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Does maternal feeding restriction lead to childhood obesity in a prospective cohort study?

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Abstract

Background—Some studies show that greater parental control over children’s eating habits predicts later obesity, but it is unclear whether parents are reacting to infants who are already overweight.

Objective—To examine the longitudinal association between maternal feeding restriction at age 1 and body mass index (BMI) at age 3 and the extent to which the association is explained by weight for length (WFL) at age 1.

Methods—We studied 837 mother–infant pairs from a prospective cohort study. The main exposure was maternal feeding restriction at age 1, defined as agreeing or strongly agreeing with the following question: “I have to be careful not to feed my child too much.” We ran multivariable linear regression models before and after adjusting for WFL at age 1. All models were adjusted for parental and child sociodemographic characteristics.

Results—100 (12.0%) mothers reported feeding restriction at age 1. Mean (SD) WFL z-score at age 1 was 0.32 (1.01), and BMI z-score at age 3 was 0.43 (1.01). Maternal feeding restriction at age 1 was associated with higher BMI z-score at age 3 before (β 0.26 (95% CI 0.05 to 0.48)) but not after (β 0.00 (95% CI –0.17 to 0.18)) adjusting for WFL z-score at age 1. Each unit of WFL z-score at age 1 was associated with an increment of 0.57 BMI z-score units at age 3 (95% CI 0.51 to 0.62).

Conclusions—We found that maternal feeding restriction was associated with children having a higher BMI at age 3 before, but not after, adjusting for WFL at age 1. One potential reason may be that parents restrict the food intake of infants who are already overweight.

In the last 30 years, the prevalence of obesity has increased dramatically among youth in the USA, even among preschool children.^{1–5} In fact, about 24% of children aged 2 through 5

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years are overweight or obese.⁴ Obesity in young children is associated with obesity later in childhood, with conditions such as hyperlipidaemia, asthma, hypertension and type II diabetes^{6–9} and with higher morbidity and mortality in adulthood.¹⁰

Recent research suggests that certain parental feeding styles may promote overeating or obesity in children. In cross-sectional^{11–14} and longitudinal^{15, 16} studies, Birch *et al* found that overly restrictive feeding styles (eg, restricting access to palatable, energy-dense foods or being careful that the child does not eat too much) are associated with increased adiposity among girls and overeating among preschool children. In a systematic review of parental feeding styles and later child eating and weight status, Faith *et al*¹⁷ found that parental restriction was the only feeding domain associated with increased eating and overweight status later in childhood.

It is possible that concurrent child overweight may lead mothers to restrict their child's intake in response to her child's weight status. Early child weight status is also highly correlated with future weight status. Thus, child weight at the time of maternal restriction may confound the relationship between maternal restriction and later overweight. Only a few studies have examined this possibility. Among 62 mother–infant pairs, Farrow and Blissett¹⁸ found that maternal feeding restriction at age 1 year was associated with lower child weight at age 2 after controlling for infant weight at 1 year. That study was limited, however, by a small sample size and inadequate control for covariates including parental body mass index (BMI). Among 24 older children at high risk for obesity, Faith *et al*¹⁹ found that parental restriction at age 5 was associated with higher child BMI z-score at age 7 before and after adjusting for BMI z-score at age 3. Another factor that few studies examine is whether a mother's weight status modifies the relationship between feeding restriction and a child's BMI. Recent evidence suggests that maternal feeding restriction is associated with higher BMI among children of obese mothers though not among children of non-obese mothers.^{19–21}

In our study, we examine the longitudinal association between maternal feeding restriction at age 1 and child BMI z-score at age 3. We also measure the extent to which this association is explained by infant weight for length (WFL) at age 1. We hypothesised that maternal feeding restriction would be associated with higher child BMI z-score at age 3 before, but not after, adjusting for WFL at age 1. Lastly, we examine if these associations differ by a mother's prepregnancy weight status.

