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Maternal responsiveness and toddler body mass index z-score: Prospective analysis of maternal and child mealtime interactions

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ABSTRACT

Responsive feeding, where parents are guided by children's hunger and satiation cues and provide appropriate structure and support for eating, is believed to promote healthier weight status. However, few studies have assessed prospective associations between observed parental feeding and toddler growth. We characterized toddler growth from 18 to 36 months and, in a subset of families, examined whether observed maternal responsiveness to toddler satiation cues and encouraging prompts to eat at 18 and 24 months were associated with toddler body mass index z-score (BMIz) from 18 to 36 months. Participants included 163 toddlers and their mothers with overweight/obesity who had participated in a lifestyle intervention during pregnancy. Anthropometrics were measured at 18, 24, and 36 months. In a subsample, mealtime interactions were recorded in families' homes at 18 (n = 77) and 24 (n = 75) months. On average, toddler BMIz remained stable from 18 to 36 months with 31.3% (n = 51) categorized with a healthy weight, 56.4% (n = 92) with at risk for overweight and 12.3% (n = 20) with overweight. Fewer maternal prompts to eat at 18 months was associated with both higher probability of having at risk for overweight/overweight ($p < .05$), and higher child 36-month BMIz ($p = .002$). Higher child weight status at 12 months was also associated with both higher probability of having at risk for overweight/overweight ($p < .05$), and higher child 36-month BMIz ($p < .001$). Neither 24-month maternal prompts nor 18 or 24 month responsiveness to satiation cues were associated with toddler BMIz. In this diverse sample, weight status was relatively stable from 18 to 36 months. Maternal prompts to eat measured earlier in toddlerhood and prior child weight status were associated with toddler BMIz.

1. Introduction

Obesity risk is shaped early in life (Brisbois, Farmer, & McCargar, 2012; Eriksson, Forsen, Tuomilehto, Osmond, & Barker, 2001). Beyond shared genetic influences, parents play a central role in shaping children's obesity risk and protection. They help establish children's eating and activity environments, model eating and activity behaviors, and engage in feeding practices that influence children's eating behaviors and obesity risk (Davison & Birch, 2001). Parental influences may be particularly important early in life given young children's limited autonomy and increased reliance on parents for their basic needs, including achievement of adequate nutrition (DiSantis, Hodges, Johnson, & Fisher, 2011). Thus, understanding the role of parents, particularly how their feeding styles and practices influence young children's growth, has been identified as an important line of research for enhancing obesity prevention efforts (Lumeng, Taveras, Birch, & Yanovski, 2015).

Emerging work demonstrates that beyond what parents feed their young children (e.g., breastmilk versus formula, energy-dense versus nutrient-dense foods), *how* they feed their children can influence

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children's eating behaviors and obesity risk. It is well recognized that parental feeding styles (i.e., broader approach to and emotional climate surrounding feeding) and feeding practices (i.e., goal-oriented behaviors) affect child eating behaviors and weight status. For instance, indulgent (Frankel et al., 2014; Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2010; Tovar et al., 2012) and intrusive (Lumeng et al., 2012) feeding styles are associated with less optimal dietary and weight outcomes during early childhood. Further, specific feeding practices such as overt restriction (e.g., keeping foods in sight but off limits) have been associated with increased likelihood of a child having or developing overweight or obesity, although the majority of evidence has been cross-sectional (Pesch, Appugliese, et al., 2018; Pesch, Miller, Appugliese, Rosenblum, & Lumeng, 2018; Shloim, Edelson, Martin, & Hetherington, 2015; Spill et al., 2019). In contrast, the role of other feeding practices are less clear. Some studies demonstrate that parental pressure/encouragement to eat predicts the development of obesogenic eating behaviors and higher weight status for children (Kroller & Warschburger, 2008; Rodgers et al., 2013; Spruijt-Metz, Lindquist, Birch, Fisher, & Goran, 2002), and other studies demonstrate the opposite – that pressure is associated with lower weight status and slower weight gain (Costa, Pino, & Friedman, 2011; Lee & Keller, 2012; Power et al., 2021; Shloim et al., 2015; Spill et al., 2019).

