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Early non-food parent-infant interactions and the development of obesity in a high-risk, diverse sample.

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Abstract

Objective: To understand the protective role of positive mother-infant interactions in the context of food and non-food behaviors against obesity risk later in life among a cohort of low-income children at high prenatal risk due to maternal substance use during pregnancy.

Methods: The sample consisted of 216 mother-infant dyads (49% boys) participating in an ongoing longitudinal study. Mother-infant interactions during a feeding episode, and a free play task were measured at 1-month and 7-months of child age, respectively. Child's length (1-23 months) or height (24-84 months) and weight were measured at 1-, 7-, 13-, 24-, 36-, 48 months-, kindergarten age, and in 2nd grade (approximately 60-, and 84-months) and BMI growth trajectories were modeled.

Results: No significant associations were found between mother-child feeding interactions and child BMI trajectories. Maternal warmth (95% CI: -0.020, -0.0005, $p = 0.04$) and child's positive affect (95% CI: -0.020, -0.002, $p = 0.014$) during free play were associated with a more normative child BMI trajectory.

Conclusion: Results from this study indicated that high maternal warmth and child positive affect during play, but not feeding interactions, are associated with reduced obesity risk from infancy to middle childhood in the context of high pre- and postnatal risks.

Keywords

Parents; early childhood risk factors; childhood obesity; socio economic deprivation

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Author contributions: KKK initiated and developed the research question. RDE was the Principal Investigator and guided all data collection. KKK, RDE and RAP conducted data analyses and interpreted all results. All authors were involved in writing and revising the paper, and had final approval of the submitted and published versions.

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Introduction

Theories such as developmental origins of health and disease and empirical evidence indicate that the prenatal period is a sensitive period in development (1). High fetal stress posed by maternal substance use in pregnancy that often co-occurs with poor nutrition and fetal hypoxia-ischemia may lead to alterations in the structure and function of various organs to promote survival. This fetal programming may result in life long changes in neuroendocrine and metabolic dysfunction (2). Similarly, early childhood is a sensitive period, and exposure to early adversity such as neglect, abuse, or poverty, is likely to increase the risk for obesity during adulthood (3). However, positive mother-infant interactions characterized by high levels of maternal warmth/sensitivity, and infant positivity may serve as a significant protective factor with lifelong implications for positive outcomes (4).

Parents play a pivotal role in influencing their child's weight status beginning in infancy. Parents can influence the emotional environment in the home and provide a context for interactions with their infants that are either collaborative and supportive, or antagonistic and harmful (5). Maternal behaviors, characterized by high levels of warmth, sensitivity, and maintenance of clear behavioral boundaries and expectations, have been associated with normal/healthy weight gain (6, 7), and greater consumption of fruits and vegetables (8). Maternal behaviors, characterized by high levels of harshness, demandingness, and non-responsiveness, have been associated with childhood obesity (9), higher fussiness during meal time (10), use of food as reward for a desired outcome that has caused an increase of candy consumption (11), and a decrease of fruits and vegetables consumption (12). However, many of the studies examining the relationship between mother-infant interaction and child health outcomes were conducted with grade school children and/or among mostly Caucasian, mid-to-high income families at low prenatal risk. The role of positive mother-infant interactions on developmental trajectories of obesity risk and resilience among children who experienced high prenatal and socioeconomic adversity is not well understood.

Parents not only create food environments for children's early experiences, but they also influence their children's non-food behaviors. Aside from mother-child interactions during feeding, maternal behaviors characterized by high levels of warmth and consideration of their child's developmental abilities, may also promote a greater capacity in the child for active play. This can potentially lead to a higher level of physical activity participation later in life that may play a role in obesity prevention (13). In addition, pleasurable mother-infant interactions may promote alternatives to eating and may mitigate food-seeking behaviors, thus altering the trajectory of weight gain. To date, there are limited studies examining the relationship between mother-infant interactions during feeding and free play and obesity risk later in life, particularly among low-income children at high prenatal and postnatal risk.