METHODS

Subjects and study design

The subjects for this study were participants from Project Viva, a prospective observational cohort study of gestational diet, pregnancy outcomes and offspring health.¹⁹ We recruited the women from eight urban and suburban obstetrical offices of a group practice in eastern Massachusetts; all were recruited at their initial prenatal visit. We required participants to be fluent in English, be at a gestational age of less than 22 weeks and have a singleton pregnancy. Recruitment and retention procedures are detailed elsewhere.²²

Of the 2128 women who delivered a live infant, 1579 were eligible for 3-year follow-up by virtue of having completed a prenatal nutritional assessment and consenting for their children to be followed up. From this group, we excluded 36 participants who refused 3-year follow-up, 148 who were lost to follow-up and 105 who did not complete the 3-year assessment in person. We also excluded those missing data, including 223 participants missing data on maternal feeding restriction, 196 missing 1-year WFL and 34 missing data on anthropometry. Thus, our sample size was 837 mother–infant pairs. When compared with

the 742 children eligible for but not included in this analysis, children in the present study were more likely to be white (70% vs 60%), have college-educated mothers (73% vs 61%) and have an annual household income greater than \$70 000 (67% vs 56%); they did not differ in birth weight or mean maternal prepregnancy BMI.

We performed in-person study visits with the mothers at the end of their first and second trimesters and with both the mothers and their infants immediately after delivery and at 6 months and 3 years postpartum. At each postpartum visit, we measured the child's length/height and weight; at the 3-year visit, we also measured skinfold thicknesses. At 1 year postpartum, participants completed questionnaires that included questions about their feeding practices. The institutional review boards of all participating institutions approved the study, and all procedures were conducted in accordance with the ethical standards for human experimentation established by the Declaration of Helsinki.

MEASUREMENTS

Main exposure—maternal feeding restriction at age 1 year

We measured maternal restriction at 1 year postpartum using the following modified item from the Child Feeding Questionnaire (CFQ)²³: “I have to be careful not to feed my child too much.” For analyses, we dichotomised the response categories to strongly agree/agree versus strongly disagree/disagree. We also measured maternal restriction at 6 months using the same question. The CFQ is a self-report measure used to assess parental beliefs, attitudes and practices regarding child feeding and has been validated among parents of children aged 2–11 years.²³ We made appropriate modifications to the CFQ for parents of children 6 months and 1 year of age. We used factor analysis to confirm our feeding restriction item and described details elsewhere.²⁴

Outcome measures—child adiposity at age 3 years

We measured the children's height and weight using a calibrated stadiometer (Shorr Productions, Olney, Maryland) and scale (Seca Model 881; Seca Corporation, Hanover, Maryland). We calculated age- and sex-specific BMI z-scores and percentiles using US national reference data²⁵ and defined obesity as BMI at or greater than the 95th percentile for age and sex. We used BMI at the 5th to less than the 85th percentiles as the comparison. We also measured the children's subscapular (SS) and triceps skinfold (TR) thicknesses with Holtain calipers (Holtain, Crosswell, UK) and calculated the sum (SS+TR). Research assistants performed all measurements following standardised techniques²⁶ and participated in biannual in-service training to ensure measurement validity (IJ Shorr; Shorr Productions, Olney, Maryland). For all measurements, inter-rater and intrarater measurement errors were well within published reference ranges.²⁷

Other measures

We used questionnaires and interviews to collect information from participants about their age, education, race/ethnicity, parity, breastfeeding duration, household income and prenatal smoking. Participants also reported their prepregnancy weight and height and paternal weight and height. We collected pregnancy weights from medical records and calculated gestational weight gain as the difference between prepregnancy weight and the last weight recorded before delivery. We obtained the infants' birth weights from medical charts.

At the 6-month visit, research assistants measured the infants' length and weight; we obtained 1-year weight and length from medical records. The mean (SD) age at the 1-year visit was 12.4 (0.7) months. At both 6 months and 1 year, we calculated age- and sex-specific WFL z-scores. In a previous measurement validation study among children aged 0

to <24 months,²⁸ we found that clinical staff systematically overestimated children's length compared with a reference method. Thus, we used a regression correction factor to adjust for the overestimation ((clinical length in cm $\times$ 0.953)+1.88 cm).

