 70% of their total energy intake at meals we would expect a mean between 230-326 kcals per meal and 120-168 kcals per snack/ beverage. While there may have been some degree of under-reporting as is common in dietary recalls it is reassuring that our means fall within the expected range (RK et al., 1996).

Unexpectedly, food fussiness was associated with increased kcal per caloric beverage consumed outside of meal/snack times, primarily from milk or nutritional supplements (e.g. Pediasure). This is important because it is possible that children who are perceived to have small appetites are consuming sufficient kcals, due to beverage intake, but are not hungry at meals when a larger variety of foods are often offered. Carnell et al found that most pre-school aged children compensate energy consumed through beverages by consuming fewer kcals at the subsequent meal (Carnell et al., 2017). Consuming caloric beverages outside of meal and snack times is generally not recommended given its potential impact on appetite at meals as well as its association with an increased risk of dental carries (Holt et al., 2011).

CEBQ subscales were not significantly associated with frequency of eating occasions. This contrasts with previous research which have found that food approach subscales (food responsiveness and enjoyment of food) to be associated with increased frequency (Jalkanen et al., 2017; Syrad, Johnson, et al., 2016). This discrepancy could be related to the method of data collection (24-hour dietary recall vs food records) which may impact how parents report children's intake. The mean and range of eating occasions, meals, and snacks were consistent with other studies, (Syrad, Johnson, et al., 2016; Vilela et al., 2019) although few studies have examined the frequency of caloric beverages outside of meal and snack time. Eating frequency and meal size were negatively correlated, with those who ate more frequently consuming fewer kcals per occasion, consistent with other research in this age group (M. K. Fox et al., 2016; Syrad, Johnson, et al., 2016; Vilela et al., 2019). This suggests that eating frequency is not the primary source of differences caloric intake, which is consistent with research suggesting that increased eating frequency has a null, or even protective effect with regards to developing obesity (Garcidueñas-Fimbres et al., 2021; Taylor et al., 2017).

Contrary to our hypothesis, no eating behaviors were significantly associated with overall diet quality as measured by the DQIS. Average DQIS scores indicated a diet quality of "needs improvement". Exploratory analysis showed that both food avoidant subscales (food fussiness and satiety responsiveness) were significantly negatively correlated with refined grain intake and decreased odds of high refined grain intake. This suggests that the decrease in kcals consumed per meal, observed with food fussiness and satiety responsiveness, may be driven by smaller portions of refined grains. These results provide preliminary evidence that the difference in caloric intake is may be related to refined grain intake, highlighting a potential target for intervention for children with low satiety responsiveness. Advocating swapping whole grains for refined grains, while improving diet quality, also has been shown to impact subjective appetite and reduce risk of overweight, obesity, and weight gain over time (Sanders et al., 2021). Future research should explore if replacing refined grains with whole grains improves satiety responsiveness or caloric intake.

While most children did not consume adequate fruits or vegetables, food approach traits (enjoyment of food and food responsiveness) were positively correlated with fruit intake and associated with 1.7-1.9 greater odds of high fruit consumption (>3.2 oz or 0.3 cups per day) . This is consistent with studies that have found that enjoyment of eating is associated with increased liking of fruits and vegetables, and food responsiveness is associated with increased intake of fruit (Fildes et al., 2015; Jalkanen et al., 2017). Together, our results and previous studies provide evidence that to decrease caloric intake and improve diet quality in children behaviorally susceptible to obesity increasing fruit intake is a viable strategy. Most children in this study (87%) were not meeting USDA guidelines for fruit intake (1-1.5 cups per day) and if food approach behaviors are associated with increased intake and liking of fruit, children who score high in food responsiveness and enjoyment of food may find it easy to decrease the caloric density of their diet through increased fruit intake. It is important to note that substituting refined grains with fruit, is cost prohibitive for families most at risk for obesity (marginalized communities who have limited income and access to grocery stores). Future research should explore if providing increased access to fresh fruit improves diet quality and weight status, particularly for children with higher appetite and interest in food.