The goal of the present study was to understand the protective role of positive mother-infant interactions in the context of food and non-food behaviors against obesity risk later in life among a cohort of primarily low-income children at high prenatal risk due to maternal substance use in pregnancy. We hypothesized that higher levels of maternal sensitivity, and warmth, and lower levels of harshness, during a feeding episode, measured at 1-month of

age and a free play task measured at 7-month of age, will be associated with a more normative child BMI trajectories, measured from 1-month to middle childhood (about 84 months) of the child's age; while less optimal parenting behaviors in infancy will be associated with steeper increases in BMI trajectories from early infancy to middle childhood.

Methods

Participants

The sample consisted of 216 mother-infant dyads (49% boys) participating in an ongoing longitudinal study, originally designed to examine developmental outcomes among children of cocaine using mothers ($n = 100$) in the context of poly-substance exposure. All families were recruited after delivery from two local area hospitals (from year 2000 to 2003). All mothers were screened after delivery for initial eligibility. Exclusionary criteria, based on administering a screening interview after delivery and medical record review of all mothers, were: (a) maternal age younger than 18 years, (b) use of illicit substances other than cocaine or marijuana or use of antipsychotic/seizure medication in pregnancy, (c) significant medical problems for the mother or infant (e.g., genetic disorders, major perinatal complications, baby in critical care for more than 48 hours), (d) maternal hospitalization due to mental illness at any point in their lifetime, and (e) mother not English speaking or lived too far away. The study received approval from the children and youth institutional review board of the University at Buffalo and the two recruitment hospitals. Informed, written consent was obtained from all recruited participants, and they were compensated for their time (14). As with all longitudinal studies, particularly those consisting of high-risk samples, we had missing data at different waves of data collection. Our retention rates at 7, 13, 24, 36, 48, kindergarten age (about 60 months), and 2nd grade assessment (about 84 months) were 79.5%, 78.1%, 72.6%, 69.3%, 71.2%, 74.4%, and 72.1%. The final samples were 172 families with covariates in the feeding analysis, and 163 families with covariates in free play analysis.

Procedure

About 2 weeks after delivery, mothers were contacted and scheduled for their first laboratory visit (i.e., 1-month assessment). After the initial visit, maternal and child follow-up assessments were conducted at 7-, 13-, 24-, 36-, 48 months, after the child entered kindergarten (about 60 months), and when the child was in 2nd grade (about 84 months). All visits consisted of a combination of maternal interviews, observations of mother-infant interactions, and infant assessments. Children born before 37 weeks gestation were scheduled for their appointments at corrected age (corrected for prematurity until the 24-month assessment). All assessments were conducted with the primary caregiver (adult who had legal guardianship of the child) of the child at that time, although for ease of presentation the terms *mother* and *maternal* are used throughout the article when referring to the primary caregiver. Biological mothers were interviewed at the 4- to 8-week assessment in addition to the primary caregiver in order to obtain accurate information about prenatal information. Children were classified as having been in non-biological parent care if they had been placed in foster or kinship care at any time point between birth and kindergarten.

Measures

Prenatal substance exposure.—Five sources were used to measure prenatal substance use: detailed selfreport, health screener, maternal and infant urine, and maternal hair (14). The Timeline Follow-Back Interview (TLFB) (15), a reliable and valid calendar based self-report measure (16), yielded data about the average number of days of cocaine use per week, average number of joints smoked per week, average number of cigarettes smoked per week, and average number of standard drinks consumed per week, per trimester and during the entire pregnancy. Mothers completed the Fagerstrom Test for Nicotine Dependence (FTND) at the first appointment (17). A prenatal substance use risk composite was created from these measures and used in all analyses. This risk composite (ranged from 0 to 13) was created by computing a count variable which included all of these measures within each trimester and then summed across all three trimesters. Participants were given a score of one, within each trimester, using the following cut-offs: maternal cigarette use per week of 7 or higher (high probability of daily smokers), as reported on the TLFB, or a nicotine dependence score of 1 or more on the FTND; any prenatal alcohol use, as indicated on the health screener, TLFB, or positive urine screen; smoking 1 joint per week or more during pregnancy on the health screener or the TLFB, or if mother/infant urine is positive for marijuana metabolites, reflecting persistent use in pregnancy; any indication of maternal cocaine use in health screener, TLFB, maternal/infant urine, or maternal hair (18).