Although several studies have focused on the negative impact of parental feeding behaviors on child eating and obesity risk, there have been calls to assess how supportive approaches to feeding can promote healthy child eating behaviors and weight status (Balantekin et al., 2020; Beckers, Karssen, Vink, Burk, & Larsen, 2021; Medicine, 2011). Specifically, a responsive approach to feeding is characterized by parental feeding behaviors that are guided by child hunger and satiation cues but that also place developmentally appropriate "demands" on the child by providing structure and support of the child's eating. Responsive feeding is believed to support healthier eating behaviors and weight status by supporting the child's developing capacity to self-regulate energy intake and promoting preferences for healthy foods (DiSantis et al., 2011; Perez-Escamilla, Jimenez, & Dewey, 2021). Responsive feeding is also thought to be particularly important during infancy and early toddlerhood when caregivers and children learn to interpret non-verbal and verbal communication signals from one another (Black & Aboud, 2011). Research on responsive feeding in the first two years of life is relatively new, but there is some indication that responsive feeding in infancy is associated with healthier eating behaviors (Schneider-Worthington, Berger, Goran, & Salvy, 2021). Further, a broad parenting intervention designed to promote responsiveness to children's cues related to eating, sleep, and crying has resulted in reduced risk for rapid weight gain during the first year of life (Savage, Birch, Marini, Anzman-Frasca, & Paul, 2016) and significantly lower body mass index z-scores at age three (Paul et al., 2018). Collectively, these studies provide initial evidence of protective effects of responsive feeding for reducing risk for obesity during early childhood. However, there are notable limitations to this work, including primary reliance on parent-report and cross-sectional designs (Shloim et al., 2015), as well as primary focus on families who identify as non-Hispanic White (Lumeng et al., 2012; Spill et al., 2019) despite evidence suggesting that feeding practices may vary by parent ethnicity (Perrin et al., 2014). Thus, there is a need for studies that assess observed parent feeding behaviors with young children within a diverse sample and to assess prospective associations with child growth.

The aim of the present study was to build upon previous work by characterizing toddler weight status change from 18 to 36 months and examining associations with an observational measure of responsive feeding in a diverse sample of toddlers and their mothers with overweight/obesity who participated in a lifestyle intervention during pregnancy. We assessed whether mothers' responsiveness to toddler satiation cues and encouraging prompts to eat at 18 and 24 months were associated with likelihood of their toddlers being categorized as having healthy weight versus at risk for overweight/overweight from 18 to 36 months as well as whether these maternal feeding behaviors were associated with toddler BMIz at 36 months. It was hypothesized that greater maternal responsiveness and fewer prompts to eat would be associated with more favorable toddler BMIz over time. Importantly, this work provides methodological rigor by focusing on prospective associations between observed feeding behaviors and measured toddler weight status in an ethnically diverse sample of women with overweight/obesity.

2. Methods

2.1. Design

An observational longitudinal cohort design was used to assess child anthropometry at 18, 24, and 36 months of age and observe feeding interactions at 18 and 24 months. Participants were a diverse sample of mother-child dyads from the Healthy Beginnings/Comienzos Saludables (HB/CS) randomized clinical trial that tested a multicomponent intervention to reduce excess weight gain in pregnancy. The HB/CS study was conducted at California Polytechnic State University, California and the Miriam Hospital, Rhode Island. Primary findings have been previously reported (Phelan et al., 2019). In brief, the prenatal lifestyle intervention reduced excess gestational weight gain in Hispanic and non-Hispanic women with overweight/obesity. However, the intervention stopped at the end of pregnancy and had no significant effect on maternal or child weight from birth through 12 months (i.e., end of the HB/CS study). HB/CS participants were subsequently approached for enrollment in the Mealtime for Toddlers (MTT) follow-up study. Consistent with findings through 12 months, there was no observed effect of intervention on child anthropometric outcomes through 36 months (Phelan et al., 2021).

2.2. Participants

Participants were 163 mother-toddler dyads. To be eligible for the MTT study, dyads had to have been enrolled in and completed the parent HB/CS trial and the toddler needed to be approximately 36 months of age or younger. Families were excluded if the child was diagnosed with a chronic health condition that could affect feeding or growth, had significant food allergies and/or dietary restrictions that could significantly affect food provided and/or the feeding interaction, was diagnosed with a child psychiatric condition, or if the child had a significant developmental delay that could affect the feeding interaction or participation in the study.

2.3. Procedures

Participants in the HB/CS study consented to follow-up through 12 months postpartum. Limited funding for the MTT study (R56DK108661) began in September 2015 with subsequent funding beginning in August 2016 (R01DK108661). As such it was not possible to enroll all HB/CS dyads, especially for the 18-month assessment. Between October 2015 and March 2019, participants who participated in and completed the HB/CS study and had a child 18–36 months old were approached and enrolled at either the 18-, 24-, or 36-month assessment time point. Interested mothers attended an orientation in which study procedures were described and written consent was obtained. Depending upon the age of the participating child at study entry, families were invited to participate in up to three assessments. At 18 and 24 months, families completed one-week assessments during which participating mothers completed study questionnaires, dyads were asked to have up to two dinner meals recorded in their homes, and dyads were also weighed and measured for length/height in their home. During the limited funding period, abbreviated assessments were completed (e.g., only one meal was recorded in homes at 18- and 24-month assessments). At 36 months, only anthropometric measures were captured. If an assessment was missed (e.g., child was enrolled at a later assessment), anthropometric measures from well child visits were requested; for one child who moved, parent-measured height and weight were obtained at one time point. All procedures were approved by the Institutional Review Boards at the Miriam Hospital and California Polytechnic State University. The study was determined to be exempt by the Institutional Review Board at Temple University due to no participant enrollment or data collection being done at this site and that data transferred and analyzed at Temple was considered by the IRB to be de-identified.