Overall diet quality of the children in the study was poor. DQIS scores were slightly higher than a nationally representative sample of 2-4-year-old-children; 23.4 out of a maximum 45 in our sample compared with 20.6 (2-3 years) and 22.5 (4 years) in NHANES (Hamner & Moore, 2020). Scores were highest for 100% fruit juice, sugar sweetened beverages, and salty snacks indicating more adherence to guidelines for these components. Scores were lowest for milk, protein, and vegetables. This is important information that will allow for the tailoring of nutrition interventions in this population. For example, while limiting SSB and juice are important nutrition behaviors that contribute to the development of obesity it may not be necessary to devote a significant amount of time covering these topics as the population is generally meeting guidelines. In addition, it would be important to focus on increasing fruits and vegetables while decreasing overconsumption of protein foods.

Strengths of this study include data on an understudied population in eating behavior research, dietary information collected using gold standard methods (multiple 24-hour dietary recalls) and validated surveys administered by trained staff using standardized methods. Limitations of this study are important to note. While it provides important information on an underserved population the sample is small and may not generalize to the larger population. Also, while multiple 24-hour dietary recalls were used several participants only provided one reliable recall (n=17) and therefore may not reflect typical intake of the child. Particularly for estimates of kcals consumed (Ma et al., 2009). Lastly, given the paucity of data on dietary intake and childhood eating behaviors we conducted exploratory analysis on intake of 10 components of diet quality. Given the number of logistic regressions run we would expect 4 to be significant by chance. These results are meant to generate hypothesis about the association between children's eating behaviors and the types and amounts of different foods they eat.

In conclusion, child eating behavior is associated with significant differences in meal size, along with intake of fruits, refined grains, and intake of caloric beverages. Future research is needed to examine the relationship between eating behaviors and dietary intake and how dietary modifications influence behavior and weight status.

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Extended Literature Review

Childhood Obesity and Diet Quality

In the United States, 1 in 5 children have obesity 1. Despite public health focus the national rate of obesity in children has been stable or worsening since 1999. There are significant disparities by race and ethnicity with 38% of African American and 46% of Hispanic youth having overweight or obese1. Early childhood obesity continues into adolescence and adulthood and costs the healthcare system $19,000 per child over the cost of their lifetime48.

While the etiology of obesity is complicated and multifactorial, poor diet quality is a major contributor to excessive weight gain, inadequate intake of micronutrients and poor health 49. In the US children do not meet for vegetables, legumes, whole grains, seafood, and iron rich foods. They consume excessive amounts of juice, sugar sweetened beverages, refined grains and added sugars 50,51. Hispanic and Non-Hispanic Black children are more likely than their white peers to consume juice, sugar sweetened beverages, and processed meats and less likely to consume nuts and seeds. 52,53 Addressing diet quality early in childhood is important because food preferences and eating habits are established early in life 54–56. Parents are the primary influencers in terms of shaping the home food and mealtime environments, therefore food parenting styles and practices are a target for intervention to improve diet quality in children.

Feeding Style and the Emotional Context of Meals

Parent feeding styles are the ways in which parents socialize children to eating behaviors57. It is often thought of as the emotional climate in which feeding takes place 58. The extent to which parents behave toward their children along two dimensions--responsiveness/nurturance and demandingness/firmness--determines their feeding style59. Parents with high responsiveness and high demandingness have and set clear limits and expectations around food and eating while remaining responsive to a child's eating cues and behaviors 54. These behaviors are positively associated with child diet quality60. Parents with low responsiveness and low demandingness have been shown to have a negative effect on diet quality and health, particularly for children with high emotional eating 61. Observational studies suggest that feeding styles play an integral role in the emotional climate of meals 62. The emotional climate of meals is important because a negative emotional climate has been associated with low responsive/low demanding feeding styles and may predict child consumption of healthy foods 62,63. The socioemotional climate created at meals along with specific food parenting practices influence how children's eating behaviors develop. Responsive feeding interventions have demonstrated ability to increase feeding practices associated with improved outcomes, however, more research is needed to identify predictors associated with feeding practices and the socioemotional context of meals across critical developmental stages (i.e. infancy and early childhood) so that we can better identify and support parents64.