STATISTICAL ANALYSIS

We examined first the unadjusted associations of maternal feeding restriction at age 1 and maternal and infant characteristics with the main outcomes, BMI z-score, SS+TR and obesity at age 3. Next, we used multivariable linear and logistic regression models before and after adjusting for infant WFL z-score at age 1. We adjusted all multivariable models for paternal BMI; child age, sex, birth weight and breast-feeding duration; and maternal race/ethnicity, education, prepregnancy BMI, pregnancy weight gain and household income. To assess if a mother's prepregnancy overweight status (BMI ≥ 25 kg/m² vs <25 kg/m²) had a modifying effect, we evaluated stratified models and included an interaction term (cross-product of restriction by prepregnancy overweight status) in our multivariable models. Finally, we ran multivariable models that used 6-month restriction as the main exposure, both before and after adjusting for 6-month WFL z-score. We conducted all analyses using SAS, V.9.1 (Cary, North Carolina).

RESULTS

As table 1 shows, 100 (12.0%) participants reported feeding restriction at age 1. At age 1, mean WFL z-score was 0.32 (1.01), which translates to the 63rd percentile using US national reference data.²⁵ At age 3, mean BMI z-score was 0.43 (1.01), SS+TR was 16.7 (4.0) mm and 9.1% of children were obese. Participants most likely to restrict food intake were younger, less educated and non-white. They also had a lower household income and a higher prepregnancy BMI. Birth weight and gestational age were not associated with feeding restriction; however, participants who restricted food breastfed their infants about 2 fewer months. Feeding restriction at age 1 was associated with higher WFL z-score at age 1 and, at age 3, with higher BMI z-score, SS+TR and prevalence of obesity.

In unadjusted linear regression, maternal feeding restriction at age 1 was associated with higher BMI z-score at age 3 (estimate 0.43 (95% CI 0.22 to 0.64)). The estimate became 0.26 (95% CI 0.05 to 0.48), a 40% attenuation, after we adjusted for paternal BMI; child age, sex, birth weight and breastfeeding duration; and maternal race/ethnicity, education, prepregnancy BMI, pregnancy weight gain and household income. Confounding by maternal and paternal BMI mostly caused the two estimates to differ. After adjusting for WFL z-score at age 1, maternal feeding restriction at age 1 was not associated with BMI z-score at age 3 (estimate 0.00 (95% CI -0.17 to 0.18)). As shown in table 2, each unit of WFL z-score at age 1 was associated with an increment of 0.57 BMI z-score units at age 3 (95% CI 0.51 to 0.62). This 0.57 increment translates to 0.7 additional kilograms in an average 3-year-old boy, or moving from the 50th percentile BMI to the 73rd percentile BMI.

Also shown in table 2, using either obesity or the sum of skinfolds as an outcome yielded similar results. Maternal feeding restriction at age 1 was associated with higher SS+TR at age 3 before (multivariable estimate 0.95 mm (95% CI 0.07 to 1.83)) but not after (0.40 mm (95% CI -0.44 to 1.25)) adjusting for WFL z-score at age 1. Each unit of WFL z-score at age 1 was associated with an increment of 1.22 mm SS+TR units at age 3 (95% CI 0.95 to 1.50). In our obesity analysis, adjusting for WFL z-score at age 1 attenuated the multivariable OR association for restriction from 2.14 (95% CI 1.02 to 4.46) to 1.04 (95% CI 0.41 to 2.62). Each unit of WFL z-score at age 1 was associated with an increased risk of obesity at age 3 (OR 10.49 (95% CI 6.01 to 18.31)).

Using 6-month maternal feeding restriction as our exposure gave similar results to those for restriction at age 1, in that it was associated with higher BMI z-score at age 3 before (multivariable regression estimate 0.27 (95% CI 0.05 to 0.50)) but not after (0.11 (95% CI -0.08 to 0.30)) adjusting for WFL z-score at age 6 months. Each unit of WFL z-score at age 6 months was associated with an increment of 0.52 BMI z-score units at age 3 (95% CI 0.46 to 0.58).

As shown in table 3, a mother's prepregnancy BMI did not modify the relationship between feeding restriction at age 1 and BMI z-score at age 3.

DISCUSSION

In this study, we found that maternal feeding restriction at age 1 was associated with higher BMI and greater sum of skinfolds at age 3. Yet, when we adjusted for WFL at age 1 and at age 6 months, the associations disappeared. These findings applied whether or not a mother was overweight. While restriction may be associated with higher BMI at age 3 years, genetic factors and other modifiable environmental and behavioural factors during pregnancy and infancy may be stronger in determining early child weight status.