2.4. Measures

2.4.1. Demographic questionnaire

Mothers reported on basic demographic information including toddler sex, race, and ethnicity as well as maternal race, ethnicity, and parity.

2.4.2. Maternal body mass index (BMI)

Maternal height and weight were measured by study staff in duplicate while in light clothing and without shoes. Height was measured during the parent study to the nearest 0.1 cm using a stadiometer. Weight was measured to the nearest 0.1 kg using a calibrated standard digital scale in families' homes at 18, 24, and 36 months.

2.4.3. Maternal responsiveness to child cues and prompts to eat

Evening mealtime interactions between mothers and their toddlers were video recorded in families' homes on up to two occasions at 18 and 24 months. The Responsiveness to Child Feeding Cues Scale (RCFCS), a reliable and valid observational coding system of parent-child mealtime interactions (Hodges et al., 2013), was used to code videos for maternal responsiveness ratings. Although the RCFCS enables coding of maternal responsiveness to both hunger and satiation cues, constraints associated with scheduling in-home assessments (e.g., needing to preschedule rather than allowing mothers to begin feeding based on observed child hunger cues) precluded coding of responsiveness to hunger cues. Rather, mothers' responsiveness to satiation cues was rated by trained research assistants on a 5-point Likert-type scale (1 = highly unresponsive to 5 = highly responsive). Mothers are considered as more versus less responsive based on the response latency to both the number and intensity of toddler-displayed satiation cues. Mothers who respond to earlier and more subtle satiation cues (e.g., slows or pauses pace of feeding) are rated as having higher responsiveness than those who respond to later and more overt child satiation cues (e.g., pushing plate away, playing with food). In addition to maternal responsiveness to child feeding cues, given previous evidence of associations between prompts to eat and weight status (Klesges et al., 1983; Lumeng et al., 2012), encouraging prompts to eat were coded from recorded meals. This included both verbal (e.g., "Eat your potatoes.") and physical (e.g., parent moves food in the direction of the child) prompts.

Twenty percent of videos were coded by two or more trained coders who were fluent in the spoken language at the meal to determine interrater reliability. Three raters coded the videos recorded in English and two coded the videos recorded in Spanish. Intraclass correlation coefficients (ICCs) were used to determine reliability, which was deemed adequate for maternal responsiveness ratings (ICC = 0.58 for videos in English and 0.60 for videos in Spanish), and very good to excellent for encouraging prompts to eat (ICC = 0.80 for videos in English; 0.91 for videos in Spanish). Although the goal was to record two meals at each assessment, many families had only one meal recorded at a given assessment (i.e., only 45% and 71% had two meals recorded at 18 and 24 months, respectively). Thus, analyses focused on the first recorded and coded meal at 18 months and 24 months.

2.4.4. Toddler body mass index Z-score

Child weight and length/height measures were measured by study staff in families' homes at 18, 24, and 36 months with the child dressed in light clothes and without shoes. Recumbent length was obtained at 18 months and standing height was measured at 24 and 36 months. Child weight and length from 12 months was also available from HB/CS. Child body mass index z-score (BMIz) was calculated with reference to the child's age and biological sex using World Health Organization (WHO) growth standards (Onis et al., 2007). The WHO growth charts were used over CDC growth charts given availability of reference data across the study period (i.e., CDC has separate reference data for birth to 24 months and 2 years and older). Primary outcomes of interest were change in toddler BMIz from 18 to 36 months, probability of belonging to a weight status class across the 18 to 36-month time period, and BMIz at 36 months.

2.5. Analytic approach

Descriptive statistics were run in SPSS Version 27 to characterize the sample. To characterize toddler weight status change, child BMIz trajectories across three time points (18, 24, and 36 months) were fit using Restricted Maximum Likelihood estimation as implemented in the R package *lme4*. We first fit an empty model to calculate the intraclass correlation, followed by a random intercept only model (i.e., allowing toddlers to have variability in 18-month weights), and a random intercept and random slope model (i.e., allowing toddlers to have variability in both initial 18-month weight and in the change in weight over time) (Fitzmaurice, Laird, & Ware, 2004). Repeated measures latent class analyses were then run in MPlus using toddler BMIz at 18, 24, and 36 months (as the items) to assess for subgroups of toddlers by weight status trajectories. Toddlers were assigned to a latent class unless they were missing all three measurements. Thus, all participating children ($N = 163$) were included. Model fit was examined for one to four classes using the following indices: Akaike Information Criterion (AIC) (Akaike, 1974), Bayesian Information Criterion (BIC) (Schwartz, 1978), adjusted BIC (Sclove, 1987), the Vuong-Lo-Mendell-Rubin Likelihood Ratio Test and associated p-value (Lo, Mendell, & Rubin, 2001; Vuong, 1989), and entropy. Based on the posterior probabilities of class membership, we assigned toddlers to the class in which they had the highest probability of belonging for further analysis.