Parenting (maternal sensitivity, warmth, and harshness).—At 4 – 8 weeks old, a laboratory assessment was scheduled around a time when the infant was likely to be awake, and a half hour before feeding. Mothers were asked to feed their infant as they normally would. The first 10 minutes of these interactions was coded using the Mother–Infant Feeding Scale (19) by coders blind to other information about the family. This scale consists of 46 items (26 maternal items and 20 infant items) rated on a 4-point Likert scale. Of the original 26 maternal items, 18 were included at the 4-8 week visit with the remaining not included due to low variability. All items require attention to affect (body posture, facial expression), sensitivity to infant cues, nonverbal communication (e.g., positioning the infant for eye contact; infant gaze and facial expressions), verbal communication, and feeding behaviors. Subscales derived from these items included dyadic reciprocity, dyadic conflict, struggle for control, maternal non-contingency used in previous studies (19), and two global measures of maternal warmth, and insensitivity based on Principal components analysis with varimax rotation. The internal consistencies of these scales ranged from *Cronbach's alpha* = .79 to .82.

At 7 months of child age, mother-infant dyads were videotaped during a free play task. Mothers were asked to interact with their child as they normally would at home, for 10 minutes in a room filled with toys. These interactions were coded using the Parent-Child Early Relational Assessment (20, 21) by two sets of coders, blinded to any information regarding the families. Coders used a collection of 5-point rating scales to assess the intensity, duration, and frequency of specific behaviors, with high scores on all items being positive. Three composite maternal scales labeled warmth, sensitivity, and low harshness, and three infant scales labeled positive affect, negative affect, and responsiveness, were derived from these items based on Principal Components analyses (22). Maternal sensitivity

included items such as contingent responsiveness to infant cues, connectedness between mother and infant, and flexibility in following infant lead. Maternal warmth was assessed by indicators such as warm/kind tone of voice, maternal enjoyment of the infant, positive maternal mood, and positive verbalizations. Maternal low harshness was indicated by low levels of angry and hostile tone of voice or mood, and expressions of anger, disapproval or criticism. The internal consistencies of these scales ranged from *Cronbach's alpha* = .92 to .94.

Coders of both feeding and free play interactions were trained by the second author until inter-rater reliability criterion was reached (agreement of 90% or above). Subsequently inter-rater reliability was established on 22% of the tapes. Inter-rater reliability on the individual items of the feeding scales ranged from intraclass correlation coefficients of .85 to .96. Inter-rater reliability on the composite Clark scales (free-play task) ranged from intraclass correlations of .83 to .91.

Assessment of growth and risk status.—Three measures of birth anthropometry were retrieved from infant's medical chart in this study: birth weight (g), birth length (cm), and head circumference (cm). Gestational age was calculated by dates and extracted from medical records. Child's length/height and weight were measured by research staff at 1-, 7-, 13-, 24-, 36-, 48-, 60-, and 84 month assessments. With minimal clothing and without shoes, weight was measured to the closest 0.1 kilogram (kg) using a Health O Meter infant toddler scale at 1-23 months, and a SECA scale at all other assessments. Length or height was measured to the closest 0.1 cm in triplicate (average used as the final measure) using a recumbent stadiometer at 1-23 months (for length), and a SECA stadiometer at all other ages (for height). The child's body mass index (BMI) (kg/m^2) was calculated. Analyses involved raw BMI scores (kg/m^2) at all ages. Recent studies support the use of raw BMI scores in assessing children's obesity risk (23). Moreover, the World Health Organization (WHO) growth chart only provides z-scores for birth up to 60 months old, which prevented us from obtaining z-score values for the 60- and 84-month assessments using the same chart.

Demographic and breastfeeding status.—Maternal age, years of education, parity, marital status, race/ethnicity, and income status (on Temporary Assistance for Needy Families or not) were measured at 1 month of age using maternal interviews. Breastfeeding status and duration of breastfeeding were measured at every time point until the child was 24 months of age. Mothers were asked if the infants were ever breastfed, if they were currently breastfeeding, and if not, how long they breastfed for. Given the small number of mothers who breastfed, the main variable used in final analyses was breastfeeding status at 7 months of age (breastfed vs. not) and breastfeeding was not exclusive.