Vaughn et al. (2016) has provided a content map of the specific ways feeding influence child diet quality and eating behaviors 65. The map organizes practices into three constructs: coercive control, structure, and autonomy support. Coercive strategies include pressure to eat, threats or bribes, and restriction. These strategies are each believed to have a negative impact on child diet quality. Research on pressuring children to eat consistently shows poor diet quality, high food fussiness, and reduced willingness to consume the food being pushed 66,67. The use of threats and bribes make it less likely that children will develop a preference for the foods presented, and the use of sweets as a bribe can increase preference for sweet foods 68–70. Restriction, or denying access to palatable foods, has been associated with problem eating behaviors

71. The data connecting restriction to long term weight status are less clear and show negative, positive and null associations 72–76. In general, coercive controlling practices thwart children's ability to grow as healthy eaters.

Conversely, structure and autonomy supportive strategies have a positive impact on children's diets. Components of structure including availability and accessibility, providing limited and guided choices, and modeling healthy behaviors have been consistently associated with improved diet quality77–81. Autonomy supportive parenting behaviors such as providing choices, praise and positive reinforcement are associated with healthier eating in children82–84. While autonomy support and structure may look different as children grow, it is important in infancy and early childhood in developing healthy food preferences and eating behaviors.

The Need for Theoretical Framework

The associations between the socio-emotional context of feeding, food parenting practices, and child diet quality has led to the development of interventions aimed at modifying parenting to improve outcomes for infants and children. A recent systematic review evaluated 63 trials aimed at modifying parenting style, parenting practices, and policy to improve fruit and vegetable intake in children and infants under 5 years old85. The researchers found that feeding practice/style interventions led to increases in fruit and vegetable intake of 0.35g/day and those that included parenting and pre-school policy changes increased fruits and vegetables 0.37 cups/day, with insufficient data to assess the long-term effectiveness. While the trend for improvement in diet quality is promising, it is clear that more effective and lasting intervention effects are needed. Given the complicated nature of the relationship between parenting practices and child diet quality, the use of a theoretical framework will be important in developing a deeper understanding of the way in which these factors relate to one another. Self-determination theory (SDT) is one such framework that has been suggested to help conceptualize the role of parenting influences on child obesity behaviors and may also provide an understanding of the antecedents to practices that support children's needs 86,87.

Self-Determination Theory

SDT is a meta-theory that explains the social-contextual conditions impacting the regulation of health behaviors by focusing on the degree to which people are able to satisfy their basic psychological needs as they choose, pursue, and attain their goal behaivors88. SDT is comprised of six "mini-theories" that address facets of motivation or personality functioning. For the purpose of this research, we will focus on the basic psychological needs theory (BPNT) and the Cognitive Evaluation Theory(CET) 88,89.

The BPNT states that psychological needs are defined as, "innate psychological nutriments that are essential for ongoing psychological growth, integrity, and wellbeing"88 and are: competence (feeling capable of achieving desired outcome), autonomy (feeling of being the origin of one's own behavior), and relatedness (feeling understood and cared for by others). The satisfaction of these needs allows for motivation to become more integrated and internalized, with the result that individuals desire to initiate and maintain health behaviors.

CET suggests that environments can either support or thwart these basic needs. For this reason, the home environment is vital to the healthy development of children. Examples of needs-supportive environments include a respective, inclusive environment, security, optimal challenges, positive performance feedback, offering choices along with rationales and acknowledging feelings. Examples of need thwarting environments include competition, criticism, excessive challenges, negative performance feedback, rewards, threats, deadlines, or imposed goals. Ensuring a supportive environment for people to grow is important for both parents and their children.

Based on the SDT literature the parents' role is to guide children through needs-supportive environments and socialization[87]. Three distinct parenting dimensions have been identified as being critical for the satisfaction of children's basic psychological needs and these are autonomy support, structure, and involvement[90].