To assess preliminary associations between primary study variables (i.e., maternal feeding behaviors at 18 and 24 months and toddler BMIz at 18, 24, and 36 months), bivariate correlations were run in the subset of families for whom mealtime interactions were recorded and child BMIz was available. We then assessed associations between maternal prompts to eat at 18 months and toddler weight status in two ways: 1) by assessing whether maternal prompts at 18 months were associated with toddler BMIz latent class, and 2) by assessing whether maternal prompts at 18 months were associated with toddler BMIz at 36 months. Specifically, an ordered logistic regression was run to assess associations between maternal prompts to eat at 18 months and belonging to a toddler BMIz latent class. To enhance computational stability, the maternal 18-month prompts variable was mean centered. Covariates (HB/CS randomization status, HB/CS study site, maternal age, parity, ethnicity, and child BMIz at 12 months) were then included to determine stability of findings. Because we are not inferring causality and to aid in interpreting the ordered logistic regression, we swapped the independent (maternal prompts) and dependent (BMIz class assignment) variables and ran an analysis of variance with BMIz class assignment as the independent variable and maternal prompts at 18 months as the dependent variable to assess post-hoc mean differences in maternal prompts between the classes. Finally, we fit a linear regression model in which BMIz at 36 months was the outcome. In addition to the mean centered 18-month maternal prompts variable, this model included the following covariates: HB/CS randomization status, HB/CS study site, maternal age, parity, ethnicity, and child BMIz at 12 months.

3. Results

One hundred seventy-three mothers and their toddlers enrolled in the MTT study. One hundred sixty-three (94%) provided toddler height and weight data at one or more assessment time points: 111 (68%) at 18 months, 118 (72%) at 24 months, and 155 (95%) at 36 months (Fig. 1). Forty-one (25%) provided BMIz data at one time point, 23 (14%) at two time points, and 99 (61%) at all three time points. Participating dyads did not differ from those who did not participate on child biological sex or ethnicity, nor on maternal age, ethnicity, prepregnancy BMI, parity, randomization status (e.g., multicomponent intervention or standard of care), or study site. As can be seen in Table 1, enrollment across sites was similar with 47% of families enrolled in California and 53% enrolled in Rhode Island. Children were 49% female and 45% were reported to be of Hispanic ethnicity. Similarly, 44% of mothers reported Hispanic ethnicity. In the present sample, mean maternal age at HB/CS study entry was 30.36 (SD = 5.34) years, and mean pre-pregnancy BMI was 33.34 (SD = 5.96) kg/m^2.

3.1. *Toddler weight status from 18 to 36 months*

Across 18, 24, and 36-month assessments, mean toddler BMIz was consistently higher than the WHO's average for a given age and sex (18-month BMIz M = 0.76, SD = 1.02; 24-month BMIz M = 0.78, SD = 0.98; 36-month BMIz M = 0.77, SD = 1.0). Toddler BMIz at 18 months was associated with BMIz at 24 (n = 100), r = 0.74, $p < .001$, and 36 months (n = 106), r = 0.63, $p < .001$, and toddler BMIz at 24 months was associated with BMIz at 36 months (n = 114), r = 0.69, $p < .001$.

The intraclass correlation coefficient for toddler BMIz was estimated to be 0.69 based on fitting an empty linear mixed-effects model. Next, we fit a random intercept only model and found there to be variability among toddlers in their initial 18-month weight (random intercept variance estimated to be 0.69). However, when a random effect for change in BMIz from 18 to 36 months was included, the model failed to converge. The random slope variance estimate from this model was 0.0008 and further investigation into the failure to converge revealed a negative eigenvalue that produced a warning that the model was singular with a boundary estimate. Thus, there was essentially no significant individual variability in BMIz change from 18 to 36 months.

Table 1
Sample Characteristics for Mothers and their Toddlers Who Participated in the Mealtime for Toddlers Study (N = 163).