Analytic Plan

We modeled growth trajectory on BMI scores assessed at 1-, 7-, 13-, 24-, 36-, 48-, 60-, and 84 months of age using a mixed model with an unstructured covariance structure and random effects of intercept and months plus each feeding or free play predictor, and those variables interactions with months. ($\text{BMI} = \text{constant} + \text{months} + \text{feeding/free play} + \text{months} * \text{feeding/free play}$). Covariance structure was assessed for best fit using Akaike's

information criterion (AIC) and maximum likelihood estimation. One-month BMI were omitted from models using 7-month free play predictors, since 1-month measurement precedes a 7-month measurement. In addition, we performed covariate-adjusted models (child's sex, birthweight, non-biological parent care status, breastfeeding status at 7-month, and maternal race, parity, education, age, and prenatal substance use risk) given potential differences in maternal behavior and BMI. The primary hypotheses were analyzed by using the mixed model regression with SAS PROC MIXED (SAS Institute Inc., Cary, NC, USA). Mixed models have the advantages of handling missing data, allowing flexibility in choosing appropriate covariance structures, and accounting for the clustering of repeated measurements within children.

Result

Mother-child dyads characteristics and socioeconomic status

Descriptive statistics including means, standard deviations (SD), and ranges are included in Table 1. The majority of caregivers were African American (75%). Most caregivers were receiving Temporary Assistance for Needy Families (81%) at the time of their first visit, and were single (85.5%). The majority of mothers in this sample engaged in substance use in pregnancy (cigarettes, alcohol, marijuana, or cocaine) with only 3.5% with 0 prenatal substance use risk score. Children in our sample experienced high prenatal and socioeconomic adversity during early childhood. By the time they were in 2nd grade, 36.4% of the children were considered obese with BMI percentile greater than the 95% tile.

Early mother-child feeding interactions and child BMI trajectories

We did not find significant associations between any of the mother-child feeding interaction variables at 1-month and child BMI trajectories in both non-adjusted and covariate-adjusted models. In order to examine if there were associations between feeding interactions and BMI at any time point, we conducted correlational analysis between mother-child interaction variables and the raw BMI scores at each assessment time point (see Table 2). Interestingly, the negative aspects of mother-child interactions [dyadic conflict ($p<.0001$), struggle for control ($p=0.007$), and maternal insensitivity ($p=0.0006$)] during 1-month feeding, significantly correlated with infants' weight at 7 months old. However, this relationship did not sustain for later ages. Again, to our surprise, we also observed that the positive aspect of mother-child interaction [dyadic reciprocity ($p=0.03$), and maternal warmth ($p=0.03$)] during feeding at 1-month were negatively correlated with the child's later BMI (preschool age), but were not with their earlier time points.

Early mother-infant free play interactions and child BMI trajectories

The covariate-adjusted model showed that maternal warmth during free play at 7-months was associated with child BMI trajectories (β for child age=0.057, 95% CI: 0.020, 0.094, $p=0.003$; β for maternal warmth=0.254, 95% CI: -0.106, 0.612, $p=0.166$; β for interaction (maternal warmth * child age) = -0.01, 95% CI: -0.020, -0.0005, $p=0.04$). Figure 1 displays this interaction where children's mothers who displayed lower warmth had steeper BMI trajectories compared with children's mothers who displayed higher warmth. We also found a marginal association between maternal sensitivity and child BMI trajectories (β for child