SDT and associated parenting dimensions coincide with the food parenting practices proposed by Vaughn's model (autonomy support, structure, and coercive control) but their constructs have not been evaluated together. This framework allows us to explore the relationship between parents' basic psychological needs and their use of food parenting practices that impact child diet quality and the emotional context meals are taking place in. It has been suggested that parental needs satisfaction or frustration is an important antecedent to their use of needs-supportive practices[91]. Psychological needs frustration can result in suboptimal parenting practices such as fostering a controlling or chaotic environment[92]. Parenting practices may also be influenced by a variety of contextual factors including parental education level, body mass index (BMI), stress, limited time, financial resources, inter-generational influences, as well as the characteristics and behaviors of the child[93,94].

Maternal Stress and Feeding

Maternal stress has been shown to increase obesity risk from toddlerhood to adolescence[95]. Proposed mechanisms by which stress in mothers could impact child BMI include modeling unhealthy behaviors, lower involvement, and lower responsiveness to children's needs[17,22,96–98]. The association between stress and child diet quality is unclear, with mixed findings in the current literature[22]. Potentially modifiable variables that have been associated with stress, dietary intake, and child adiposity are feeding practices, feeding style, and food security[99]. High levels of perceived stress are associated with obesogenic feeding styles, controlling practices and fewer meals prepared at home100101. Although stress is shown to increase obesity risk in toddlerhood and not infancy, more research is needed to evaluate whether stress impacts feeding practices and infant weight gain even earlier so that it is possible to intervene before childhood obesity develops.

Child Eating Behavior

Child eating behaviors are phenotypes of how, versus what, a child eats. They typically relate to the self-regulation of eating behaviors and are often associated with child weight status102. The Children Eating Behavior Questionnaire (CEBQ) is one of the most commonly used surveys to measure parents' report of children's eating behaviors and measures the following constructs: food responsiveness, enjoyment of food, emotional overeating, desire to drink, satiety responsiveness, slowness in eating, emotional under-eating, and food fussiness103. Of these constructs, enjoyment of food (EF), food responsiveness (FR), satiety responsiveness (SR), and slowness in eating (SE) have consistently been shown to be associated with child BMI104–109. While FR and SR have similar relationships with BMI, their influence on diet varies. A recent study conducted with a large sample (n=2203) of predominately white children (95.5%) between 1 and 2 years old found that food responsive children ate more frequently, while children with lower satiety responsiveness ate more calories at each eating occasion110. These findings identified how eating patterns differ between high FR and low SR children. More research is needed to explore if these differences are found in preschool aged, more diverse children who may have more autonomy over how they eat. It will also be important to understand if there are any differences in the types of foods children with high FR or low SR consume, or if differences in eating pattern alone explain caloric intake/ obesity risk. Emotional eating (EE) and food fussiness (FF) have also been shown to have an association with BMI, although the data are inconsistent74,106–108,111. Despite the lack of association with obesity, FF is inversely associated with intake of fruits, vegetables, greens and beans, total protein, and total Healthy Eating Index scores and this relationship tracks overtime112,113 which is important given that poor diet quality is the leading risk factor for health loss in the US114. FF is also important to understand in the context of pediatric obesity because it significantly impacts children's response to treatment of pediatric obesity115. While the data on diet quality is clearer for FF, compared to other eating behaviors, their eating patterns, such as eating frequency and meal size, are less studied.

More research is needed to understand the way in which child eating behaviors impact dietary outcomes so that interventions hoping to improve food parenting practices and diet quality can provide specific guidance to parents, acknowledging that children respond in different ways. General parenting literature based in SDT suggests that parents' basic psychological needs satisfaction, child behavior, and contextual factors including stress, impact the use of parenting practices that either support or thwart the child's needs. The identification of antecedents of how parents feed their children at critical developmental stages will allow for the further refinement of food parenting interventions, to support parents more effectively in guiding their children for a lifetime of healthy eating. Investigating the impact of child eating behavior on dietary outcomes will provide valuable information on the most important targets for intervention.

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