Site, No. (%)	
California	76 (47%)
Rhode Island	87 (53%)
Randomization, No. (%)	
Intervention	79 (48.5%)
Standard Care	84 (51.5%)
Maternal Hispanic Ethnicity, No. (%)	72 (44%)
Maternal Age, M (SD)	30.4 (5.3)
Maternal Prepregnancy BMI, M (SD)	32.26 (5.66)
Parity, No. (%)	
Primiparous	48 (29%)
Child Female Sex, No. (%)	79 (48.5%)
Child Hispanic Ethnicity, No. (%)	74 (45%)
Child BMIz, M (SD)[a]	
18-Months	0.76 (1.02)
24-Months	0.78 (0.98)
36-Months	0.77 (1.00)
Maternal Responsiveness Rating, M (SD)[b]	
18-Months	3.25 (1.07)
24-Months	3.51 (1.08)
Number of Maternal Encouraging Prompts to Eat, M (SD)[a]	
18-Months	26.69 (20.87)
24-Months	19.71 (14.88)

Note. Presented values are those from MTT study entry unless otherwise noted.
[a] Child BMIz data is available for 111 children at 18 months, 118 children at 24 months, and 155 children at 36 months.
[b] Maternal responsiveness ratings and encouraging prompts to eat are available for 77 dyads at 18 months and 75 dyads at 24 months.

Latent class models (LCMs) were run to identify subgroups of toddlers, based on weight status at 18, 24, and 36 months. Specifically, one, two, three, and four latent classes were fit to the data. Although model parameters suggested that a four-class model demonstrated the best fit, one class was limited by a small sample size (n = 3). Thus, a three-class model was chosen for the purpose of further analyses (Table 2). Fig. 2 presents the estimated BMIz means and standard error of the means by latent class to aid in interpretation of the classes. As can be seen in Fig. 2, Class 1 represents toddlers with healthy weight from 18 to 36 months, per the WHO growth standards (31.3%; n = 51). Class 2 represents

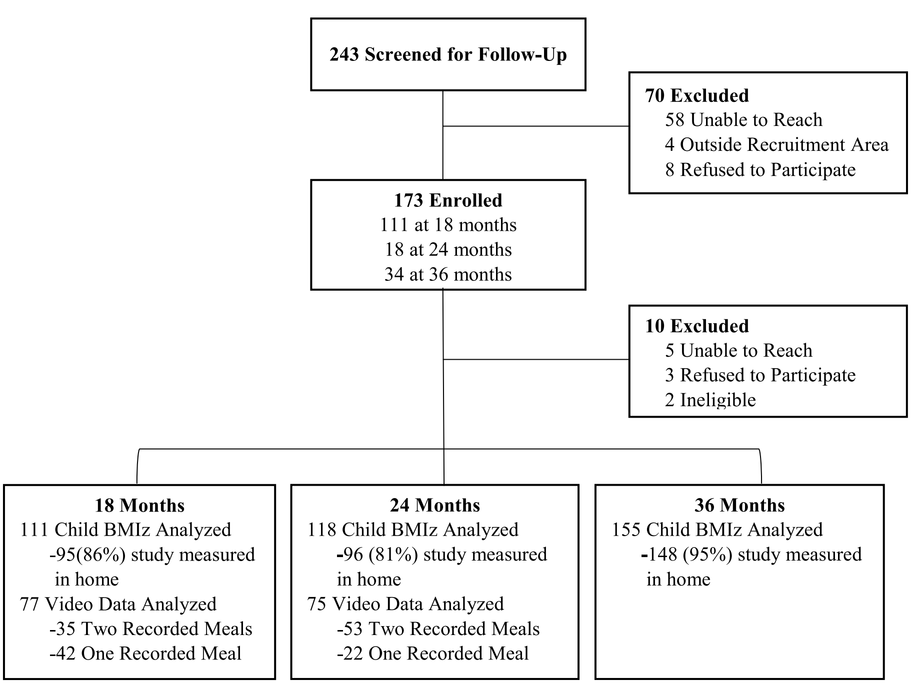

Fig. 1. Enrollment and Assessment Completion in the Mealtime for Toddlers Study (N = 163).
Note. Given that this study enrolled dyads from a parent trial, *Healthy Beginnings/Comienzos Saludables*, dyads could be enrolled at any of the three assessment time points. Of the 163 participating families, 111 were enrolled and provided their first data at 18 months, 18 were enrolled at 24 months, and 34 at 36 months. Ninety-nine (61%) families provided BMIz data at all three assessments, 23 (14%) provided BMIz data at two time points, and 41 (25%) provided BMIz data at one time point. Sixty-three (39%) families had at least one recorded meal at both the 18- and 24-month assessment.

Table 2
Model fit indices for latent class models (N = 163).