The confounding effect of WFL may occur because of a mother's response to an infant's increased weight or from differences in feeding patterns at age 1. In other words, a mother with a heavier infant may exercise more caution in feeding her child than a mother with a lighter infant. Our findings contrast Farrow and Blissett¹⁸ who found that, among 62 mother-infant pairs, maternal feeding restriction at age 1 was associated with lower child weight at age 2 after controlling for weight at age 1 ($\beta = -0.31$ standardised z-scores, p value < 0.05). Our study had a larger sample size, however, and controlled for covariates, including parental BMI.

An alternate explanation is that a cycle already may be established by age 1 whereby feeding restriction causes overeating which then causes restriction. Studies have shown that parent-child relations around eating are bidirectional over time.²⁹ While our results suggest that child weight at 1 year influences maternal feeding restriction, that does not negate that maternal feeding restriction influences child eating and weight. Our secondary analysis, which shows similar results for restriction and WFL at age 6 months, argues against this interpretation, however. In addition, restriction was not associated with birth weight. Similar to other studies,^{24, 30} we also found that maternal feeding restriction was associated with shorter breastfeeding duration. This indicates that infants were fed differently during the first 6 months of life, the time when differences in weight trajectories emerged.

Another possible explanation is that restriction is a stronger determinant of obesity among children who are older. Among 57 white families, Faith *et al*¹⁹ investigated the association between parental restriction at age 5 and child BMI z-score at age 7. Results were examined before and after adjusting for BMI z-score at age 3 and stratified by obesity risk, defined as parental weight status. Among high-risk children, parental restriction at age 5 was associated with higher BMI z-score at age 7 before ($\beta = 0.55$, $p = 0.05$) and after ($\beta = 0.39$, $p = 0.05$) adjusting for BMI z-score at age 3. However, this association was not found among low-risk children.

The present study had several potential limitations. Generalisability may be limited because, though participants had diverse racial and ethnic backgrounds, their education and income levels were relatively high. In addition, we examined only the first 3 years of life, before children develop many independent eating behaviours. Moreover, maternal restriction may have long-term effects that our study did not allow us to measure, including disinhibited

eating and weight gain in later childhood. Lastly, our restriction measure was from self-report, which is subjective and could have introduced bias.

In conclusion, we found that maternal feeding restriction was associated with children having a higher BMI at age 3 before, but not after, adjusting for WFL at age 1. Our findings do not support the use of this restriction measure in clinical practice among infants. One potential reason may be that parents restrict food intake for children who are already overweight, itself a strong predictor of later obesity. We also found that higher WFL at age 1 was associated with higher BMI and markedly elevated odds of obesity at age 3. Our findings are consistent with an extensive body of literature showing that infants who grow rapidly and are at the highest end of the weight distribution are more likely to be obese later in life.^{31, 32} In short, our findings point to the need to develop interventions to prevent excess weight gain early in life.

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What is already known on this topic

- Some studies show that greater parental control over children's eating habits predicts later obesity, but it is unclear whether parents are reacting to infants who are already overweight.

What this study adds

- We found that maternal feeding restriction was associated with children having a higher body mass index at age 3 before, but not after, adjusting for WFL at age 1. One potential reason may be that parents restrict food intake for children who are already overweight, itself a strong predictor of later obesity.

Table 1

Bivariate associations between maternal feeding restriction at age 1 and maternal and infant characteristics, among 837 mother–infant pairs