age=0.052, 95% CI: 0.016, 0.087, $p=0.005$; β for maternal sensitivity=0.156, 95% CI: -0.128, 0.440, $p=0.280$; β for interaction (maternal sensitivity * child age) = -0.007, 95% CI: -0.015, 0.0006, $p=0.07$). In addition, children's positive affect during free play was associated with child BMI trajectories (β for child age=0.056, 95% CI: 0.026, 0.087, $p=0.0004$; β for child positive affect=0.463, 95% CI: 0.133, 0.792, $p=0.006$; β for interaction (child positive affect * child age) = -0.011, 95% CI: -0.020, -0.002, $p=0.014$). Figure 2 illustrates the interaction where children who displayed lower positive affect had steeper BMI trajectories compared with children who displayed higher positive affect during the free play mother-child interaction observational task. The BMI values in both Figure 1 and 2 are model-estimated means. There were no substantial differences in the estimated interactions between non-adjusted and covariate-adjusted models, suggesting non-significant evidence of confounding. Birthweight is the only covariate that positively ($p < 0.001$) predicted BMI trajectories for all models.

Discussion

In a prospective U.S. high-risk infant cohort, we examined the association of mother-child interactions during feeding and free play with child BMI growth trajectories, tracked from infancy to middle childhood. The majority of the children in our cohort experienced prenatal and early socioeconomic adversity and more than 36% of them were considered obese at the age of 7, which is higher than the 18.5% of children aged 2–18 years in the US (24). Our findings provide initial evidence that early mother-child interactions during free-play at 7-months had a longer lasting impact on the health outcomes of the children, specifically obesity risk trajectories compared to mother-child interactions during feeding at 1-month.

Understanding the role of mother-infant interactional quality as a protective factor among high-risk samples such as those who were exposed to prenatal and postnatal adversity provides a critical target for intervention. Maternal substance use in pregnancy co-occurs with high levels of postnatal risks and taken together, these risk factors increase the likelihood of negative, physical health across the lifespan, including obesity (25, 26). The quality of the parent-infant relationship such as secure attachment has been shown to be protective against the development of childhood obesity (27). In a recent publication, Bernard and colleagues extended this work to a group of high-risk, child protective services-referred children (28) in which they demonstrated that secure attachment was associated with a steeper decline in BMI from age 2 to 4 years ($\beta = -1.08$, $p < 0.001$). Additionally, using a parenting program, which promoted parent-child attachment and positive parenting behaviors, Ordway and colleagues significantly reduced the rate of obesity among 2 years old children living in marginalized families (29). Our results are supportive of these findings, but extend them by highlighting the protective role of early mother-infant interactional quality in a non-food context as promoting a more normative BMI trajectory from infancy to middle childhood, in a low-income sample at high prenatal risk.

There may be multiple mechanisms involved in the role of maternal parenting as a protective factor in high-risk samples. For instance, parental warmth and sensitivity helps children to increase their ability to regulate negative emotions and cope with stress (30). The areas of the brain that govern stress response and emotion regulation also help to regulate energy

homeostasis (31). These areas are significantly impacted among children exposed to maternal substance use in pregnancy (32). Studies using animal models have shown that stress preferentially increases consumption of highly palatable junk foods, as these foods act to soothe the stress-perceiving areas of the brain (33, 34). Maternal warmth, sensitivity and support could protect against obesity by improving children's ability to modulate their physiologic and behavioral responses to stress. However, inappropriate parenting behaviors such as the use of feeding to soothe, in particular with infants who are high in negativity and cry frequently, can exacerbate the effects of obesogenic environments, promoting overfeeding and maladaptive eating behaviors that can lead to obesity later in life (35). An early intervention program in which parents were instructed how to identify and respond sensitively to infant hunger and satiety cues, with a goal to promote self-regulation, has demonstrated success in minimizing early rapid weight gain (35). Results from the current study extend this prior work, indicating that such interventions beginning in early infancy and focusing on play interactions may have long lasting impact on obesity risk among high-risk children.

To date, most of the research on parental influences on children's weight has focused on food domain of the home environment, such as the study of parental responsive feeding on childhood obesity later in life (36). Albeit, there is a lack of understanding as to how or if positive parenting during active play (non-food domain of home environment) can play a role in promoting healthful lifestyles of the children. While food is a primary reinforcer (37) in which infants innately are motivated to eat for survival purposes, the motivation to engage in many non-food behaviors, is learned. As infants grow, they are exposed to many opportunities for greater learning to occur. As they gain more independence, they can choose for themselves, activities they enjoy. As a result, for older infants, eating can often be a choice among many other activities, including interacting with parents/siblings or playing with toys. Early home environments that promote comfort and pleasurable behaviors that are an alternative to eating may mitigate young children's food seeking behavior, and thus alter the trajectory of weight gain. Furthermore, a high quality of mother-infant interactions is an aspect of an enriched environment. Enriched environments can reduce sensitivity to rewards (38) and maladaptive choices (39). To understand how an enriched environment can serve as a protective factor against maladaptive behaviors, such as overeating among young children who are exposed to early prenatal and socioeconomic adversity, is of importance to the next step in obesity prevention effort.