	Number of Classes			
	1	2	3	4
AIC	1098.33	1004.54	965.18	945.04
BIC	1116.89	1035.48	1008.50	1000.73
aBIC	1097.90	1003.82	964.17	943.74
VLMR LRT		−543.16	−492.27	−468.59
P value		0.074	0.114	0.043
Entropy		0.709	0.747	0.770

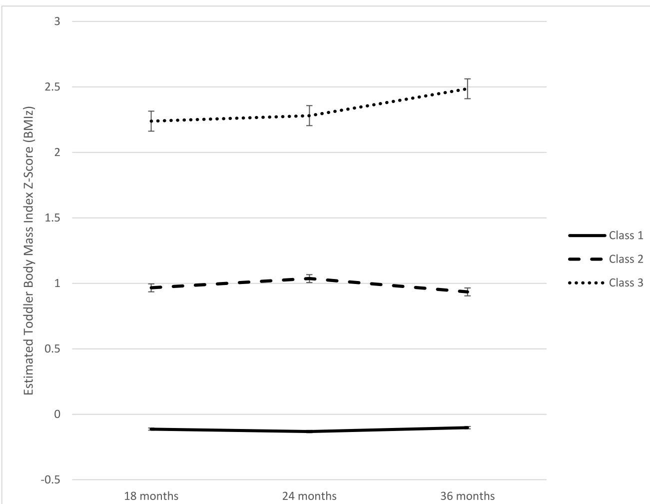

Fig. 2. Estimated means and standard error of the means for toddler BMIz at 18, 24, and 36 Months by latent class (N = 163).

toddlers with at risk for OW (56.4%; n = 92), and Class 3 represents toddlers with OW (12.3%; n = 20).

3.2. Observed maternal feeding behaviors

Of the 163 enrolled dyads, 89 (55%) families provided mealtime interaction data at one or more time points: 77 (47%) families had a mealtime interaction recorded and coded at the 18-month assessment and 75 (46%) families had a mealtime interaction recorded and coded at the 24-month assessment. Sixty-three (39%) families had a meal recorded at both the 18 and 24-month assessments. Importantly, dyads who provided a mealtime interaction did not differ from those who did not on child biological sex or ethnicity, nor on maternal age, ethnicity, pre-pregnancy BMI, parity, randomization status (e.g., multicomponent intervention or standard of care), or study site.

As can be seen in Table 1, on average, at 18 months, mothers were rated as being ‘moderately’ responsive to their toddlers’ satiation cues (M = 3.2, SD = 1.1) and provided 27 (SD = 21) encouraging prompts to eat during the meal. At 18 months (n = 77), maternal responsiveness to satiation cues was not significantly associated with the number of encouraging prompts to eat provided by mothers, r = −0.21, p = .07. At 24-months (n = 75), on average, mothers were also rated as being ‘moderately’ responsive to their toddlers’ satiation cues (M = 3.5, SD = 1.1) and provided 20 (SD = 15) prompts to eat during the recorded meal. Maternal responsiveness to satiation cues at 24 months (n = 75) was significantly and inversely associated with encouraging prompts at 24 months, r = −0.44, p < .001. Across time (n = 63), maternal responsiveness to satiation cues at 18 months was neither associated with responsiveness at 24 months, r = 0.07, p = .56 nor with prompts to eat at 24 months, r = 0.01, p = .93. Maternal encouraging prompts to eat at 18 months was associated with prompts to eat at 24 months, r = 0.33, p = .01, but not maternal responsiveness at 24 months, r = −0.13, p = .32.

3.3. Association between maternal responsiveness, prompts to eat, and child BMIz

Bivariate correlations demonstrated that fewer maternal encouraging prompts to eat at 18 months were associated with higher child BMIz at 18-months, r(75) = −0.26, p = .025, 24-months, r(66) = −0.39, p = .001, and 36-months, r(71) = −0.36, p = .002. Similarly, ordered logistic regression demonstrated that the number of maternal prompts at 18 months was associated with probability of belonging to a latent class. Each additional prompt decreased the odds by 3% (or 0.968 times) of having at-risk for OW or OW versus having healthy weight, n = 77, z = −2.73, p < .05. Post-hoc analysis of variance confirmed these findings, *F* (2, 74) = 5.27, *p* = .007, with Tukey post-hoc comparisons indicating that the significant mean difference for maternal prompts at 18 months (mean centered) was between toddlers with healthy weight (Mean = 10.9) and those with at-risk for OW (Mean = −4.67; 95% familywise error rate adjusted p-value = .008) but not toddlers with OW (Mean = −6.31). Neither maternal responsiveness to toddler satiation cues at 18 or 24 months nor maternal encouraging prompts to eat at 24 months were associated with child BMIz from 18 to 36 months.

In ordered logistic regression analyses that adjusted for randomization status in the HB/CS study, study site, maternal age, parity, ethnicity, child biological sex, and child BMIz at 12 months, the number of maternal prompts at 18 months was still significantly associated with probability of belonging to a latent class, n = 69, z = 2.11, p < .05. The estimate did not change – each additional prompt decreased the odds by 3% (or 0.968 times) of having at-risk for OW or OW versus having healthy weight. In addition, child BMIz at 12 months, z = 4.50, p < .05, and Hispanic ethnicity, z = 2.56, p < .05, were significantly associated with latent class membership. Specifically, higher BMIz at 12 months and child Hispanic ethnicity were associated with a greater probability of being in the higher BMIz classes from 18 to 36 months.