		Maternal feeding restriction		p Value
		No	Yes	
	Total	(n=737, 88%)	(n=100, 12%)	
Maternal characteristics	Mean (SD)	n%	n%	
Age at enrolment, years	32.6 (4.9)	32.8 (4.9)	31.3 (5.2)	0.004
Prepregnancy BMI, kg/m ²	24.4 (5.0)	24.3 (4.8)	25.8 (5.8)	0.01
Pregnancy weight gain, kg	15.4 (5.4)	15.5 (5.4)	15.1 (5.7)	0.51
Paternal BMI, kg/m ²	26.5 (3.9)	26.3 (3.7)	28.0 (4.6)	0.001
	N (%)			
Education <college graduate	224 (27)	178 (24)	46 (46)	<0.0001
Household income <\$70,000	257 (33)	209 (30)	48 (54)	<0.0001
Race/ethnicity				<0.0001
White	627 (75)	571 (78)	56 (56)	
Black	88 (11)	68 (9)	20 (20)	
Hispanic	47 (6)	38 (5)	9 (9)	
Other	74 (9)	59 (8)	15 (15)	
Child characteristics	Mean (SD)			
Birth weight, kg	3.49 (0.55)	3.49 (0.55)	3.51 (0.56)	0.63
Gestational age at delivery, weeks	39.5 (1.8)	39.5 (1.8)	39.5 (1.8)	0.14
Breastfeeding duration, months	6.4 (4.5)	6.7 (4.5)	4.4 (4.2)	<0.0001
WFL z-score at age 6 months	0.70 (0.95)	0.66 (0.92)	0.98 (1.10)	0.02
WFL z-score at age 1	0.32 (1.01)	0.25 (0.98)	0.82 (1.13)	<0.0001
Age, years	3.2 (0.3)	3.2 (0.3)	3.2 (0.2)	0.22
BMI z-score at age 3	0.43 (1.01)	0.38 (1.00)	0.81 (0.99)	<0.0001
SS+TR* mm	16.7 (4.0)	16.5 (4.0)	17.6 (3.9)	0.02
	N (%)			
Female	425 (51)	374 (51)	51 (51)	0.96
BMI status at age 3				<0.0001
< 5th percentile	20 (2)	19 (3)	1 (1)	
5th to <85th percentile	595 (71)	542 (74)	53 (53)	
85th to <95th percentile	146 (17)	117 (16)	29 (29)	
95th percentile	76 (9)	59 (8)	17 (17)	

BMI, body mass index; SS, subscapular; TR, triceps skinfold; WFL, weight-for-length. *Sum of SS and TR thicknesses.

Table 2

Association of maternal feeding restriction at age 1 and obesity-related outcomes at age 3, before and after adjusting for weight-for-length z-score at age 1, among 837 mother–infant pairs

Model	Predictor	BMI z-score	SS+TR*	Obesity [†]
		β (95% CI)	β (95% CI)	OR (95% CI)
M1. Unadjusted	Restriction	0.43 (0.22 to 0.64)	1.03 (0.17 to 1.88)	2.95 (1.60 to 5.42)
M2. M1 + covariates [‡]	Restriction	0.26 (0.05 to 0.48)	0.95 (0.07 to 1.83)	2.14 (1.02 to 4.46)
M3. M2 + WFL	Restriction	0.00 (−0.17 to 0.18)	0.40 (−0.44 to 1.25)	1.04 (0.41 to 2.62)
z-score at age 1	WFL z-score	0.57 (0.51 to 0.62)	1.22 (0.95 to 1.50)	10.49 (6.01 to 18.31)

BMI, body mass index; SS, subscapular; TR, triceps skinfold; WFL, weight-for-length. *Sum of SS and TR thicknesses.

[‡]BMI 95th percentile versus 5th to <85th percentile.

[†]Paternal BMI; child age, sex, birth weight and breastfeeding duration; and maternal race/ethnicity, education, prepregnancy BMI, pregnancy weight gain and household income.

Table 3

Association of maternal feeding restriction at age 1 and BMI z-score at age 3, before and after adjusting for weight-for-length z-score at age 1, stratified by maternal overweight status, among 837 mother–infant pairs

		<u>Maternal prepregnancy BMI</u>		
		<25 kg/m ² (n=553)	≥25 kg/m ² (n=281)	
Model	Predictor	β (95% CI)		Interaction p Value [*]
M1. Unadjusted	Restriction	0.35 (0.08 to 0.62)	0.40 (0.07 to 0.73)	0.81
M2. Adjusted [†]	Restriction	0.25 (−0.04 to 0.53)	0.30 (−0.05 to 0.64)	0.68
M3. M2 + WFL	Restriction	0.03 (−0.20 to 0.26)	−0.01 (−0.31 to 0.28)	0.91
z-score at age 1	WFL z-score	0.57 (0.51 to 0.64)	0.55 (0.44 to 0.65)	

BMI, body mass index; WFL, weight-for-length.

^{*} p Value for interaction term maternal feeding restriction by prepregnancy BMI.

[†] Paternal BMI; child age, sex, birth weight and breastfeeding duration; and maternal race/ethnicity, education, prepregnancy BMI, pregnancy weight gain and household income.