This study has many strengths, including prospective design, multiple methods used to ascertain prenatal substance use risk, assessment of birth outcomes, repeated assessments within a narrow age range at each time point, a diverse sample, and a large sample size with the majority of the children having experienced early socioeconomic adversity. Mother-child interactions were collected by using direct observational methods instead of a questionnaire, which allowed for assessment of a range of verbal and nonverbal behaviors and reduced method bias. Additionally, we collected child length/height and weight at least once a year since they were 1 month of age until middle childhood. This allowed us to assess longitudinal changes in BMI over time as opposed to cross-sectional (static) measures.

However, our study is not without limitations. We did not have pre-pregnancy BMI of the mothers. Research has shown that pre-pregnancy BMI is associated with child birthweight and later weight status (40). Infant temperament data were not included in these analyses. Our previous work has showed that certain aspects of infant temperament are associated with infant's reinforcing value of food versus non-food reward, which is related to obesity risk (41). Additionally, the feeding and free play interaction assessments occurred at two different time points, which could contribute to the differences in significance findings. It is possible that the feeding interactions were not predictive because infants at this age are just beginning to regulate their physiology, and becoming more socially responsive. Free play interactions were not developmentally appropriate at 1-month. On the other hand, due to the solid food introduction phase, infants are in constant flux with feeding at 7-months of age, which can introduce additional variance. Due to sample size, we were not able to perform analysis looking at effects of gender (boys vs. girls) and non-biological parent care (foster or kinship care vs. not) separately. In the future, these effects can be studied, perhaps with data pooled across multiple cohorts. Finally, the results are limited in generalizability to other low-income samples of children at high prenatal risk due to maternal substance use in pregnancy. However, despite this limit to generalizability, the diversity and low-income nature of the sample is a strength, given the preponderance of studies on more normative samples.

Conclusion

In conclusion, results from this study indicated that positive mother-infant play, but not feeding interactions, has enduring protective effects on altering obesity risk from infancy to middle childhood. Interventions targeting non-food behavior that guide caregivers to promote active play might be a new and promising avenue for the prevention of obesity in high-risk infants.

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Study Important Questions

What is already known about this subject?

- Maternal substance use in pregnancy co-occurs with high levels of postnatal risks increasing the likelihood of negative, physical health across the lifespan, including obesity.
- The quality of the parent-infant relationship has been shown to be protective against the development of childhood obesity.
- However, most of the research on parental influences on children's weight has focused on parent-child interactions in feeding contexts, (e.g., parental responsive feeding on childhood obesity later in life among grade school children), using mostly Caucasian, mid-to-high income families at low prenatal risk.

What does your study add?

- Prospectively examining the role of positive mother-infant interactions in food and non-food contexts on developmental trajectories (from infancy to middle childhood) of obesity risk and resilience among children who experienced high prenatal and post-natal socioeconomic adversity.
- Our findings provide initial evidence that early mother-child interaction during free-play at 7-months had a longer lasting impact on the health outcomes of the children, specifically obesity risk trajectories from infancy to middle childhood, compared to mother-child interaction during feeding at 1-month.

Figure 1: Maternal warmth during free play and child BMI trajectory (n = 163)

Children's mothers who displayed lower warmth (−1 SD below mean) had steeper BMI trajectories (model-estimated means) compared with children's mothers who displayed higher warmth (+1 SD below the mean) during a free play task at 7 months of age.

Figure 2: Child's positive affect during free play and child BMI trajectory (n = 163)
 Children who displayed lower positive affect (−1 SD below mean) had steeper BMI trajectories (model-estimated means) compared with children who displayed higher positive affect (+1 SD below the mean) during a free play task at 7 months of age.