Linear regression with child BMIz at 36 months as the outcome (n = 65) and adjusting for the above-noted covariates (randomization status in the HB/CS study, study site, maternal age, parity, ethnicity, child biological sex, and child BMIz at 12 months), demonstrated that a greater number of maternal prompts at 18 months was associated with lower child 36-month BMIz, t(56) = −2.521, *p* = .02 (Table 3). Child BMIz at 12 months, t(56) = 5.779, *p* < .001, and study site, t(56) = 2.015, *p* = .049, were also associated with BMIz at 36-months. When child BMIz at 18 months was entered into the model (instead of BMIz at 12 months; n = 73), maternal prompts remained significantly associated with child 36-month BMIz, t(64) = −2.025, *p* = .047. Child 18 month

Table 3
Predictors of child BMIz at 36 Months (N = 64).

predictor	B	SE	95% CI	t	p-value
(Intercept)	0.889	0.681	−0.474, 2.253	1.307	0.197
Maternal prompts (mean-centered, 18 months)	−0.012	0.005	−0.022, −0.002	−2.521	0.015
Child female gender	−0.212	0.182	−0.577, 0.153	−1.163	0.250
BMIz at 12 months	0.585	0.101	0.382, 0.788	5.779	<.001
Hispanic ethnicity	0.034	0.189	−0.346, 0.413	0.179	0.859
Maternal primiparous	0.012	0.220	−0.428, 0.453	0.056	0.955
Maternal age	−0.008	0.021	−0.050, 0.034	−0.399	0.692
Study site (TMH)	0.403	0.200	0.002, 0.804	2.015	0.049
Randomization	−0.185	0.183	−0.551, 0.181	−1.012	0.316

BMIz also remained statistically significant, $t(64) = 6.410$, $p < .001$ but study site was no longer statistically significant, $t(64) = 1.297$, $p = 199$.

4. Discussion

In an ethnically diverse sample of children whose mothers had overweight/obesity and participated in a prior lifestyle intervention during pregnancy, weight status was relatively stable during the toddler years. Most children entered toddlerhood at risk for overweight and remained at that weight status through 36 months. Observed maternal prompts to eat at 18 months were associated with concurrent and subsequent toddler weight status – with children with a lower (healthier) BMIz receiving a greater number of encouraging prompts to eat during meals. This association remained when controlling for key covariates. However, prior child weight status remained the most robust predictor of subsequent weight status from 18 to 36 months, underscoring that in the present sample, toddler weight status was likely established early in life.

Our hypothesis that maternal feeding behaviors would be associated with toddler weight status was partially supported. Specifically, only maternal encouraging prompts to eat at 18 months were associated with concurrent and subsequent weight status. Interestingly, children of a healthy weight status were more likely to receive prompts to eat – a finding that adds to mixed evidence to date. Although some studies have demonstrated that parents who provide more encouraging prompts to eat are more likely to have a child with a higher weight status (Lumeng et al., 2012), other studies have found that pressure to eat is associated with lower weight status and decreased weight gain (Costa et al., 2011; Lee & Keller, 2012; Power et al., 2021; Shloim et al., 2015; Spill et al., 2019). Extant findings suggest that maternal feeding practices may be shaped by child traits, including their weight status (Shloim et al., 2015) or concerns regarding children's body weight (Spill et al., 2019). As such, children with lower BMI may experience greater encouragement to eat while children at risk for overweight or with overweight/obesity may not. It is also possible that children with overweight/obesity have appetitive traits that drive eating behaviors and are thus less contingent upon external prompts from parents. Given mixed findings to date, additional work is needed to better understand how associations between maternal encouragement to eat and weight status unfold over time. In particular it may be important to collect both observational measures and maternal perceptions of child weight status at earlier time points.

Further, although a responsive approach to feeding is believed to foster healthier eating behaviors and weight status (DiSantis et al., 2011; Perez-Escamilla et al., 2021), the present study did not find an association between observed maternal responsiveness to child satiation cues and toddler BMIz. Our study is among the few to use objective/observational measures of responsive feeding and assess prospective associations with weight status, but it is possible that single observations at 18 and 24 months that focused on maternal responsiveness to toddler satiation cues (rather than, for example, to hunger cues) limited our ability to detect associations between responsive feeding and child weight status. It is also possible that while maternal responsiveness has been shown to impact weight status in infancy (Schneider-Worthington et al., 2021), other facets of responsive parenting may start to become more salient in the toddler years. For example, it has been suggested that during early childhood, parenting dimensions such as the provision of structure and limit setting may be particularly important for promoting healthy eating behaviors and growth (Balantekin et al., 2020). These potential developmental differences may also account for the lack of an association in the present study between maternal prompts to eat at 24 months and child weight status. It is possible that as children develop increased autonomy in their eating, different and more salient feeding practices will have greater influence over child eating and growth. How child characteristics, such as appetitive traits, affect and/or interact with parent feeding behaviors to shape child eating and obesity risk may also be important to consider.

The fact that toddler BMIz relative to WHO standards between 18 and 36 months remained relatively stable suggests that risk of overweight had been established earlier in life. In the present sample, higher BMIz at 12 months and Hispanic ethnicity were significant predictors of toddler BMIz from 18 to 36 months – findings that have been well characterized previously. Given that weight status tracks through middle childhood, adolescence and beyond (Evensen, Wilsgaard, Furberg, & Skeie, 2016; Ward et al., 2017), it will be important to continue to explore key, modifiable risk factors during the first year to enhance prevention efforts.

The present study should be considered in light of its strengths and limitations. Strengths include the focus on an ethnically diverse sample and on women who had overweight and obesity and their toddlers. Further, measurement of maternal feeding behaviors within the home and observation of feeding behaviors (rather than reliance on maternal report) enhances the ecological validity of study findings while limiting reporter bias. In contrast, the present study is limited by a relatively small sample, focus on a single mealtime interaction at 18 and 24 months, and focus on maternal feeding behaviors, but not fathers or other caregivers. Further, although adequate, interrater reliability for the maternal responsiveness measure was not robust and thus may have negatively affected the ability to assess associations with toddler weight status. Future work that prospectively assesses multiple meals within the home to better characterize mealtime interactions between parents and their children – potentially at younger ages – will be important.

In sum, although maternal encouraging prompts to eat at 18 months were associated with toddler BMIz through 36 months, other measured maternal feeding behaviors at 18 and 24 months were not. Further, earlier child weight status remained the most robust predictor of toddler BMIz through 36 months. Future prospective studies that assess risk factors early in life, including objective measures of feeding practices starting in infancy, are needed to identify the degree to which parental feeding approaches affect toddler obesity risk.

Declaration of interest

Dr. Hart previously provided consultation work to WW International, and Dr. Jelalian is currently a Consultant for WW International. Dr. Wing is on the Scientific Advisory Board at NOOM. Dr. Phelan has a grant from WW International that is unrelated to this work. Neither Weight Watchers nor NOOM provided financial support for this study, nor did they have any influence on the methods in this study. The other authors have no financial relationships relevant to this article to disclose.

Clinical trials registration

ClinicalTrials.gov, www.clinicaltrials.gov, NCT01545934 and NCT02766218.

Data and code availability

Data described in this manuscript as well as the codebook and analytic code will be made available upon reasonable request. The lead author has full access to the data reported in this manuscript.

Author contributions

Chantelle N. Hart, Suzanne Phelan, & Rena R. Wing: Drs. Hart, Phelan, and Wing conceptualized and designed the study, obtained funding, oversaw execution of the study, drafted the initial manuscript, and approved the final manuscript submitted. Donna Coffman: Dr. Coffman carried out data analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted. Elissa Jelalian: Dr. Jelalian helped to design and execute the study, reviewed and revised the manuscript, and approved the final manuscript as submitted. Alison K. Ventura: Dr. Ventura helped to design the study, reviewed and revised the manuscript, and approved the final manuscript as submitted. Eric A. Hodges: Dr. Hodges helped to design the study, reviewed and revised the manuscript, and approved the final manuscript as submitted. Nicola Hawley: Dr. Hawley helped to design the study, reviewed and revised the manuscript, and approved the final manuscript as submitted. Jennifer O. Fisher: Dr. Fisher helped to design and execute the study, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Ethics statement

The present study was approved by the Institutional Review Boards (IRB) at the Miriam Hospital (Committee #214411 Pedi Cat A) and California Polytechnic State University (Committee # 2018-266). The study was deemed exempt by the Institutional Review Board at Temple University due to no participant enrollment or data collection being done at this site and that data transferred and analyzed at Temple was considered by IRB to be de-identified (Protocol #23356). Informed written parental consent was obtained prior to study participation.

Declaration of competing interest

Dr. Hart previously provided consultation work to WW International, and Dr. Jelalian is currently a Consultant for WW International. Dr. Wing is on the Scientific Advisory Board at NOOM. Dr. Phelan has a grant from WW International that is unrelated to this work. Neither Weight Watchers nor NOOM provided financial support for this study, nor did they have any influence on the methods in this study. The other authors have no financial relationships relevant to this article to disclose.

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Data availability

Data will be made available on request.

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