Table 1:

Characteristics of eligible dyads (n = 172)

	n (%)	Mean (SD)	Range
Maternal characteristics			
Age at enrollment, y		29.83 (6.01)	18 - 42
Education (years completed)		11.90 (1.91)	8 - 18
Marital status, single	147 (85.5)		
Parity		3.83 (2.11)	0 - 13
Race/ethnicity			
African-American	129 (75)		
Other	43 (25)		
Prenatal substance use risk		4.35 (3.10)	0 - 13
Child characteristics			
Gestational age, week		38.97 (1.65)	32 - 42
Premature infants (< 37 weeks gestation)	14 (8.1)		
Birth weight, g		3,129.09 (553.98)	1531 - 5072
Birth weight z-score		-0.57 (1.04)	-3.26 - 3.87
Birth weight z-score corrected for gestational age and sex		-0.485 (1.07)	-2.77 - 4.15
Birth length, cm		49.05 (3.21)	32 - 56
Birth length z-score		-0.28 (1.47)	-11.56 - 2.35
Head circumference, cm		33.35 (1.84)	26.5 - 48.5
Head circumference z-score		-1.06 (1.03)	-7.12 - 5.78
Sex, male	84 (48.8)		
Breastfeeding at 7 month (non-exclusive)	11 (6.4)		
Non-biological parent care (foster or kinship care)	48 (27.9)		
BMI at 1 month		16.25 (2.56)	6.77 - 25.74
BMI at 7 months		17.68 (3.08)	10.79 - 42.30
BMI at 13 months		17.37 (2.21)	11.42 - 23.33
BMI at 24 months		17.85 (1.79)	14.10 - 23.69
BMI at 36 months		17.27(1.71)	13.78 - 23.43
BMI at 48 months		17.48 (2.09)	13.65 - 27.54
BMI at 60 months		18.15 (2.89)	12.74 - 29.89
BMI at 84 months		19.67 (4.59)	13.39 - 35.96
Mother-child interactions during feeding at 1 month variables			
Dyadic reciprocity		1.77 (0.43)	0.79 - 2.93
Non-contingency		0.19 (0.30)	0 - 1.67
Dyadic conflict		0.13 (0.28)	0 - 1.75
Struggle for control		0.20 (0.33)	0 - 1.50
Maternal warmth		10.87 (4.24)	1 - 21
Maternal insensitivity		7.22 (2.68)	2 - 20
Mother-child interactions during free play at 7 months variables			
Maternal warmth		3.73 (0.94)	1.2 - 5.0

	n (%)	Mean (SD)	Range
Maternal harshness (low)		4.70 (0.55)	1.0 - 5.0
Maternal sensitivity		4.31 (1.18)	1.14 - 8.0
Child negative affect		4.32 (0.96)	1.0 - 5.0
Child responsiveness		3.98 (0.80)	2.0 - 5.0
Child positive affect		3.26 (1.01)	1.0 - 5.0

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Table 2:

Correlation between mother-child interactions during feeding at 1 month of age and child BMI at each assessment time point (n = 172)

Child BMI	Mother-child interactions during feeding at 1 month					
	Dyadic reciprocity	Non contingency	Dyadic conflict	Struggle for control	Maternal warmth	Maternal insensitivity
1-m	-0.103	0.045	-0.033	-0.080	-0.041	-0.019
7-m	-0.026	0.146	0.356**	0.214*	-0.015	0.270**
13-m	-0.021	-0.086	-0.060	-0.087	-0.098	-0.090
24-m	-0.114	-0.039	-0.168	-0.031	-0.135	0.057
36-m	-0.140	0.135	0.035	-0.069	-0.129	-0.029
48-m	-0.183*	0.061	-0.008	-0.085	-0.186*	-0.044
60-m	-0.100	0.079	-0.026	-0.016	-0.065	0.025
84-m	-0.039	-0.050	-0.097	-0.049	-0.054	-0.060

**
 $p < 0.001$;

*
 $p < 0.05$